PHONOLOGICAL PROCESSING AND SPEECH MOTOR CONTROL IN BILINGUAL ADULTS WITH STUTTERING

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CERTIFICATE

This is to certify that this dissertation entitled **"PHONOLOGICAL PROCESSING AND SPEECH MOTOR CONTROL IN BILINGUAL ADULTS WITH STUTTERING"** is a bonafide work submitted in part fulfilment for the degree of Master of Science (Speech language Pathology) of the student (**Registration number: 10SLP036**). 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.

MYSORE
JUNE 2012

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DECLARATION

I hereby declare that this dissertation entitled **"PHONOLOGICAL PROCESSING AND SPEECH MOTOR CONTROL IN BILINGUAL ADULTS WITH STUTTERING"** is the result of my own study and has not been submitted earlier to any other university for the award of Diploma or Degree.

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IN THE FOND MEMORY OF

GRANDPA

WE ALL MISS YOU..

DEDICATED TO MY MUMY

AND PAPA

FOR ALL YOUR LOVE AND

BLESSINGS

CHAPTER I

INTRODUCTION

The World Health Organisation (WHO, 1977) defined stuttering disorders as: Disorders in the rhythm of speech, in which the individual knows precisely what he wishes to say, but at the same time is unable to say it because of an involuntary repetition, prolongation or cessation of a sound. However, it cannot be denied that what is identified as stuttering is sometimes evident not only in the intermittent impairment of fluency but also in the rate, pitch, loudness, inflectional patterns, articulation, facial expression and postural adjustments. Several definitions reflects a continuing belief amongst many professionals who specialize in stuttering that people who stutter (PWS) do not have difficulty formulating in their minds (in inner speech) the words they want to say, but encounter difficulty when they attempt to express those words out loud.

Stuttering is a disorder of high inter and intra individual variability and in spite of decades of research it remains a mystery with regards to its definition, characteristic features, its assessment and management. The term “stuttering”, as popularly used, covers a wide spectrum of severity: it may encompass individuals with barely perceptible impediments, for whom the disorder is largely cosmetic, as well as others with extremely severe symptoms, for whom the problem can effectively prevent most oral communication. Primary stuttering behaviours are the overt, observable signs of speech fluency breakdown including repeating sounds, words, phrases, silent blocks, and prolongation of sounds. These differ from the normal disfluencies found in all speakers in that, stuttering disfluencies may last longer, occur more frequently and are produced with more effort and strain. Normal disfluencies (NDs) are seen in all individuals including persons with stuttering (PWS), whereas stuttering like disfluencies (SLDs) are not seen in normal individuals. Stuttering disfluencies also vary in quality: normal disfluencies involve repetition of whole words, phrases or parts of sentences, pauses (both filled and unfilled), interjections and hesitations while stuttering like disfluencies are characterized by prolongations, blocks and part-word repetitions (sound/syllable repetitions). Secondary stuttering behaviours are unrelated to speech production and are learned behaviours which become linked to the primary behaviours. Secondary behaviours include escape behaviours, in which PWS attempt to terminate a moment of stuttering using various bodily movements like facial grimaces, head or hand movements during the moments of disfluencies. Secondary behaviours also refer to the use of avoidance strategies such as avoiding specific words, people or situations that the person finds difficult.

Another challenge is regarding an explanation for stuttering. Since long, researchers have been trying to find the etiology of stuttering. Among the various theories of stuttering, some theories attempt to explain why people begin to stutter or the factors that cause them to be at greater or lesser risk for stuttering. Others attempt to explain the symptomatology and phenomenology of moments of stuttering, and still others attempt to explain why the disorder persists after it has begun. The fact that researchers do not agree upon a common etiology for stuttering has several implications for clinicians. First, the clinicians themselves have to decide which explanations for stuttering are the most plausible, which are the most consistent with both research on the disorder and information they have received from their clients (Perkins, 1990). Thus, competent clinicians can differ on how they explain aspects of its etiology. A second implication of the lack of agreement about the etiology of stuttering is that it results in a lack of agreement about how to treat the disorder. The approach a clinician uses to treat the disorder should be based, at least in part, on the assumptions he or she makes about its etiology (Williams, 1968). If for example, a clinician believes that a client's stuttering is a symptom of psychopathology, he or she should treat the disorder, at least in part, by means of psychotherapy. On the other hand, if a clinician believes that an aspect of stuttering is a learned behavior, he or she should treat it by means of learning-theory-based behavior modification strategies. A third implication is that each clinician has to decide the best way to answer a client on the etiology of stuttering. Researchers disagree not only about the cause of stuttering, but about whether it always has the same cause (Van Riper, 1982). The manner in which the question is answered can affect the person asking it in various ways. For example, for some the answer is more likely to have a negative impact if it indicates that the cause is "psychological" rather than "physiological".

These evidences suggest that stuttering is not a unitary disorder and there exist a need to identify component that affect child/adult threshold for fluency. This has led to research on speech production in PWS from a phonological perspective. There is also evidence that there may be a link between early stuttering and phonological deficit (Louko, Edwards, & Conture, 1990; Postma & Kolk, 1993; Kolk & Postma, 1997; Louko, Conture & Edwards, 1999) which have led to the development of covert repair hypothesis (Postma & Kolk, 1993), arguing that stuttering is related to an unstable phonological system.

Current psycholinguistic theories of typical language formulation refer to this process as "phonological encoding” (Dell, 1986; Dell & O'Seaghdha, 1992; Jansma & Shiller, 2004; Levelt, 1989; Levelt, Roelofs, & Meyer, 1999; Roelofs, 2004; Shattuck-Hufnagel, 1979, 1992). Phonological encoding involves the retrieval of segments of phonological code (i.e., phonemes or syllables of a word) in an incremental, just-in-time manner to allow for efficient construction of phonological words. Although details of the stuttering theories vary, they all hypothesize that a delay or breakdown occurs when phonological words are constructed from individual phonemes (i.e., during the process of phonological encoding). There is evidence to suggest that aspects of phonological encoding may not be as efficient or effective in individuals who stutter, although some of these findings are equivocal (Bosshardt & Fransen, 1996; Burger & Wijnen, 1999; Hennessey, Nang & Beilby, 2008; Sasisekaran & de Nil, 2006; Sasisekaran, de Nil, Smith & Johnson, 2006; Weber-Fox, Spencer, Spruill & Smith, 2004; Wijnen & Boers, 1994). Few studies have investigated these same processes in adults who stutter. This is surprising considering that the theoretical models of stuttering are nearly all based on the fully-specified adult speech system (Howell & Au-Yeung, 2002; Kolk & Postma, 1997; Perkins, Kent & Curlee, 1991; Postma & Kolk, 1993; Wingate 1988; Karniol, 1995). Thus, it would be beneficial to investigate the phonological processing skills of adults who stutter to be able to equate the results directly with the theoretical models of stuttering.

Non-word repetition tasks have been used mainly for testing phonological working memory skills in children (e.g., Dollaghan, Biber & Campbell, 1993, 1995; Gathercole & Baddeley, 1996; Dollaghan & Campbell, 1998) and adults (Gupta, 2003). There is only handful of studies with respect to non-word repetition in PWS.

Most studies are done in CWS compared to CWNS which have examined how the number of correct responses, phoneme errors and fluency varied across different syllable length during non-word repetition task (eg., Hakim & Ratner, 2004; Anderson, Wagovich & Hall, 2006; Seery, Watkins, Ambrose & Throneburg, 2006; Bakhtiar, Abad Ali & Sadegh, 2007).

Peters and Starkweather (1990) hypothesized that there are subgroups of PWS such that one group develop the disorder primarily out of a linguistic deficit. According to them, combinations of such deficits are also possible, and it could be that an imbalance between linguistic and motoric development could be related to stuttering. Peters (1990) suggests three hypotheses that seem to account for these findings:

1. **Sub-group Hypothesis**: there are sub-groups of PWS that one develops primarily out of motoric deficit while another develops it primarily out of a linguistic deficit.
2. **Interference Hypothesis**: this hypothesis is based on research in PWNS, which suggest that the simultaneous performance of language formulation and motor programming may result in deterioration of performance in one or both areas (Kinsboume & Hicks, 1978).
3. **Competence and performance Hypothesis:** these have different effects on fluency. Higher levels of language competence (knowledge) could hinder fluency by creating large lexicon and a greater available pool of syntactic forms from which to choose words and formulate sentences. Higher-level performance skills such as word finding and sentence construction can only

improve fluency by increasing the rate at which language performance is executed.

Articulatory abilities in PWS were measured using various paradigms like reaction time and kinematic analysis of articulatory movements. A study conducted by, Caruso, Abbs and Gracco (1988) found that PWS showed longer movement durations and longer temporal intervals between articulatory and phonatory events than did non-stuttering speakers. In addition, several acoustic studies have shown longer VOT, stop gap durations, vowel durations and consonant-vowel transition durations in PWS compared to PWNS, although these differences were sometimes limited to certain conditions of phonetic context or articulatory complexity. The above studies were focusing only on speech movements and not on the speech motor control systems and sequential motor movements that require speech motor coordination. Production of tongue twisters is the task that requires precise, sequential speech motor coordination and it is difficult to produce quickly and correctly, even for normal individuals.

AWS are slower to decide whether an item is a word in a language than AWNS (Hand & Haynes, 1983; Rastatter & Dell, 1987). They are also slower to name pictures, even when the stimuli consist of a few as eight familiar nouns and verbs that had been previously pre-tested to assure their recognition (Prins, Main, & Wampler, 1997). AWS also show differences in priming; priming refers to the fact that people are typically faster to respond to a word (such as CAT) after hearing either a semantically related word (such as DOG) or phonologically related word (such as CAP). Pellowsky and Conture (2005) found that CWS did not appear to benefit from semantic priming, and Burger and Wijnen (1998) reported that AWS showed weaker phonological priming than AWNS (Burger & Wijnen, 1999). The notion that items in the mental lexicons of AWS might be less well specified for phonological and other attributes has support from a number of studies. For example, AWS have also shown slower RT's on tasks requiring monitoring of phonological structure (such as judging whether stimuli rhyme) and lexical analysis (making semantic category judgements; Bosshardt, 1993, 1994; Weber- Fox, Spruill, Spencer, & Smith, 2008), as well as while monitoring for particular phonemes (Sasisekaran, De Neil, Smyth, & Johnson,2006).

Very few researchers have attempted to explicate the role of these linguistic and phonological encoding features in the bilingual PWS, although bilingualism contributes to structural change through borrowing across languages. Also there is notion that bilinguals will have a high level of concept formation since they have access to two verbal codes which influences the primary language of a speaker. Stuttering in bilinguals is an area that has not received much attention. In bilinguals, there may be much disfluency related to word finding in the weaker language (Lw), or to uncertainty in planning syntax. Distinguishing normal speech disfluencies (NSDs) from stuttered disfluencies is difficult enough with monolingual participants. In the embryonic literature on bilingual stuttering, there are no guidelines on how to classify disfluencies in adults who stutter, how to determine which are due to language proficiency, which are normal speech disfluencies and which are instances of stuttering. Thus, measuring stuttering severity, as opposed to overall disfluency level, will be particularly difficult.

Need for the study

In the Indian context there is a dearth of research pertaining to stuttering in general and AWS in particular. India being a multi-lingual country, there is a vast scope for research pertaining to linguistic issues influencing stuttering. Recent research implicates the phonological processing abilities and motor control required for producing complex, co-ordinated speech in AWS. It is interesting to know the differences if any in non-word and tongue-twister repetition skills in Hindi (mother tongue) compared to English (second language) in bilingual AWS. Also, studies on the ability of AWS to produce tongue twisters which require complicated articulatory precision has received little attention especially in the Indian context, may be because of relatively poor understanding of how the task is accomplished and how it induces error. It is important to note the differences if any in the production of tongue twisters in Hindi as compared to English with respect to reading task. Hence the present study is planned to study these parameters in terms of non-word repetition and production of tongue twisters in AWS across mother tongue (Hindi) and second language (English).

Aim of the study

The present study is undertaken with the objective of investigating differences if any in some of the phonological and articulatory parameters in AWS compared to those without. The specific hypothesis includes:

1. AWS do not differ from AWNS in the reaction time and total duration on a non-word repetition task of the two lengths (bi-/tri-) in mother tongue (Hindi) and second language (English).

2. AWS do not differ from AWNS in the number of correct responses produced on a non-word repetition task compared to a word repetition task.
3. There is no difference in the fluency of non-word repetition responses as non-word length (in syllables) increases between AWS and AWNS.
4. There is no relationship of non-word repetition performance across mother tongue (Hindi) and second language (English) AWS and AWNS.
5. AWS and AWNS do not differ in the production of tongue twisters in terms of types and frequency of disfluencies.
6. To compare AWS and AWNS with respect to production of tongue twisters in Hindi and English.

CHAPTER II

REVIEW OF LITERATURE

Several investigations have been done to explore for the exact cause for stuttering. Stuttering is described as a disorder of high variability and cannot be attributed to a single cause and remains unverified. Several studies have put forth different causes leading to stuttering. The reasons include genetic predispositions, emotional and autonomic arousal, linguistic and cognitive processing demands, neurogenic, and psychological. Recent studies have described stuttering associated with motoric deficits (Adams, 1974; 1984; Freeman, 1984; Kent, 1984; Van Riper, 1982; Zimmerman, 1980) and neuromotor disorder characterized by temporal discoordination of the movements involved in speech.

Also, studies have found several factors contributing to risk for stuttering, its development and recovery which are discussed below:

a) **Age**: The preschool children are at the greatest risk of developing stuttering. Three quarters of all who stutter will have started before the age of six years and nearly all stuttering starts before age twelve (Andrews & Harris, 1964; Andrews, 1984; Kloth, Janssen, Kraaimaat & Brutten, 1995; Proctor, Duff & Yairi, 2002; Yairi & Ambrose, 2005). Stuttering typically arises in young children, where it affects > 15% children in the age range of 4-6 years (Bloodstein, 1995).

b) Sex Ratio: Stuttering has significant bias towards male, where male outnumbers females by ratio 3:1 to 5:1 (Yairi, Ambrose, Paden, & Throneburg, 1996).

c) Genetic predisposition: The fact that stuttering runs in the families suggests that there is a strong link between genetic factors and stuttering. High concordance of stuttering is found in monozygotic than dizygotic. Male relatives of females who stutter show the highest risk for developing stuttering (Andrews, 1984).

d) Learning disorders: Stuttering appears to be more prevalent amongst the learning disabled. Blood, Ridenour, Qualls, and Hammer (2003) found that children with LD made up 15% of their large sample of children who stuttered.

e) Environmental factors: This is one of the major causes for stuttering. Some researchers have attributed putting extra pressure on the child can lead to increased risk for stuttering (Rustin, Botterill & Kelman, 1996; Stewart, 1960).

1. Stuttering and Bilingualism

Although stuttering in bilinguals is an area of interest to both clinicians and researchers, data on bilingualism and stuttering are scanty. Literature suggests that stuttering is probably more prevalent in bilinguals than in monolinguals, that stuttering can affect one or both languages, that the two languages any be equally or differently affected, and that diagnosis and treatment in bilingual PWS seem to require a different approach. Apart from the clinical significance, bilingual PWS can be used for testing validity of models postulating linguistic factors which play a role in stuttering moments (Bernstein Ratner & Benitez, 1985). The bilingualism and stuttering has been seen from the issues such as number and age of the subjects, language pairs involved, age of language acquisition, proficiency and usage of both languages and the methodology used in assessing stuttering as well as bilingualism. Siguan and Mackay (1987) referred bilingualism as "the simultaneous and alternating mastery of two languages" to "some degree of knowledge of a second language in addition to spontaneous skills which any individual in his/her first language".

Two main questions are hypothesized for PWS who speak more than one language. First, whether PWS stutter in both the languages equally, and second, whether some stutter in one language and fluent in the other language.

1.1 Prevalence of stuttering bilinguals

The belief that stuttering is more prevalent in bilinguals than in monolinguals seems to be widespread (Eisenson, 1984; Shames, 1989; Karniol, 1992). It can be assumed that in the United States there are 450,000 bilingual PWS, and close to 35,000 of them are Spanish/English bilinguals (American Psychiatric Association, 1994; Ardila, Bateman, Nino, Pulido, Rivera, & Vanegas, 1994; Mannson, 2000). However, differences in prevalence of stuttering between monolinguals and bilinguals cannot be attributed only to bilingualism. There are other factors which can play a role such as economic insecurity and emotional instability during the time when the child is acquiring a second language (Travis, Johnson & Shover, 1937).

1.2 Effects of similarities and difference between the two languages on stuttering

There are very limited studies in this direction, so further investigation should be done to see whether or not prevalence of stuttering in bilinguals is affected by the similarities of the languages involved. For example, is stuttering prevalence higher in individuals speaking two linguistically related languages than in those who speak two totally different languages? It is conceivable that closely related pairs of languages produce more confusion and therefore more disfluencies than more different pairs.

1.3 Manifestation of stuttering in bilinguals

Evangeline Nwokah (1988) spoke about three possibilities to explain the manifestation of stuttering in bilinguals. One possibility is that ***stuttering occurs in one language but not the other.*** Nwokah analyzed the stuttering behavior of sixteen high-school educated PWS, between 16-40 years in Anambra State, Nigeria. Samples of reading aloud (300 word passage) and conversation were analyzed. It was seen that there was no overall difference in the amount of stuttering in either Igbo or English in both reading and spontaneous speech.

The second possibility is that ***stuttering occurs in both languages: the same hypothesis i.e. PWS will show similar behavioural patterns in speaking any language.*** Lebrun, Bijleveld, and Rousseau (1990) did a study and found their patient, a right handed French-Dutch speaking male, began to stutter following a brain damage. Authors reported that the severity of his speech impediment fluctuated but never disappeared and affected French and Dutch equally.

The third hypothesis was that ***stuttering occurs in both languages: the difference hypothesis i.e. stuttering behavior will vary from one language to another.*** A case reported by Shenker, Conte, Gingras, Courcey, & Polomeno (1998) seems to confirm this possibility. They studied the impact of bilingualism on developing fluency in an English-French speaking pre-school age child. A dysfluency analysis of transcripts of the child's spontaneous speech samples revealed more stuttering like disfluencies in English than in French (13.51 % and 9 .89% respectively). More word repetitions were noted in French and more part-word repetitions were noted in English, but this reflected the child's uneven languages development in English and French. There was a higher frequency of monosyllabic words in French in the sample, hence more word than part-word repetitions.

In the Indian context, Jayaram (1983) studied ten bilingual male PWS, aged 19-32 years (mean age 25.6 years) who knew both English and Kannada but Kannada was their primary language. There appeared to be no difference in the two languages in either the pattern or distribution of stuttering on different sound groups. However, subjects were reported to stutter more in Kannada than English, particularly in spontaneous speech, though this difference is not statistically significant. This study suggests that some bilingual PWS may differ in the severity of their stuttering in both the languages, but not in the pattern or distribution of stuttering. More recently, Sneha, Shruthi and Geetha (2008) studied the pattern of distribution of stuttering in 10 adult bilingual PWS. The results of the study indicate that there is no significant difference in stuttering in the two languages used by bilinguals with regard to severity and percentage of SLD's and ND's, although there were individual variations with regard to different speaking situations.

2. Language and stuttering

Linguistic and language variables play an important role in the moments of stuttering and there are number of findings which support the association between linguistic variables and stuttering (Wall & Meyers, 1982; Hamre, 1984; Homzie & Lindsay, 1984; Blood, Ridenour, Qualls, and Hammer (2003).

2.1 Loci and class of stuttering:

Studies have investigated the loci and frequency of stuttered events related to the phonetic, lexical, syntactic and pragmatic components of language which suggest there may be an interaction between linguistic processing and instances of stuttering.

- More stuttering is seen on the first few words of an utterance (Brown, 1938; Wingate, 1979; Wall, Starkweather, & Cairns, 1981; Howell & Au-Yeung, 1995).
- Decrease in stuttering is found on consecutive words in a sentence (Hejna, 1955).
- More unpredictable words carry more severe stuttering (Quarrington, 1965).
- Word position was a more accurate determiner of loci of stuttering than length of word or phonetic identity of the syllables (Taylor, 1966).
- Initial word is more susceptible to stuttering than medial or final words (Conway & Quarrington, 1963).
- Word frequency effect was only seen with lists of short rather than longer words (Wingate, 1976).
- Children show stuttering on longer or grammatically more complex utterances (Kadi-Hanifi & Howell, 1992; Howell & Au-Yeung, 1995; Logan & Conture,

1995, 1997; Logan & LaSalle, 1999; Yaruss, 1999; Melnick & Conture, 2000) although some authors have suggested that this effect diminishes in adults (Logan, 2001).

- Longer the word greater the likelihood of stuttering (Hejna, 1955; Silverman, 1972; Soderberg, 1966, 1967; Griggs & Still, 1979).
- Low frequency words are stuttered more than high frequency words (Schlesinger, Forte, Fried & Melkman, 1965; Soderberg, 1966).

However some studies which provided these data contained some significant design weaknesses, for example, failing to control for word frequency or potential phonetic influences. Jayaram (1979), in his study found the following results in bilingual (Kannada-English) individuals who stutter:

- Stuttering is seen to occur more on lexical words than functional words.
- Stuttering increases with increase in sentence length, whether it is a simple or complex sentence.
- Stuttering is more on verbs in spontaneous speech in Kannada, while it is more on nouns in English.
- Significantly less stuttering occurs on reading a meaningful passage than on nonsense passage.
- In a meaningful passage, siginificantly more stuttering occurred on the initial syllable of words, while in nonsense passage more stuttering occurred on the medial and final syllables of words.
- Stuttering was seen more on familiar words than less familiar words.

Another area of enduring interest has been the study of stuttering from a word class perspective. A consistent research finding is that stuttering occurs more commonly on content words amongst the adult population (Johnson & Brown, 1935; Brown, 1938, 1945; Hejna, 1955; Geetha, 1979; Howell, Au-Yeung & Pilgrim, 1999), while stuttering occurs more on function words in young children (Bloodstein & Gantwek, 1967; Wall, 1977; Bernstein, 1981; Bloodstein & Grossman, 1981; Howell et al., 1999). Jayaram (1979)'s study results indicated the order of difficulty on grammatical parts of speech in Kannada to be verbs, nouns, adjectives, prepositions and pronouns, and in English as nouns, adjectives, verbs, pronouns and prepositions.

3. Phonological processing/ encoding abilities in stuttering

There is evidence too that children who stutter may have reduced abilities to plan, or retrieve sentence level units of speech (Cuadrado & Weber-Fox, 2003; Anderson & Conture, 2004) and that there may be a link between early stuttering and phonological deficit (Louko, Edwards, & Conture, 1990; Postma & Kolk, 1993; Kolk & Postma, 1997; Louko, Conture & Edwards, 1999).

There is data supporting the fact that there is language encoding impairments in PWS. Wijnen & Boers (1994) did a study on implicit priming in AWS compared to control group. Their findings revealed that AWS benefited from primes containing both the initial consonant and vowel of the target word but the control group benefitted from primes containing only the initial consonant, suggesting, AWS have more difficulty encoding stress bearing phonemes. However, Burger and Wijnen (1999) failed to replicate the same results. Despite of these mixed results from phonological priming studies (Sasisekaran & De Nil, 2006; Sasisekaran, De Nil, Smith, & Johnson, 2006) found that PWS were slower in formulating words in inner speech and identify them later. No significant difference was found between the two groups on auditory monitoring, identifying phonemes when listening to tape recordings, picture naming, and simple motor responses, suggesting slower responses of AWS on phoneme monitoring task stemmed from impaired phonological encoding and not from general monitoring impairment or slow motor response.

3.1 Lexical retrieval in stuttering

One hypothesis that emerges from time to time is that stuttering may be associated with a deficiency in assessing a word (Wingate, 1988; Gregory & Hill, 1999; Packman, Onslow, Coombes & Goodwin, 2001), that is, difficulties in lexical retrieval. One of the problems in testing this notion lies in distinguishing differences in response latencies as being due to word fear, rather than difficulties with lexical access (Conture, 1990). The arguments both for and against this possibility have been recently reviewed in a study which found PWS to be disfluent on non-words as well as on real words, thus indicating that the meaning of the word itself was not implicated in any failure in its production (Packman, Onslow, Coombes & Goodwin, 2001). These findings were subsequently questioned by Au-Yeung and Howell (2001) who pointed out some methodological weaknesses in the study's design. However, a subsequent study (Batik, Yaruss & Bennett, 2003) also found that there was no significant difference in word- finding ability between a group of twenty children who stuttered and matched control group with no stuttering. They concede, however, that their test only required a single word response and that as the demands of other linguistic factors (grammatical complexity, length of utterance) increase in running speech, this could lead to difference in word retrieval between CWS and CWNS. Packman, Onslow, Coombes and Goodwin (2001) could not clearly define 'lexical retrieval', so they adopted Levelt's model of speech production (Levelt & Wheeldon, 1994; Levelt, Roelofs & Meyer, 1999) where they included 'morphological and phonological encoding' as the last three lexical stages in the retrieval process, and therefore Packman, Onslow, Coombes and Goodwin (2001) included phonological encoding as part of lexical retrieval.

3.2 Covert repair hypothesis and EXPLAN hypothesis

A number of studies suggest that PWS and PWNS differ in their language production abilities, and findings suggests that, PWS take longer time in formulating their utterances, which may stem from slow phonological, lexical and/ or semantic encoding. And this conclusion supports the two psycholinguistic hypotheses: The Covert Repair Hypothesis (CRH) (Kolk & Postma, 1997; Postma & Kolk, 1993), and EXPLAN hypothesis (Howell & Au-Yeung, 2002), and both pose a causal relationship between slow language encoding and stuttering. Wingate (1988) described stuttering as a result of disturbance of lexical access where the speaker is unable to generate the word though the onset of the syllable is retrieved appropriately. Wingate suggests that this problem occurs during the third stage of Levelt's model of lexical retrieval.

CRH is essentially a psycholinguistic theory of error production in non-stuttering speakers, which can also explain the speech errors seen in stuttering from a phonological perspective. Postma and Kolk (1993) and Kolk and Postma (1997) assumed that all language production is subject to various self-monitoring procedures, which occur at different stages along the language production process. Early monitoring occurs for the phonetic plan of the utterance while the final monitoring stage, occurring fractionally after the speech end product, is auditory. The theory contends that the speech flow of those who stutter is interrupted by an internal feedback loop during pre-vocalization, just before the speech is produced (Levelt, 1998). When an error plan is detected, speech/language production is halted and "repairs" are made before the process can continue.

The CRH explains Stuttering-Like Disfluencies (SLDs) as language encoding errors. This hypothesis describes that the speaker plans out speech before articulation and stores it in articulatory buffer for anything up to a few milliseconds before being articulated. During this, speaker also cancels and reformulates these plans through internal monitoring loop if necessary (Levelt, 1983; Levelt, 1989). If an error is perceived in this way and the speech plan is cancelled before the onset of overt articulation, a silent pause or "block" may ensue while the plan is reformulated. However, errors occurring later in the plan may not be noticed immediately. Thus situations may occur where overt articulation of the first phonemes, syllables or words of a plan may have already begun before the error is detected. In such cases, the speaker stops, retraces to a suitable point and starts again, the result being that, although the error itself is not articulated, the phoneme(s) or word(s) immediately preceding it will be repeated at least once and perhaps several times, depending on how many reformulations of the plan are needed before the correction is achieved. Repetition of continuants may occur without breaks in between, producing symptoms of prolongation rather than repetition. In this way, the CRH accounts for the three main types of stuttering-like disfluency: repetitions, prolongations and blocks.

Part- word repetitions are found commonly in developmental stuttering which results due to repairing the errors in phonological encoding (Postma & Kolk, 1993). Furthermore, as phonological encoding is effectively the end of the line with respect to production of the speech plan, slow syntactic or lexical encoding may impact upon the amount of time available for phonological encoding to be completed before motor execution begins. Therefore, CRH predicts that phonological symptoms are universally found in PWS. Conture (2001) argues that there may be two strands to the way in which time affects the likelihood of an increase in stuttering:

a) At a normal speech rate the speaker demonstrates a slow activation rate of both the target unit and competing targets. This increases the likelihood of selection error and consequently the likelihood of stuttering, because all the units are equally activated.

b) On the other hand, when speaking rate is increased, the rate of activation of the speech units remains normal, but the speaker speeds up the phoneme selection time. This increases that the speaker may mis-select because both the target and competing units now have similar levels of activation.

EXPLAN describes speech language disfluencies as a result of slowness of language encoding than covert error repair. Rather, it occurs when speech planning below the rate of execution and the speaker runs out of speech plan to articulate, and the speaker articulates the speech plans already available to them. According to EXPLAN, the key factor that differentiates persistent PWS from normally fluent speakers is that, when the rate of planning falls behind the rate of execution, whereas normally-fluent speakers habitually adopt a “stalling strategy” whereby they only repeat whole words that have already been formulated, persistent PWS habitually adopt a maladaptive “advancing strategy” whereby they utter (and repeat) the incomplete fragment of the word currently being formulated.

3.3 Phonological Working Memory

Baddeley (2003) referred working memory as a process of phonological encoding. He gave the working memory system which involves two subcomponents: a phonological store and a sub-vocal rehearsal system. The phonological store holds material to be remembered in a phonological code; material that is subject to decay over time. The sub-vocal rehearsal system is a silent verbal repetition process that refreshes the material in a phonological code, allowing it to be preserved in the memory for a longer period of time. Thus, phonological encoding and sub-vocal rehearsal are thought to directly influence memory capacity.

4. Speech motor control in stuttering

Van Lieshout, Hulstijn and Peters (2004) and Van Riper (1982) described stuttering as breakdown in sequencing of movements which is required to produce a smooth flow of speech related to aberrant speech motor control (McFarland & Baum, 1995). Researchers have established several reasons to believe that PWS take longer time to adapt to perturbations. First, due to limited speech motor abilities in persons with stuttering, they take prolonged time to adapt to their perturbations. Second, due to limited speech and non-speech practice in PWS, they take longer time to adapt to novel speaking tasks and conditions. PWS were slower than PWNS to exhibit enhanced speed or accuracy when producing sequences of nonsense syllables over practice (Ludlow, Siren & Zikira, 1997).

The commonest paradigm used by the researchers to see the speech movement in PWS is reaction time (speech initiation time, laryngeal reaction time). The speech RT studies related to isolated vowel have found significant difference between PWS and PWNS (Adams & Hayden, 1976; Cross & Luper, 1979; 1983; Cross, Shadden, &

Luper, 1979; Hayden, Adams, & Jordahl, 1982; Horii, 1984; Starkweather, Franklin, & Smigo, 1984). Literature suggests that motoric complexity plays an important role in the precipitation of stuttering behavior and longer utterances require additional motoric complexity which causes them to be stuttered more. Many studies (Monsell & Sternberg, 1981; Sternberg, Monsell, Knoll & Wright, 1978) reported that the motor programming is an important aspect of speech motor control; suggesting effect of utterance length on reaction time, i.e., one would expect longer, motorically more complex utterances to result in longer reaction times. Another study by Watson and Alfonso (1983) emphasized interpreting phonatory lag in PWS using physiological details. Their results concluded that, although both PW mild and severe stuttering is delayed in programming phonatory responses, PW severe stuttering experience an additional delay in adjusting the larynx for phonation.

5. Approaches for measurement

a. Non word repetition

Not all studies that compared stuttering and fluent populations find differences in their language and phonological abilities (Nippold, 1990, 2002). Authors have attributed stuttering to either anxiety or motor demands and not to lexical retrieval process. In a non word reading task, the word retrieval is eliminated, eliminating the need to access the cognitive representations of words or word meaning'. Several models recommend that non-words take the phonological route and real words take the lexical route to process and it is established that activation of real words are accessed quickly as they are already constructed. Non-word takes longer time to complete as the novel words need to be assembled newly and there is a requirement of increased length of time to complete phonological awareness task (Durgunoglu &

Oney, 1999; Wagner, Torgesen & Rashotte, 1999). Also, Packman, Onslow, Coombes and Goodwin (2001) in one of their studies have concluded that high-frequency words would be processed differently from low-frequency or non-words. Many studies explain that non-word repetition task engages the speech motor system and offers an opportunity to study the effect of speech movement coordination in stuttering with repetition of novel materials.

b. Tongue twister paradigm

One promising technique received little attention is tongue twister paradigm in which the phonological errors are induced artificially by taking advantage of the feature inherent in tongue twister by reciting the word strings over fast rate. Production of tongue twisters is the task that requires precise, sequential speech motor coordination and it is difficult to produce quickly and correctly, even for normal individuals. The tongue twister paradigm involves reciting a word string several times over at a fast rate and its feature includes combinations of similar phonemes. Ellis (1980) found that there is a breakdown in normal speech production and errors are found in serial recall when elements share more similar phonetic features (Wickelgren, 1965).

Postma and Kolk (1990) conducted a comparative study where they compared the disfluencies, self-repairs and speech errors in PWS and PWNS during production of tongue twisters and neutral sentences in Dutch language under low-accuracy and high -accuracy conditions. The results showed that tongue twisters elicited more speech errors, disfluencies and self-repair than neutral sentences.

In the Indian context a study by Vedha, Deepa and Geetha (2008) tried to find the speech motor control in PWS. They took five PWS and presented six tongue twisters each in Kannada and English. They were asked to read and later recite the tongue twister. Their results suggested that number of disfluencies were more in PWS than controls. SLD's, OD's and speech errors were found in both the groups, but all the errors were found to be more in PWS than controls. One promising technique which has so far received relatively little attention is the tongue twister paradigm, in which phonological errors are induced artificially by taking advantage of the features inherent in "tongue twisters." This has the advantage that it generates both quantitative and qualitative information, and can be used to test a wide range of empirical questions.

CHAPTER III

METHOD

The present study was basically aimed to investigate the phonological/articulatory skills in AWS in terms of non-word and tongue twister repetition abilities in mother tongue (mother tongue) and second language (English). All the samples were audio recorded in DMDX software. The detailed procedure used for this study is as follows:

Participants

30 subjects in the age range of 18-30 years were taken for the study, of which 15 were adults with stuttering (AWS) and remaining 15 were age matched adults without stuttering (AWNS).

a) Criteria for selection of AWS: in this group only those subjects were selected who:

  i) were native speakers of Hindi
  ii) had adequate proficiency in English (at least educational background till 12th standard)
  iii) were diagnosed by speech-language pathologist as having stuttering of moderate to severe degree
  iv) had normal hearing sensitivity in both the ears
  v) had no other associated problems like apraxia, oro-motor deficits, misarticulations, or cognitive deficits

b) Criteria for selection of AWNS: in this group, only those subjects were selected who:

i) were native speakers of Hindi

ii) had adequate proficiency in English (at least educational background till 12^{th} standard)

iii) were diagnosed as having normal speech and language by a speech-language pathologist

iv) had normal hearing sensitivity in both the ears

v) had no other associated problems like apraxia, oro-motor deficits, misarticulations, cognitive deficits.

Ethical standards used in the study

Each subjects selected to participate in the study were briefed about the study, aims, method and duration of the testing and a written consents were obtained.

Materials

The test materials used in the study included:

- Stuttering Severity Instrument-3 (SSI-3; Riley, 1994)
- List of bi-syllabic and tri-syllabic words, comprising of all the base phonemes in the initial position of words in Hindi taken from Deep test of articulation in Hindi-picture form (Deepa, 1998) and Photo Articulation test in Hindi (UNICEF project, AYJNIHH; Regional Rehabilitation Training Centre government institute Rehabilitation Medicine campus, Madras, 1990)

- List of bi-syllabic and tri-syllabic words, comprising of all the base phonemes in the initial position of words in English taken from Edinburg Articulation Test (Antony, Bogle, Ingram & Mclsaac, 1971) and the Academic Word List (Averil Coxhead, 2000)
- List of bi-syllabic and tri-syllabic non-words (prepared by the investigator based on words from Deep test of Articulation in Hindi, Picture Articulation Test in Hindi and Edinburgh Articulation Test).
- Six commonly used tongue twisters in Hindi and English language with stop consonants common to both languages.

Experiment 1:

Preparing list of words and non-words- A list of bi- and tri-syllabic true words (TWs) and non-words (NWs), comprising of base phonemes (Hindi and English language) in the initial position of the words and non-words were prepared (see Appendix 1). The following rules were used in the preparation of the non-words:

- Rules used for preparation of bi-syllabic non-words starting with consonants:
  - The consonants of the original word were maintained
  - The vowels of the original word were transposed such that it forms a non-word in Hindi and English.

    For example, ha:thi (true word) to hi:tha (non-word).

    pencil (true word) to pinsel (non-word)
- Rules used for preparation of tri-syllabic non-words
  - The first syllable of the original word was maintained

- The second syllable of the original word was transposed with the third syllable such that it forms a non-word in Hindi and English

  For example, sipahi (word) to sihipa (non-word)

  formula (word) to forlamu (non-word).

Experiment 2

Frequently used tongue twisters were taken from both the language with the common base phonemes. All the tongue twisters across languages were of same length i.e., 4 words for each tongue twister (see Appendix 2).

The prepared list of word/non-word and tongue twister were given to a linguist for the validation. The prepared list of words, non-words and tongue twisters were then fed in the DMDX software (downloadable for speech recording and analysis). An interval of 2 seconds was given between each word, non-word and each tongue twister recorded. Each word/non-word was presented for 2.5 secs and each tongue twister was presented for 10 secs.

Procedure

Each of the subjects was tested individually. The subject was made to sit in a distraction free environment and the tester had a general conversation with the subject so as to record spontaneous speech. Stuttering Severity Instrument-3 (SSi-3; Riley, 1994) was administered to AWS to get the stuttering severity score and to the PWNS to screen out any stuttering like disfluencies. Informally all the subjects and control groups were assessed to check for their articulatory ability and presence of any abnormal phonological processes. The study is undertaken in two experiments. In both the below mentioned experiments the subjects were made to wear Rocky iball supra-aural headphones which was connected to the DELL inspiron 15" laptop. Subjects were given instructions (verbal and written) to repeat each of the items i.e., true word/non-word and read the tongue twisters in each language presented. Each of the true words and non-words were presented only once. The recorded list of words/non-words and tongue twisters were then presented on the laptop with white background, font Times New Roman and size 20. The responses of the adults for all the tasks were audio recorded using DMDX software. The duration of testing lasted for about 45 minutes.

Experiment 1

Prior to presentation of the list of true words and non-words, practice items were given to the subjects to familiarize them with the task in both the languages. The practice items had two words and non-words each in the bi-syllabic and tri-syllabic list. And, the target items had ten words and ten non-words in each category. The true word/non-word in the Hindi was presented prior to the presentation of word/non-word in English. Also, the non-words were presented before the words to reduce the familiarity effect and bi-syllabic words were presented before the tri-syllabic words.

Experiment 2

Prior to the presentation of the tongue twisters, one practice tongue twister in each language was presented to make the subjects familiar with the tasks. The subjects were asked to read the tongue twisters presented on the laptop screen thrice as fast as possible within the given time window of 10 seconds. Hindi tongue twisters were presented before the English tongue twisters.

Scoring: All the tests administered were scored according to the norms provided by each of the tests.

Experiment 1

For the non-word repetition task, the reaction time and the total duration of the words were noted down manually recorded DMDX software. Then the responses of each of the subjects were first transcribed and then scored as either correct or incorrect. All phonemes within a true word/non-word had to be produced correctly for the responses to be scored as correct i.e., presence of one or more phoneme errors was considered as an incorrect response. The number of true words/non-words correctly repeated was calculated for each subject at each syllable length and across all stimulus items.

Secondly, the total number of true words/non-words incorrectly repeated was calculated for each subject at each syllable length and across all stimulus items.

Third, each of the responses was also judged as fluent or non-fluent. The total number of stuttering-like disfluencies (SLD's), other disfluencies (OD's) and other speech errors (articulatory, metathetical etc) was noted for each subject in both true word and non-word repetition tasks. Then the total number of fluent responses was calculated for each subject at each syllable length in both the languages (Hindi and English) of true words and non-words.

Finally, number of correct responses given by subjects for true words and non-words at each syllable length and language was noted down to verify the variability effect among each subject in both AWNS and AWS.

Experiment 2

The samples obtained from each subject were transcribed and errors with respect to speech errors and disfluencies were analyzed. The data was compared across experimental and control groups separately. Also, it was analyzed separately across the languages.

Reliability

Inter-judge and intra-judge reliability was checked. Part of the recorded samples of randomly selected subjects were transcribed and analyzed again to see for the intra judge reliability. Also, randomly selected responses for the word/non-word and repetition task were analyzed by two speech-language pathologist proficient in analyzing for the fluency errors. This was done to establish the inter-judge reliability.

Analysis

For analysis, the scores obtained were tabulated under different headings, as follows;

RT- score obtained from the subjects' attempt to initiate the articulatory movement for the production of true word/non-word (including disfluent response)

TD- score obtained from the time the subjects attempt to initiate the articulatory movement till the time they could manage to finish the word (including disfluent response).

SLD- scores obtained for the prolongations, blocks and part-word repetitions (sound/syllable repetitions).

OD- scores obtained for the whole word repetitions, phrase repetitions, pauses, hesitations and interjections.

SE- scores obtained for the phoneme transpositions, phoneme addition, phoneme substitution, phoneme deletion.

RTbiENGNW- scores obtained for the reaction time of bi-syllabic English non-word.

RTbiENGTW- scores obtained for the reaction time of bi-syllabic English true-word.

RTtriENGNW- scores for the reaction time of tri-syllabic English non-word.

RTtriENGNW- scores for the reaction time of bi-syllabic English true-word.

RTbiHindNW- scores obtained for the reaction time of bi-syllabic Hindi non-word.

RTbiHindTW- scores obtained for the reaction time of bi-syllabic Hindi true-word.

RTtriHindNW- scores obtained for the reaction time of tri-syllabic Hindi non-word.

RTtriHindTW- scores obtained for the reaction time of tri-syllabic Hindi true-word.

TDbiENGNW- scores for the total duration of bi-syllabic English non-word.

TDbiENGTW- scores for the total duration of bi-syllabic English true-word.

TDtriENGNW- scores for the total duration of tri-syllabic English non-word.

TDtriENGNW- scores for the total duration of tri-syllabic English true word.

TDbiHindNW- scores obtained for the total duration of bi-syllabic Hindi non-word.

TDbiHindTW- scores obtained for the total duration of bi-syllabic Hindi true-word.

TDtriHindNW- scores obtained for the total duration of tri-syllabic Hindi non-word.

TDtriHindTW- scores obtained for the total duration of tri-syllabic Hindi true-word.

The obtained raw scores were also converted into their percentages/proportions for the analysis because total scores for all parameters to be compared were not the same. The data was subjected to statistical analysis using the "SPSS 17.0" software. Statistical tests such as ANOVA, MANOVA, independent samples t-test, paired samples t-test, test of proportion were carried out to answer the research questions. Karl Pearson's correlation coefficient was also done to establish the reliability of the data.

CHAPTER IV

RESULTS AND DISCUSSION

To review, the purpose of the present study was to explore the articulatory/phonological abilities and speech motor control of adults who stutter (AWS) and adults who do not stutter (AWNS) using two experimental tasks. First, the participants had to repeat a set of 10 words and non-words each across two syllable categories of increasing length (bi-syllable and tri-syllable) (N = 40 total true words and non-words each) in L1 (Hindi as mother tongue) and L2 (English as second language). The second task required the participants to repeat the set of 3 tongue twisters each in Hindi, and English languages. The results are discussed relative to performances on each of these tasks. For the **first set of analyses** a) AWS and AWNS are compared for the reaction time and total duration in producing bi- and tri-syllabic true words/non-words in L1 and L2, b) the ability of AWS versus AWNS to accurately produce non-words of varying syllable lengths and also their speech and fluency errors while producing those words and non-words were compared. For the **second set of analyses**, the focus was to determine the frequency and types of errors in AWNS and AWS across L1 and L2.

A. Word/nonword repetition task

1. Reaction Time And Total Duration

1. a. Interaction of RT and TD in AWNS & AWS

Repeated measure ANOVA or mixed ANOVA was done to compare the reaction time (RT) between language, length, and type of words and their interactions in AWNS and AWS. The result on RT depicts that there was no significant difference found between languages, and no interaction was found between language and group. Significant difference ($p<0.05$) and interaction was found between length & group and type & group. Also, the interaction was present between language & length, language & type, and length & type. The results on total duration (TD) depicts that a significant difference was found between both L1 and L2 but no interaction was present for language & group and length & group. A significant difference ($p<0.05$) and interaction was present for type & group. Interaction was present between language & length, language & type, length & type, and language & length & group. But no other three way interactions were found. The result reveals that when RT was taken into account, there was no language effect on both the groups (AWNS & AWS), whereas the types of words and word lengths had interaction with AWNS and AWS. For TD, AWNS and AWS had interaction with the type of word only. The values are shown in Table 1 and Table 2 below.

Table 1: ANOVA values for RT in bi-/tri-syllabic length in TW/NW in L1 and L2 between AWNS and AWS

Parameters	df	F (1, 28)
(A) Group	1	38.22*
(B) Language	1	.854
(C) Length	1	77.81*
(D) Type	1	301.56*
AxB	1	1.76
AxC	1	14.52*
AxD	1	13.15*
BxC	1	8.31*
BxD	1	26.14*
CxD	1	25.51*
AxBxC	1	3.01
AxBxD	1	3.87
AxCxD	1	1.56

BxCxD	1	1.34
AxBxCxD	1	.245

[*-significant difference, p<0.05]

Table 2: ANOVA values for TD in bi-/tri-syllabic length in TW/NW in L1 and L2 between AWNS and AWS

Parameters	df	F (1, 28)
(A) Group	1	.341
(B) Language	1	11.75*
(C) Length	1	215.49*
(D) Type	1	41.38*
AxB	1	2.97
AxC	1	.352
AxD	1	4.61*
BxC	1	10.17*
BxD	1	10.59*
CxD	1	20.08*
AxBxC	1	5.51*
AxBxD	1	1.25
AxCxD	1	4.01
BxCxD	1	.155
AxBxCxD	1	1.58

[*-significant difference, p<0.05]

Since, for RT both length and type and for TD the type is showing interaction with the groups, further repeated measure ANOVA was done separately for both the groups (AWNS and AWS) to see the significant difference between languages, lengths, and types within each group.

1. b. Mean and standard deviations of RT and TD in AWNS and AWS

The AWNS and AWS were compared for their performance in the reaction time and total duration. The mean and standard deviations of the RT and TD of bi- and tri-syllabic TW/NW in L1 and L2 are given with respect to AWNS and AWS in Table 3 and Table 4 respectively. As per the mean and SD, there are differences seen in RT and no difference found in TD across AWNS and AWS for the two lengths of the words (bi- and tri-), the two types of words (NWs and TWs) and the two languages (English and Hindi).

Table 3: Mean and SD of the RT of bi- and tri-syllabic TW/NW in L1 and L2 in AWNS and AWS

Parameters	AWNS			AWS		
	N	Mean	SD	N	Mean	SD
RTbiENGNW	15	842.61	140.45	15	1152.31	190.55
RTbiENGTW	15	589.04	93.80	15	768.43	136.55
RTtriENGNW	15	963.35	98.20	15	1470.78	289.67
RTtriENGTW	15	643.21	118.25	15	929.53	221.68
RTbiHINDNW	15	814.94	137.55	15	1054.04	233.80
RTbiHINDTW	15	666.01	171.19	15	836.50	119.44
RTtriHINDNW	15	947.63	131.14	15	1284.77	231.90
RTtriHINDTW	15	657.29	167.02	15	879.81	176.31

Table 3: Mean and SD of the RT of bi- and tri-syllabic TW/NW in L1 and L2 in AWNS and AWS

Parameters	AWNS			AWS		
	N	Mean	SD	N	Mean	SD
TDbiENGNW	15	619.26	96.38	15	605.50	133.25
TDbiENGTW	15	523.57	86.33	15	524.75	89.89
TDtriENGNW	15	882.30	135.51	15	742.73	151.84
TDtriENGTW	15	647.06	94.13	15	647.37	109.92
TDbiHINDNW	15	588.68	88.99	15	552.71	162.63
TDbiHINDTW	15	558.69	93.17	15	555.47	83.92
TDtriHINDNW	15	717.87	103.65	15	707.73	115.19
TDtriHINDTW	15	586.40	100.39	15	624.34	110.19

[AWNS= Adults with no stuttering; AWS= Adults with stuttering; N= number of subjects; SD= standard deviation; TDbiENGNW= total duration of bisyllabic English non-word; TDbiENGTW= total duration of bisyllabic English true word; TDtriENGNW= total duration of trisyllabic English non-word; TDtriENGTW= total duration of trisyllabic English true word; TDbiHINDNW= total duration of bisyllabic Hindi non-word; TDbiHINDTW= total duration of bisyllabic Hindi true word; TDtriHINDNW= total duration of trisyllabic Hindi non-word; TDtriHINDTW= total duration of trisyllabic Hindi true word]

Table 5: MANOVA values for RT of bi- and tri-syllabic TW/NW in L1 and L2 between AWNS and AWS

Parameters	F(1, 28)
RTbiENGNW	25.68*
RTbiENGTW	17.59*
RTtriENGNW	41.29*
RTtriENGTW	19.48*
RTbiHINDNW	11.65*
RTbiHINDTW	10.01*
RTtriHINDNW	24.02*
RTtriHINDTW	12.59*

Table 6: MANOVA values for TD of bi- and tri-syllabic TW/NW in L1 and L2 between AWNS and AWS

Parameters	F(1, 28)
TDbiENGNW	.136
TDbiENGTW	.004
TDtriENGNW	6.65*
TDtriENGTW	.043
TDbiHINDNW	.472
TDbiHINDTW	.012
TDtriHINDNW	.017
TDtriHINDTW	1.24

[*= significant difference (p<0.05); TDbiENGNW= total duration of bisyllabic English non-word; TDbiENGTW= total duration of bisyllabic English true word; TDtriENGNW= total duration of trisyllabic English non-word; TDtriENGTW= total duration of trisyllabic English true word; TDbiHINDNW= total duration of bisyllabic Hindi non-word; TDbiHINDTW= total duration of bisyllabic Hindi true word; TDtriHINDNW= total duration of trisyllabic Hindi non-word; TDtriHINDTW= total duration of trisyllabic Hindi true word]

MANOVA was administered to find the significant difference of reaction time and total duration between AWNS and AWS in both the lengths of words (bi- and tri) and the types of words (word and non-word) across L1 and L2, which are given in Table 5 and Table 6 respectively. The results revealed that there was a significant difference for RT in both the groups across all the parameters ($p<0.05$) but for TD AWNS and AWS differed significantly only for tri-syllabic English non-word.

It indicates that the AWS took more time to process and articulate both the bi- and tri-syllabic TW and NW both in L1 and L2 compared to AWNS. Also, it was noted that both AWNS and AWS took more time to process the non-words compared to true words and tri-syllabic compared to bi-syllabic both in L1 and L2. The mean value for TD does not reveal any significant effect between AWNS and AWS. This result replicates many studies and one by Peters, Hulstijn, and Starkweather (1989), where they reported that longer utterances result in longer RT attributable to input processing and this effect of utterance length was stronger for PWS than for PWNS.

It might be due to that AWS found it difficult to read and program/process the longer utterances and non-words. AWS might have slowed down to think and start the utterance and speak more fluently. Also, in many studies it is reported that AWS demonstrate an unusual way of talking with less clear articulation and fast rate of speech, which might be a reason for having no significant difference in total duration between AWNS and AWS, as AWS using fast rate of speech could manage to finish the TW and NW within the time as AWNS finished.

1. c. Within group comparisons: AWNS and AWS

Paired t-test was done to compare the RT (Table 7) of the types of words (NWs and TWs) and the lengths of words (bi- and tri-) across L1 and L2 between AWNS and AWS. Results revealed that there was a significant difference in TW/NW in both the lengths of words (bi- and tri-) and languages (L1 & L2) in AWNS and AWS. Also, significant difference was found in the two lengths of words in both TW and NW and L1/L2 in AWNS and AWS except for TW in Hindi language ($t[14]$, AWNS=.243 and AWS=-1.24, $p>0.05$). There was no significant difference found in

L1 and L2 in both the lengths of words and the types of words in AWNS and AWS except between triENGNW and triHINDNW in AWS (t[14]=2.74, p<0.05).

Paired t-test was done to compare the TD between TW/NW and the lengths of words (bi- and tri-) across L1 and L2 between AWNS and AWS (TD included both the fluent and disfluent response). Results revealed that there was a significant difference in TW/NW for both the lengths of words and L1 and L2 in AWNS and AWS except for bi-syllabic Hindi NW and TW in AWNS and AWS (p[14, AWNS=1.51 and AWS=-0.54, p>0.05).

Table 7: Paired sample t-test values for RT of bi- and tri-syllabic TW/NW across L1 and L2 in AWNS and AWS

Between Parameters	t (1,14) AWNS	t (1,14) AWS
RTbiENGNW and RTbiENGTW	11.75*	10.35*
RTtriENGNW and RTtriENGTW	19.33*	9.87*
RTbiHINDNW and RTbiHINDTW	4.53*	4.08*
RTtriHINDNW and RTtriHINDTW	8.79*	8.67*
RTbiENGNW and RTtriENGNW	-6.04*	-5.44*
RTbiENGTW and RTtriENGTW	-3.93*	-5.00*
RTbiHINDNW and RTtriHINDNW	-3.52*	-5.74*
RTbiHINDTW and RTtriHINDTW	.243	-1.24
RTbiENGNW and RTbiHINDNW	.68	1.63
RTbiENGTW and RTbiHINDTW	-1.87	-1.91
RTtriENGNW and RTtriHINDNW	.45	2.74*
RTtriENGTW and RTtriHINDTW	-.36	.771

Table 8: Paired sample t-test values for TD of bi- and tri-syllabic TW/NW lengths across L1 and L2 in AWNS and AWS

Between Parameters	t (1,14) AWNS	t (1,14) AWS
TDbiENGNW and TDbiENGTW	6.11*	3.46*
TDtriENGNW and TDtriENGTW	10.31*	2.48*
TDbiHINDNW and TDbiHINDTW	1.51	-.054
TDtriHINDNW and TDtriHINDTW	4.12*	3.03*
TDbiENGNW and TDtriENGNW	-12.81*	-4.07*
TDbiENGTW and TDtriENGTW	-13.68*	-6.64*
TDbiHINDNW and TDtriHINDNW	-4.80*	-2.83*
TDbiHINDTW and TDtriHINDTW	-3.15*	-4.91*
TDbiENGNW and TDbiHINDNW	1.45	.908
TDbiENGTW and TDbiHINDTW	-2.90*	-2.13
TDtriENGNW and TDtriHINDNW	6.53*	1.029
TDtriENGTW and TDtriHINDTW	4.93*	1.084

[*= significant difference ($p<0.05$); AWNS= Adults without stuttering; AWS= Adults with stuttering; TDbiENGNW= total duration of bisyllabic English nonword; TDbiENGTW= total duration of bisyllabic English trueword; TDtriENGNW= total duration of trisyllabic English nonword; TDtriENGTW= total duration of trisyllabic English true word; TDbiHINDNW= total duration of bisyllabic Hindi nonword; TDbiHINDTW= total duration of bisyllabic Hindi true word; TDtriHINDNW= total duration of trisyllabic Hindi nonword; TDtriHINDTW= total duration of trisyllabic Hindi true word]

Also, significant difference was found in the two lengths of words in both TW/NW and L1 and L2 in AWNS and AWS. There was no significant difference found for TD in AWS in L1 and L2, but significant difference was found in AWNS in both L1 and L2 for both TW/NW and lengths of words except between bi-syllabic English and Hindi true/non-words. Overall, the result reveals that there was a significant effect of both TW & NW and lengths of word (bi- and tri-) on AWNS and AWS. But no language effect was seen for AWNS and AWS in TD.

This supports the notion that additional motoric complexity is required for processing longer utterances and non-words. Also, non-words and longer utterances require more input and output processing time resulting in increased reaction time and total duration. The total duration in the present study has significant effect of length on both TWs and NWs in both L1 and L2 countering the results of Huggins, 1978; Lehiste, 1972; Malecot, Johnston and Kizziar, 1972, that longer the utterance shorter the duration i.e., longer utterances are spoken more quickly than shorter ones. This may be an indication that observable stuttering like event in speech that otherwise appears fluent, slows the stuttering in longer utterance. The result from the present study reveals that both AWNS and AWS are slower to repeat NWs compared to TWs suggesting that the adults are not sensitive to phonotactic probability. This disproves the findings of Vitevitch and Luce, 1999; Vitevitch, Luce, Charles-Luce and Kemmer.er, 1997 that adults are faster in repeating non-word compared to word.

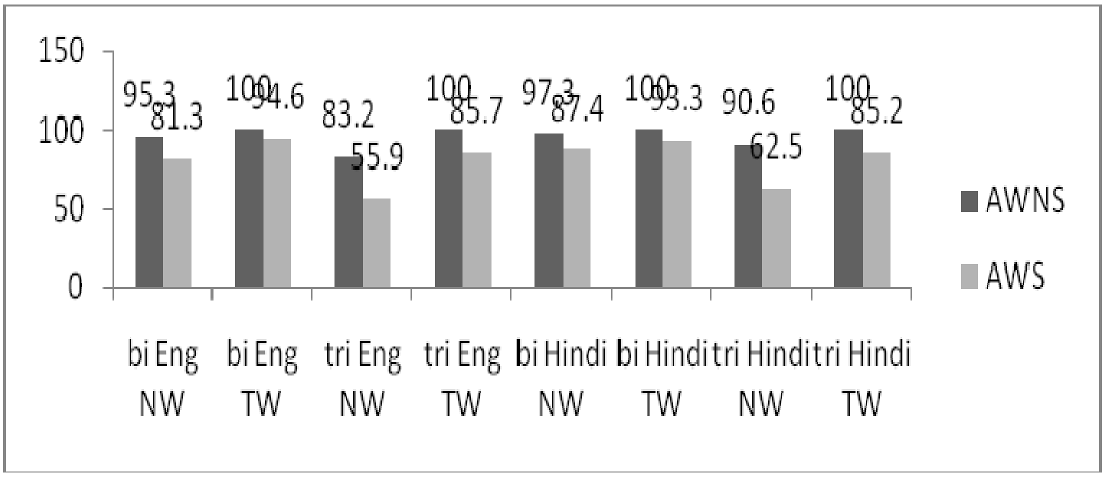
2. **Correct responses**, **SE (speech errors), SLD's (stuttering like disfluencies) and OD's (other disfluencies) in AWNS and AWS**

The performance of the subjects in non-word repetition task with respect to four major aspects i.e., percentage score of correct response, speech error, SLD's and OD's in both TW/NW and the lengths of words across L1 and L2 between AWNS and AWS are given in Picture 1, Picture 2, Picture 3, and Picture 4 respectively.

2.a Comparison of percentage scores with respect to correct responses to the types of words, lengths of words, and languages between AWNS and AWS.

The percentage scores for the TW/NW repetition of bi- and tri-syllabic words across L1 and L2 in AWNS and AWS, are given with respect to correct responses in, Figure 1 and SE, SLD's and OD's in Figure 2, Figure 3, and Figure 4 respectively. It is observed that in Figure 1, the AWNS performed better in terms of correct responses across all TW/NW, lengths of words and L1 and L2 compared to AWS.

Figure 1: Percentage score of the correct responses of bi- and tri-syllabic TW/NW in L1 and L2 between AWNS and AWS



The differences observed were significant across all the parameters at $p<0.05$ and the z-values are given in the Table 9 below. This result suggests that the AWNS significantly produced more number of correct responses compared to AWS for TW/NW of bi- and tri-syllabic lengths in L1 and L2.

Table 9: z-values for the correct responses of bi- and tri- syllabic TW/NW in L1 and L2 between AWNS and AWS

Parameters	z-value
biENGNW	3.75*
biENGTW	2.88*
triENGNW	4.97*
triENGTW	4.81*
biHINDNW	3.22*
biHINDTW	3.22*
triHINDNW	5.65*
triHINDTW	4.89*

[*= significant difference (p<0.05); AWNS= Adults without stuttering; AWS= Adults with stuttering; TDbiENGNW= total duration of bisyllabic English nonword; TDbiENGTW= total duration of bisyllabic English trueword; TDtriENGNW= total duration of trisyllabic English nonword; TDtriENGTW= total duration of trisyllabic English true word; TDbiHINDNW= total duration of bisyllabic Hindi nonword; TDbiHINDTW= total duration of bisyllabic Hindi true word; TDtriHINDNW= total duration of trisyllabic Hindi nonword; TDtriHINDTW= total duration of trisyllabic Hindi true word]

Considering the speech errors in AWNS and AWS, they were not present for TW for both bi- and tri-syllablic words across L1 and L2. Differences were found between AWNS and AWS only for non-words, and it was significant only for tri-syllabic English non-words between AWNS and AWS. The z-values are given in the Table 10 below.

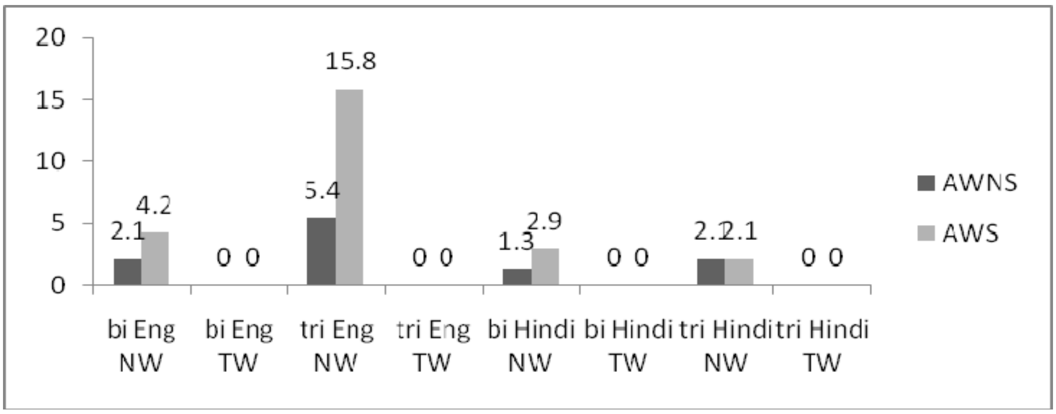


Figure 2: Percentage Score of the SE’s of bi- and tri-syllabic TW/NW in L1 and L2 between AWNS and AWS

Table 10: z-value for the SE's of bi- and tri- syllabic TW/NW in L1 and L2 between AWNS and AWS

Parameters	z-value
biENGNW	1.07
biENGTW	-
triENGNW	2.85*
triENGTW	-
biHINDNW	.89
biHINDTW	-
triHINDNW	1.4
triHINDTW	-

The result suggests that both AWNS and AWS did not produce any speech errors for true words, while for non-words the subjects produced them either as true words (eg: /sagur/ as /sugar/), or deletion, addition or phoneme transposition was present. As shown in Table 11 below, SLD's were not present in AWNS for true words, whereas it was present for both true and non-words in AWS. The significant difference was found in the SLD's across all parameters between AWNS and AWS.

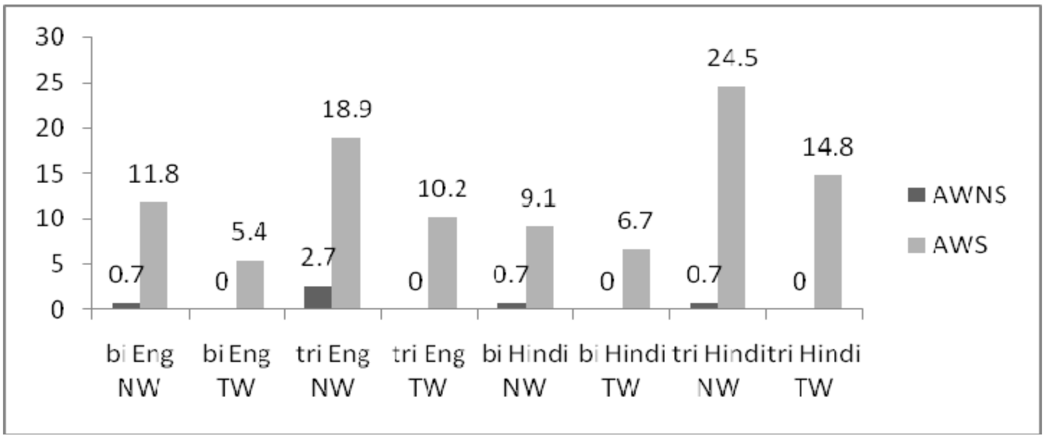


Figure 3: Percentage score of the SLD's of bi- and trisyllabic TW/NW in L1 and L2 between AWNS and AWS

Table 11: z-value for the SLD's of bi- and tri- syllabic word/non-words in Eng and Hindi between AWNS and AWS

Parameters	z-value
biENGNW	3.97*
biENGTW	2.87*
triENGNW	4.45*
triENGTW	4.01*
biHINDNW	3.38*
biHINDTW	3.23*
triHINDNW	6.18*
triHINDTW	4.89*

[*= significant difference ($p<0.05$); AWNS= Adults without stuttering; AWS= Adults with stuttering; TDbiENGNW= total duration of bisyllabic English nonword; TDbiENGTW= total duration of bisyllabic English trueword; TDtriENGNW= total duration of trisyllabic English nonword; TDtriENGTW= total duration of trisyllabic English true word; TDbiHINDNW= total duration of bisyllabic Hindi nonword; TDbiHINDTW= total duration of bisyllabic Hindi true word; TDtriHINDNW= total duration of trisyllabic Hindi nonword; TDtriHINDTW= total duration of trisyllabic Hindi true word]

The result implies that AWNS had no problem in processing the TW, but while saying NW there were phoneme and part-word repetitions present. AWS produced errors both on TW and NW in terms of repetitions (phoneme & part-word), prolongations and blocks. Postma and Kolk (1993, 1997) suggested that speech plans of PWS contain abnormally high number of errors due to impaired phonological encoding and the stuttering like disfluencies stem primarily from covert repair of errors.

Considering other disfluencies depicted in Figure 4, OD's were not present in AWNS and AWS except tri-syllabic TW in AWS, with the percentage score of 4.08. OD's were present in all bi- and tri-syllabic non-words across L1 and L2 in AWNS and AWS. The only significant difference found was for tri-syllabic English true word, rest all were not significant. The z-values are given in Table 12.

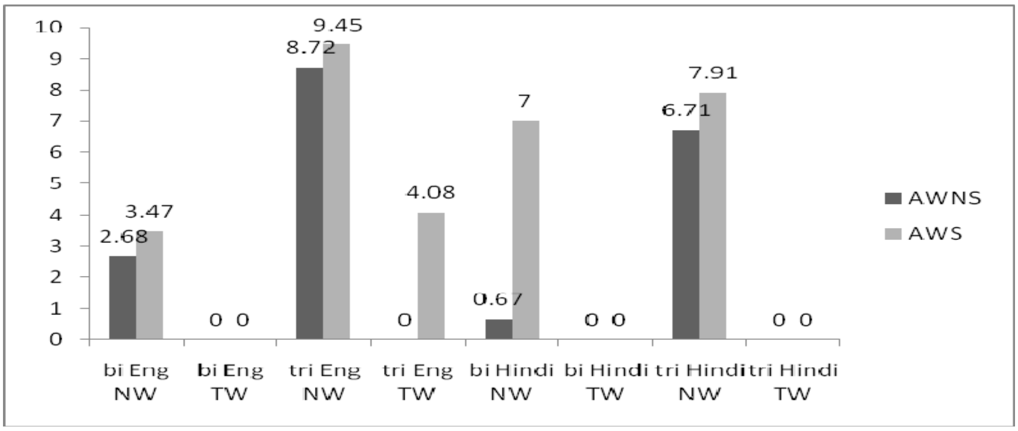


Figure 4: Percentage Score of the OD's of bi- and trisyllabic TW/NW in L1 and L2 between AWNS and AWS

Table 12: z-value for the SE's of bi- and tri- syllabic TW/NW in L1 and L2 between AWNS and AWS

Parameters	z-value
biENGNW	0.39
biENGTW	-
triENGNW	0.21
triENGTW	2.49*
biHINDNW	0.03
biHINDTW	-
triHINDNW	0.39
triHINDTW	-

AWNS and AWS did not differ in terms of producing other disfluencies like hesitations, pause, and revisions across all parameters.

2.b Paired proportion value comparison within each group for the two types of words, the two lengths of words, and the two languages separately.

Test of proportion was used to determine how the pairs each from the two types of words, the two lengths of words, and the two languages differ significantly in AWNS and AWS, respectively when the other two parameters will be kept constant. Figure 5 and Figure 6 depict the paired proportions values in AWS and AWNS for the correct responses and SE's, SLD's and OD's respectively, across the two lengths (bi-/tri-) of words and the other parameters (type and language) were kept constant.

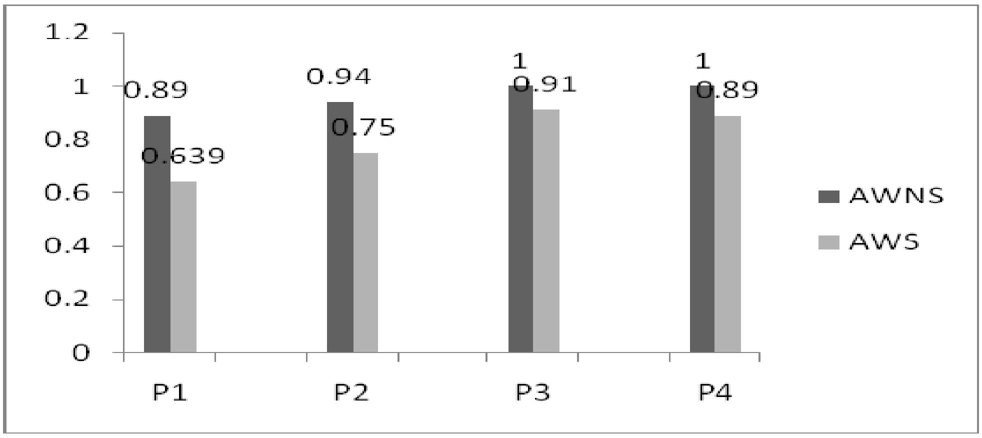


Figure 5: Paired proportion values for the correct responses across the two lengths of the words (bi- and tri-) for TW/NW and L1/L2 in AWNS & AWS

[AWNS= Adults without stuttering; AWS= Adults with stuttering; **P1**= biEngNWcor/ triEngNWcor; **P2**= biHindiNWcor/triHindiNW; **P3**= biEngTWcor/ triEngTWcor; **P4**= biHinTWcor/ triHinTWcor]

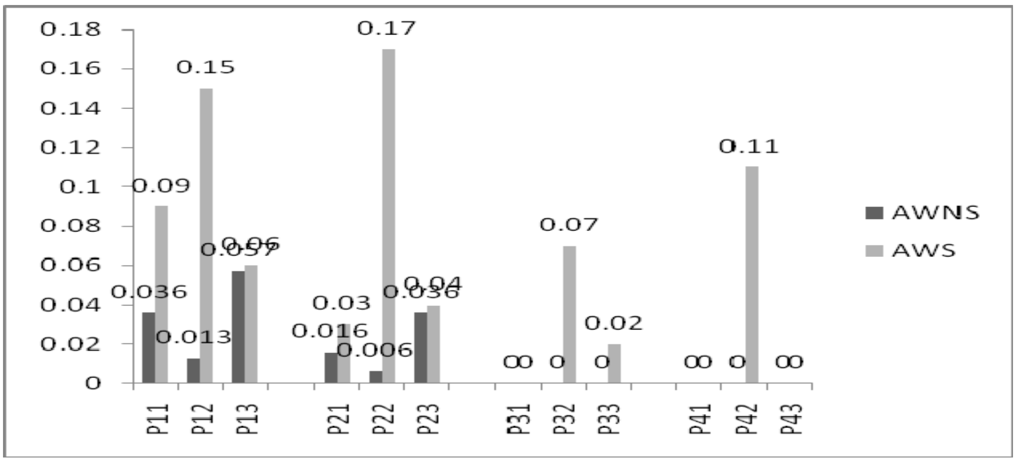


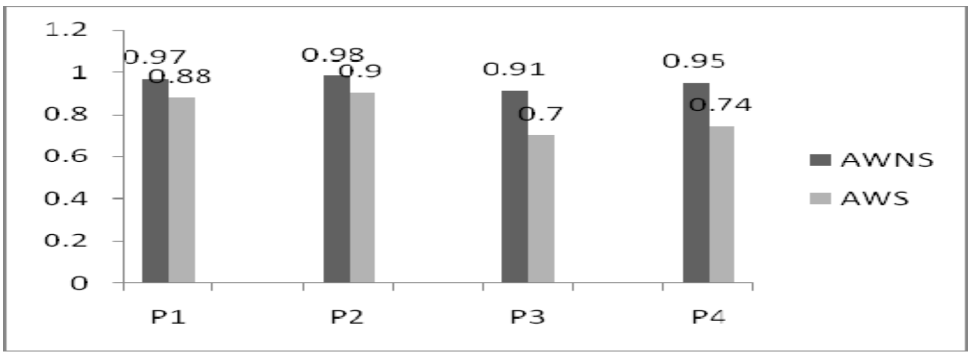
Figure 6: Paired proportion values for the incorrect responses (SE's, SLD's and OD's) across the two lengths of the words for TW/NW and L1/L2 in AWNS & AWS

[AWNS= Adults without stuttering; AWS= Adults with stuttering; **P11**= biEngNWSE/ triEngNWSE; **P12**= biEngNWSLD/ triEngNWSLD; **P13**= biEngNWOD/ triEngNWOD; **P21**= biHindiNWSE/ triHindiNWSE; **P22**= biHindiNWSLD/ triHindiNWSLD; **P23**= biHindiNWOD/ triHindiNWOD; **P31**= biEngTWSE/ triEngTWSE; **P32**= biEngTWSLD/ triEngTWSLD; **P33**= biEngTWOD/ triEngTWOD; **P41**=biHindiTWSE/triHindiTWSE; **P42**=biHindiTWSLD/triHindiTWSLD; **P43**= biHindiTWOD/triHindiTWOD]

The Figure 5 shows that both AWS and AWNS differed significantly ($p<0.05$) in terms of correct responses for the two lengths (bi- and tri-) of words. When compared for incorrect responses in Figure 6, the AWS differed significantly in all parameters except for the SLD's in ENG TW and ENG NW and SE's in Hindi NW ($p>0.05$), saying that there was no effect of lengths in AWS on SLD's in both true and non-word in English and no effect of speech errors in Hindi non-word. The AWNS had significant difference for the SLD's and OD's in English NW and for OD's Hindi NW, whereas the pair was not significantly different for SE Eng NW and SLD's and SE's in Hindi NW depicted in the figures below.

The significant effect of length found in AWNS and AWS could be due to the inability to speed up in planning or providing a longer utterance with more syntactic content which increases the demands on the capacity of the adults system to give fluent response or when producing errors.

The two pictures below, Figure 7 and Figure 8 compares the pairs in AWNS and AWS for TW and NW when the other two parameters (length and language) are kept constant in terms of correct responses and SE's, SLD's & OD's respectively.



Picture 7: Paired proportion values for the correct responses between TW and NW in the two lengths and L1 and L2 in AWNS & AWS

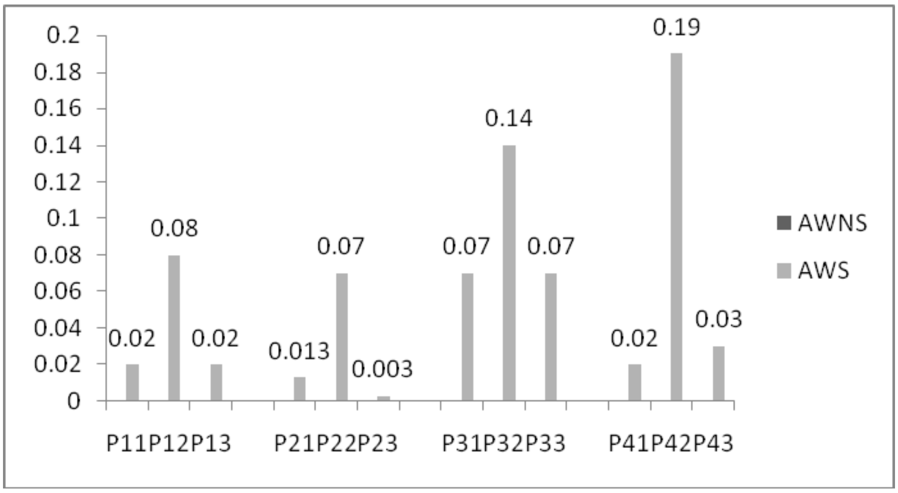


Figure 8: Paired proportion values for the SE's, SLD's and OD's between TW and NW in the two lengths and L1 and L2 in AWNS & AWS

[AWS= Adults with stuttering; **P11**= biEngNWSE/biEngTWSE;
P12= biEngNWSLD/biEngTWSLD; **P13**= biEngNWOD/biEngTWOD;
P21= biHindiNWSE/ biHindiTWSE; **P22**= biHindiNWSLD/ biHindiTWSLD;
P23= biHindiNWOD/ biHindiTWOD; **P31**= triENgNWSE/triEngTWSE;
P32= triENgNWSLD/triEngTWSLD; **P33**= triENgNWOD/triEngTWOD;
P41= triHindiNWSE/triHindiTWSE; **P42**= triHindiNWSLD/triHindiTWSLD;
P43= triHindiNWOD/triHindiTWOD]

The Figure 7 shows that both the groups i.e., AWNS and AWS differed significantly ($p<0.05$) in terms of correct responses for NW and TW. When compared for incorrect responses in Figure 8, the AWS differed significantly in all parameters except for the SLD and OD in Hindi NW ($p>0.05$). The proportion value of incorrect responses could not be obtained for AWNS as they did not produce any SE, SLD's and OD's for TW.

The two figures below, Figure 9 and Figure 10 compare the pairs in AWNS and AWS across the two languages when the other two parameters (length and type) are kept constant in terms of correct responses and SE's, SLD's and OD's respectively.

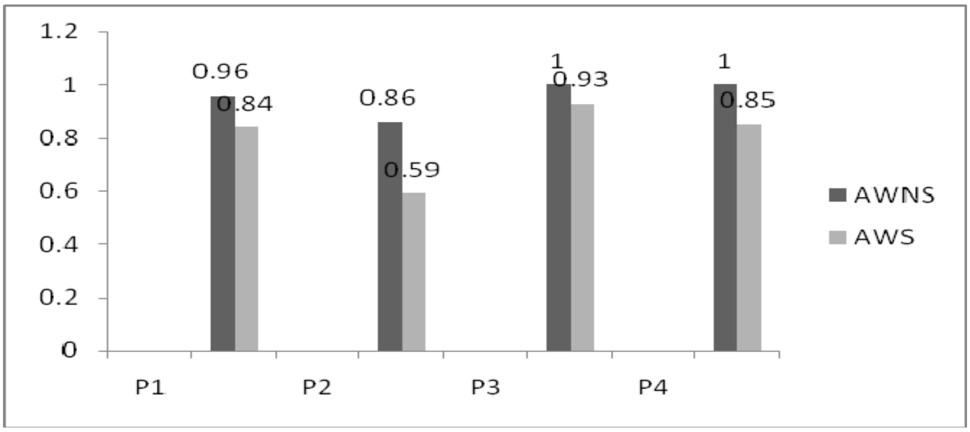


Figure 9: Paired proportion values for the correct responses across L1 and L2 for bi-tri-syllabic TW/NW in AWNS and AWS

[AWNS= Adults without stuttering; AWS= Adults with stuttering;
P1= biEngNWcorrect/ biHindiNWcorrect; **P2**= triEngNWcorrect/ triHindiNWcorrect;
P3= biEngTWcorrect/ biHindiTWcorrect; **P4**= triEngTWcorrect/ triHindiTWcorrect]

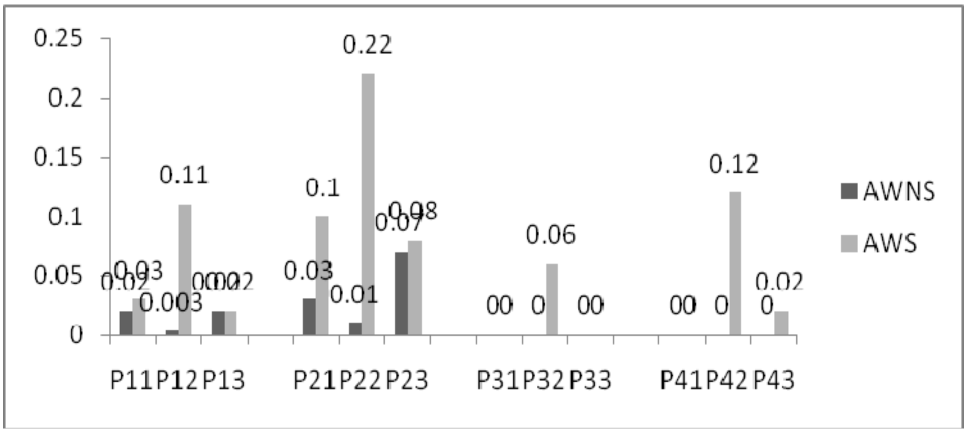


Figure 10: Paired proportion values for the incorrect responses (SE's, SLD's and OD's) across L1 and L2 for bi-tri-syllabic TW/NW in AWNS and AWS

[AWNS= Adults without stuttering; AWS= Adults with stuttering;
P11= biEngNWSE/ biHindiNWSE; **P12**= biEngNWSLD/ biHindiNWSLD;
P13= biEngNWOD/ biHindiNWOD; **P21**= triEngNWSE/ triHindiNWSE;
P22= triEngNWSLD/ triHindiNWSLD; **P23**= triEngNWOD/ triHindiNWOD;
P31= biEngTWSE/ biHindiTWSE; **P32**= biEngTWSLD/ biHindiTWSLD;
P33= biEngTWOD/ biHindiTWOD; **P41=** triEngTWSE/ triHindiTWSE;
P42= triEngTWSLD/ triHindiTWSLD; **P43**= triEngTWOD/ triHindiTWOD].

Both the groups (AWNS & AWS) did not differ significantly for L1 and L2 in terms of correct responses for bi-/tri-syllabi TW/NW. For incorrect responses only AWS differed in one parameter i.e., SE of tri-syllabic NW, and rest all parameters were insignificant in both the groups. This result suggests that there was no language effect for the production of fluent responses in both AWNS and AWS.

This overall paired proportion result across all parameter proposes that though the AWNS and AWS differ significantly in RT and TD for the types of words, there was no significant difference proposing no lexicalization effect while producing correct responses or while making errors. This refutes the findings of Packman, Onslow, Coombes and Goodwin (2001) that non-word removed lexical retrieval process from speech and eliminates the need to access the cognitive representations of words or word meaning. Also, no language effect was seen in AWNS and AWS.

3. **Variability in correct responses produced for types of words, lengths of words and languages between AWNS and AWS.**

Number of correct responses produced by each subject out of ten words from each category is calculated for AWNS and AWS separately which is represented in the figures given below.

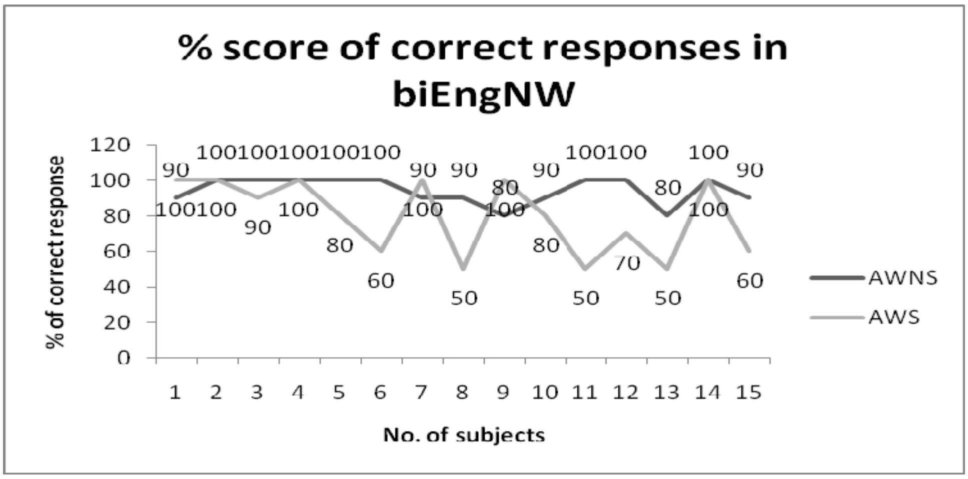


Figure 11: Variability of correct responses for biENGNW

The Figure 11 depicts that compared to AWNS, more variability is found in AWS as the score varies from 50%-100% in bi-syllabic English non-words.

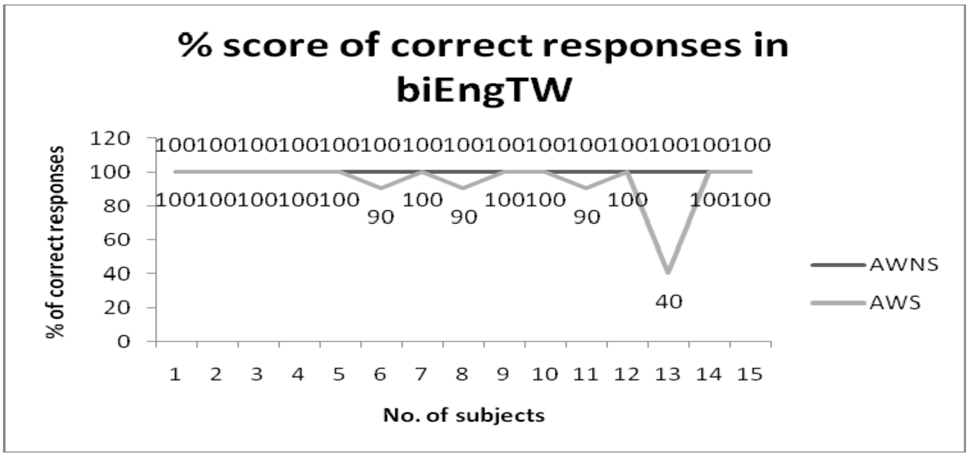


Figure 12: Variability of correct responses for biENGTW

Variability found in bi-syllabic English true words are given in Figure 12, which shows not much variability in both AWNS and AWS except for the subject no.13 in AWS who's score dropped to 40%.

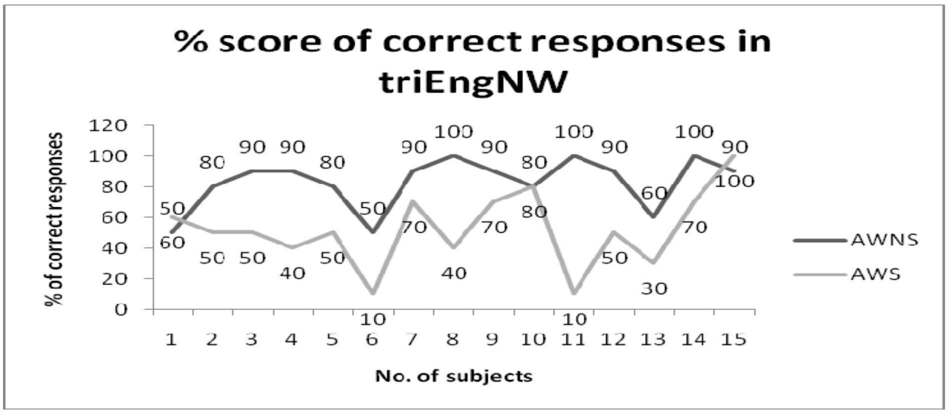


Figure 13: Variability of correct responses for triENGNW

In Figure 13, variability in tri-syllabic English non-words was demonstrated for both AWNS and AWS, but AWS was more variable compared to AWNS.

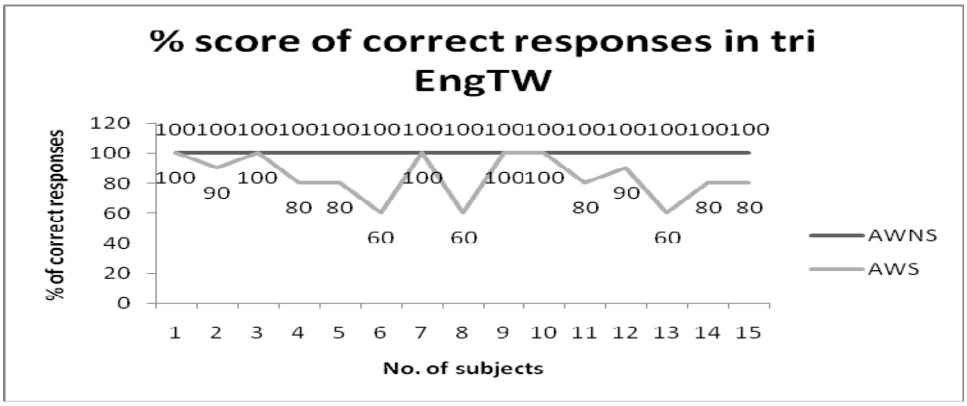


Figure 14: Variability of correct responses for triENGTW

For tri-syllabic English true words, AWS showed more variability with score 50%-100% comparable to AWNS who showed constant scores for all the ten words, given in Picture 14.

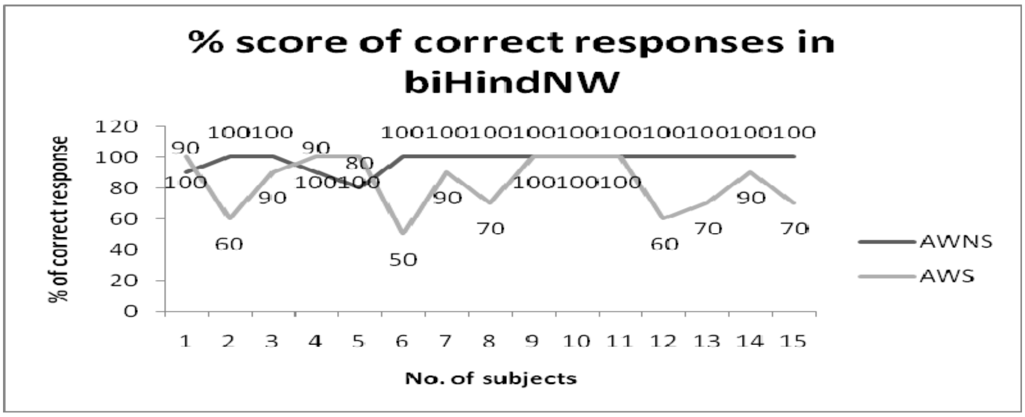


Figure 15: Variability of correct responses for biHindNW

The Figure 15 predicts AWS to be more variable compared to AWNS in bi-syllabic Hindi non-words.

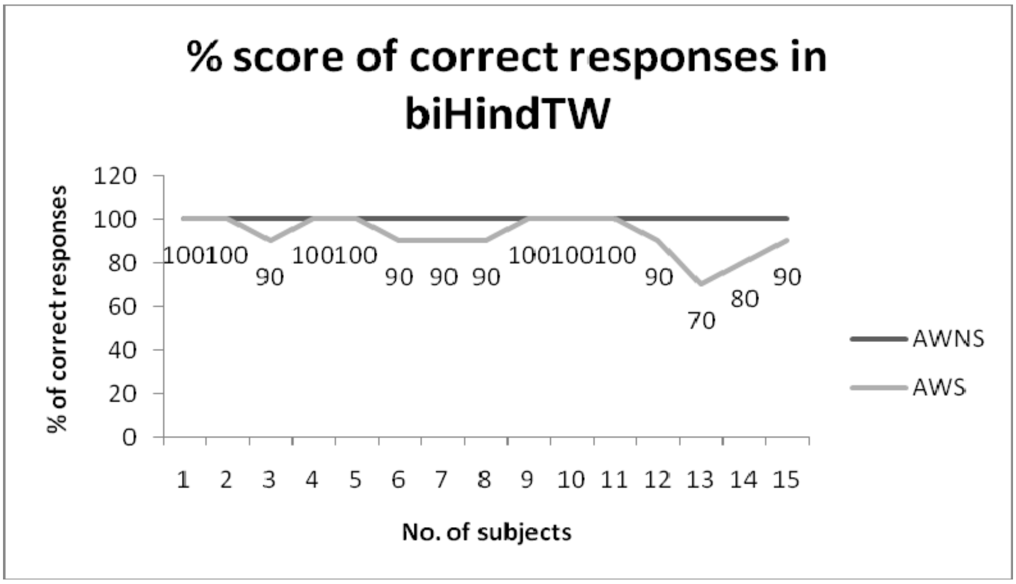


Figure 16: Variability of correct responses for biHindTW

No variability was noted down in AWNS whereas AWS was very less variable in bi-syllabic Hindi true words shown in Picture 16.

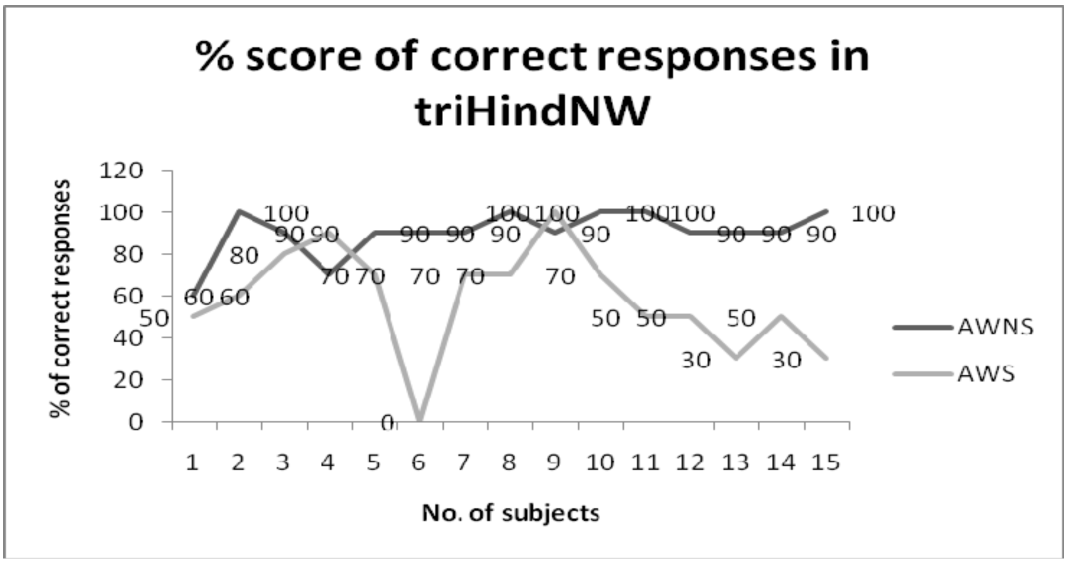


Figure 17: Variability of correct responses for triHindNW

Figure 17 depicts maximum variability in tri-syllabic Hindi non-words for AWS with the score ranging from 0%-100%. In AWNS not much variability was seen except subject 1 score falling to 60%.

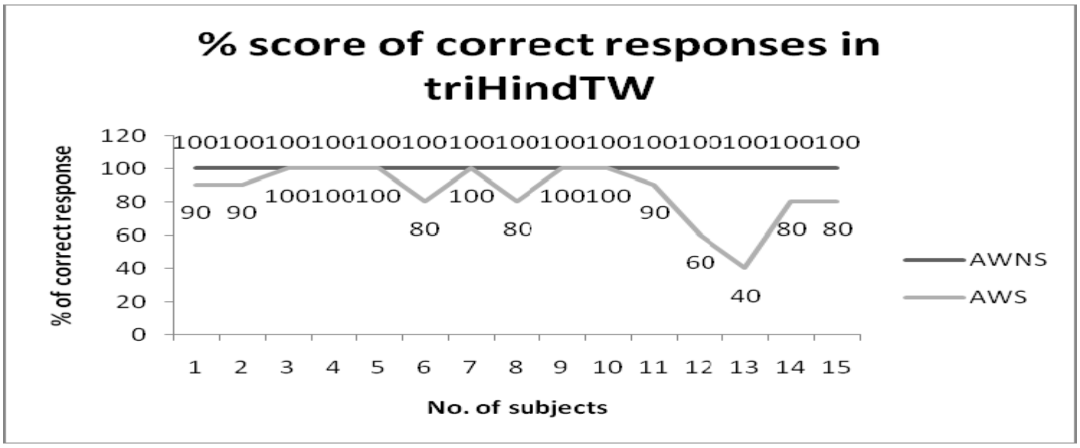


Figure 18: Variability of correct responses for triHindTW

AWNS showed constant response and no variability was seen. AWS did not vary much in the scores for tri-syllabic Hindi true words, except for the subject 13 who’s score dropped to 40%, as given in picture 18.

These graphs depict that the AWS show more variability than AWNS in producing correct responses. This result supports the viewpoint of different authors. Brown, Zimmerman, Linvilla and Hegman, (1990) found stuttering individual speech movements were associated with decreased timing variability as compared with normals. Also, Bousten, Brutten and Watts, (2000) revealed that PWS show increased variability when producing sequence of syllables.

B. Tongue twisters

1. Frequency of speech errors and disfluencies

As done in Postma, Kolk & Povel's (1990) study, speech errors seen in the subjects were categorized as: word blends, word substitutions, sound omissions, sound transpositions etc, and disfluencies. Table 13 shows that frequency of speech errors was more in AWNS than AWS and disfluencies were more in AWS than in AWNS.

Table 13: Frequency of SE's and disfluencies for AWS and AWNS in L1 and L2

Language	AWS		AWNS	
	SE	Dysfluencies	SE	Dysfluencies
Hindi	22	85	29	40
English	40	135	70	45

[AWNS=Adults without stuttering; AWS=Adults with stuttering; SE=Speech errors]

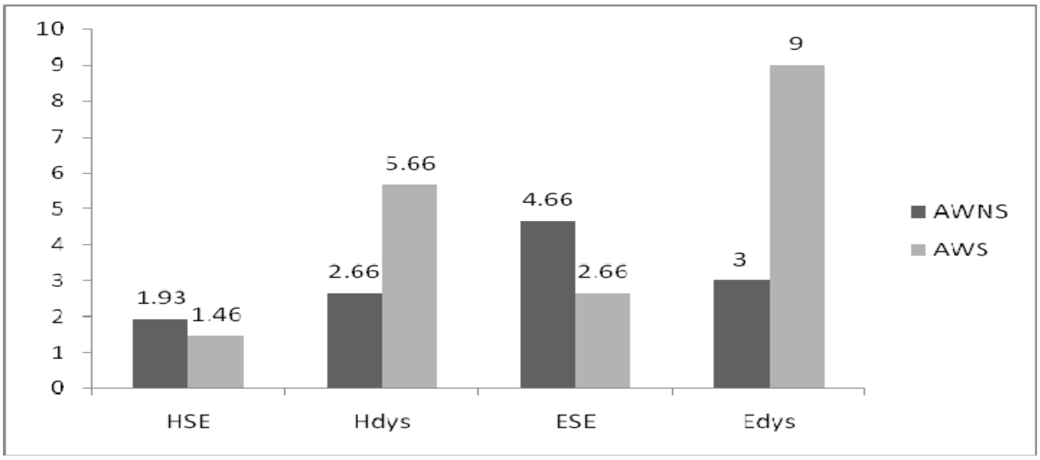


Figure 19: Comparative scores of SE's and disfluencies in TT for AWS and AWNS L1 / L2

[AWNS= Adults without stuttering; AWS= Adults with stuttering; HSE=Hindi speech errors; Hdis= Hindi disfluencies; ESE= English speech errors; Edis= English disfluencies]

Independent t-test showed no significant difference in the number of speech error in Hindi language between AWNS and AWS, whereas the groups showed significant difference ($p<0.05$) in the number of speech errors in English language. Also, significant difference between AWNS and AWS was found in the number of disfluencies in both Hindi and English languages. This result supports the study by Postma, Kolk, and Povel (1990) where the disfluencies were more in PWS than controls during production of neutral sentence and tongue twisters.

Table 14: Results of the paired samples t-test for the parameters of bi- and trisyllabic TW/NW across L1 and L2 in AWNS and AWS

Between Parameters	t (14)	t (14)
	AWNS	AWS
HindiSE and HindiDys	-1.028	-4.482*
EngSE and EngDys	1.561	-4.570*
HindiSE and EngSE	-3.385*	-2.736*
HindiDys and EngDys	-.412	-3.529*

[AWNS- Adults with no stuttering; AWS- Adults with stuttering; SE- Speech errors; Dys- disfluencies,]

Within group comparison using paired t-test revealed that there was a significant difference in AWS across all the paired parameters, i.e., they differed significantly in terms of SE and disfluencies across both the languages. But when seen in AWNS the only significant difference was found across English and Hindi languages in terms of speech errors. It indicates that in both AWNS and AWS there was a significant effect of language while producing tongue twisters and more errors were produced in the second language compared to the mother tongue.

As the tongue twister recitation requires fast rate of speech and repeated use of same phonemes, it is demonstrated that both in AWNS and AWS these factors not only influenced the overall incidence of errors but also have an effect of kind of errors obtained (Dell, 1986; Dell, Burger & Svec, 1997; Stemberger, 1985, 1992). These authors described the kind of errors in terms of anticipatory and perseveratory. These errors due to fast rate of speech might be because of interference to program or execute motor commands necessary for correct articulation. The increased likelihood of errors produced due to inclusion/repeated use of similar phonemes can be predicted by a number of models. The Models of speech production, i.e., bottom up and top down processing (Dell, 1986, 1988; Stemberger, 1985, 1990) explain that the feedback from subphonemic levels of processing flows back to the phonological level increasing the competition between similar phonemes.

In the present study the subjects in both AWNS and AWS were aware of their errors and experienced the sensation of their output failing to meet their intention which argued against a short term memory account. Also the errors involved anticipatory of upcoming rather than perseveration of recently processed phonemes indicating that the subjects did not complete the tongue twister task by processing a single word at a time but instead planned ahead across the target word string.

Reliability

Inter-judge and intra-judge reliability were obtained for the present study. For inter-judge reliability, the scores obtained on for the fluent and disfluent responses obtained on the selected samples by another speech-language pathologist were compared with that of the investigator carrying out the study. Alpha reliability coefficient was calculated for this. The alpha reliability coefficient obtained for the scores between the two judges was greater than 0.7, signifying there is good inter-judge reliability.

Alpha reliability coefficient was also obtained for intra-judge reliability. Here the scores obtained on a second analysis of the selected samples by the first speech language pathologist were compared with that of the first data. This coefficient was also found to be greater than 0.7, indicating the presence of intra-judge reliability.

To summarize, the results from the present study and evidence suggest that it is logical then that phonological encoding process of non-word reading must be much more complex than for word reading as naming latency is longer for them. RT results support the hypothesis that language processing of AWS has a greater vulnerability to interfere from additional processing demands compared to TD. Also, adult's performances on the tasks suggest that phonological processing of non-words is grounded in generalization about sub-lexical patterns over all known words. The errors which are predominantly present during non-word repetition and tongue twister repetition task in AWS indicate that SLD's primarily results due to errors in covert repair. And errors (fluency and articulatory) present in both AWNS and AWS while repeating non-words and tongue twister suggest that while producing non-words, longer utterances and speaking at a faster rate, there is an increased linguistic load/demand which affects speech motor output. And it is found that AWS are more susceptible to linguistic processing problems compared to AWNS. AWS have lower threshold for speech motor breakdowns and smaller changes affect speech motor execution.

CHAPTER V

SUMMARY AND CONCLUSION

The present study was mainly aimed at studying the phonological processing and speech motor control through the non-word and tongue twister repetition in bilingual adults with stuttering and to compare it with age matched controls.

The study thus focused on how the adults with stuttering (AWS) differed from adults with no stuttering (AWNS) in the reaction time and total duration produced on a non-word repetition compared to a word repetition task of bi- and tri-syllabic lengths in mother tongue (Hindi) and second language (English). Also, the number of correct responses, speech errors, stuttering like disfluencies, and other disfluencies produced on a non-word (NW) repetition task compared to true word (TW) repetition task. Other objectives of the study were to find differences in the correct response and fluency of response during the TW/NW repetition task as the word/non-word length increases and between the languages (Hindi and English). Tongue twister repetition abilities in terms of number and frequency of errors produced as well as how it differs across mother tongue, Hindi and second language, English were also studied to look into the existence of any possible relationship between phonological processing/speech motor control and non-word repetition/ tongue twister repetition skills.

Two groups of Hindi speaking adults (15 each) were considered for this study who studied English at least up to 12th standard. The AWNS (Adults with no stuttering) and the AWS (adults with stuttering) were in the age range of 18;0-30;0

years. The study was carried out in two experiments. For the experiment one both the groups were tested for the reaction time, total duration, word and non-word repetition skills and their responses were transcribed and scored. For experiment two, the frequency of errors across both mother tongue (Hindi) and second language (English) was noted down.

Appropriate statistical analyses were done and the results of the study can be summarized as follows:

A) **EXPEIMENT 1: Non-word repetition task**

1. Reaction Time and Total Duration

a) Between group comparisons

- Nearly similar values for total duration were seen between AWNS and AWS. The reason attributed to this is that AWS might fasten their rate of speech with unusual way of talking to match the TD with those of AWNS.
- AWNS and AWS had difference for reaction time across all the parameters of bi-/tri-syllabic TW/NW in both L1 and L2.

b) Within group comparisons

- AWS had longer on reaction time for non-words than words compared to AWNS across both the lengths of the words and the languages (Hindi and English) compared to AWNS. It depicts that there is an effect of processing difference for word vs non-word.
- Within the two groups, longer RT's was found for AWS than AWNS for the tri-syllabic than bi-syllabic for both the TW/NW's and the languages. Also, it

shows that both AWNS and AWS take more time to start the articulation for the longer utterance compared to the shorter ones.

- AWNS and AWS were different significantly on total duration, i.e. AWS took more time to finish the non-words than words compared to AWNS across both the lengths of the word and the languages. It reveals that more input and output processing time is required for non-words. (Peters, Hulstijn, & Starkweather, 1989).
- AWS took more time to finish the tri-syllabic than bi-syllabic compared to AWNS across the TW/NW and the languages.
- No language effect was found on both the RT and TD between the parameters for both AWNS and AWS. But descriptively it was found that AWNS and AWS performed slightly better in Hindi compared to English.

2. <u>Fluency in AWNS and AWS</u>

a) *Percentage scores with respect to correct responses to the types of words, lengths of words, and languages between AWNS and AWS.*

- AWNS produced more number of correct responses compared to AWS across all parameters.
- AWS produced more number of speech errors as phoneme deletion and transpositions on non-words compared to AWNS who's speech errors were mostly producing non-words as true words, showing more processing difficulties in AWS. Both AWNS and AWS did not produce any speech errors for TW as expected.

- AWS produced more SLD’s on both TW/NW as prolongations, phoneme/syllable repetitions and blocks, compared to AWNS which produced only SLD’s on NW as phoneme/part-word repetition less frequently.

- It was found that AWS produced more pauses and hesitations compared to AWNS who’s production dominated by revisions and few interjections.

b) *Paired proportion value comparison within each group for the two types of words, the two lengths of words, and the two languages separately.*

i) Across the two lengths (bi-/tri-) of the words:

- In AWNS and AWS both, more number of correct responses were persent for bi-syllabic TW/NW compared to trisyllabic TW/NW.
- For incorrect responses, AWS produced more number of errors in tri-syllabic than bi-syllabic TW/NW, except for SLD’s in EngTW and NW and SE in HindNW.
- For incorrect responses, AWNS had significant difference, i.e. more number of errors in EngNW as SLD’s and OD’s but not for SE’s, whereas only difference found in HindNW was for OD’s and not for SLD’s and SE’s.

ii) Across the two types (TW/NW) of the words.

- In AWNS and AWS both, correct responses were more for true words compared to non-words.
- For incorrect responses, AWS produced more errors for all non-words than true words except for SLD and OD in Hindi NW.

- AWNS did not produce any incorrect response for the TW.

iii) Across the languages (Hindi and English)

- AWNS and AWS both produced same number of correct responses across the mother tongue (Hindi) and second language (English).
- For incorrect responses, no difference was found across the languages except for SE in triNW in AWS.

3. <u>Variability of correct responses between AWNS and AWS</u>

- *For biENGNW*- AWS was more variable compared to AWNS with score ranging from 50-100% in AWS
- *For biENGTW*- Not much variability found between the groups.
- *For triENGNW*- Variability was found across both the groups but AWS was more variable compared to AWNS.
- *For triENGTW*- No variability was demonstrated in AWNS, whereas AWS was more variable with score ranging from 50-100%.
- *For biHindNW*- AWS was more variable than AWNS.
- *For biHindTW*- No variability found for AWNS, whereas AWS was a little variable.
- *For triHindiNW*- maximum variability was found for AWS as score ranged from 0-100%, whereas AWNS was less variable comparatively.
- *For triHindTW*- AWS was little more variable compared to AWNS which did not show any variability.

B) **EXPERIMENT 2- Repetition of tongue twisters**

1. Frequency of speech errors and disfluencies

- No difference found for speech errors in Hindi between AWNS and AWS.

- Significant difference for the number of speech errors in English was found between AWNS and AWS.
- Both AWNS and AWS were significantly different for the number of disfluencies in Hindi and English.

2. Within group comparison

- AWS had significant difference for SE's and disfluencies in both Hindi and English.
- AWNS did not reveal any difference, except for speech errors produced between Hindi and English.

Conclusions

To conclude, the results of the present study done in bilingual adults with stuttering (Hindi as mother tongue and English as second language) did not reveal the similar results in most aspects of reaction time and total duration as well as the fluent response for the bi-/tri-syllabic TW/NW repetition and the frequency of errors in tongue twister repetition task in both Hindi and English.

With respect to reaction time and total duration, greater differences between AWNS and AWS were seen on reaction time than total duration. With respect to fluent response, the AWS score poorly than AWNS in the number of correct responses. The AWNS had more problems in maintaining their fluency as they produced more number of stuttering-like and other disfluencies, whereas the AWNS fluency was disrupted mainly because of speech errors.

With respect to lengths, types of words and the language, both AWNS and AWS had more problems while producing tri-syllabic compared to bi-syllabic and non-words compared to words. No overall language effect was seen in AWNS and AWS for non-word repetition task.

The tri-syllabic non-word repetition task was found to be a good indicator for the phonological processing and speech motor control between AWNS and AWS.

For tongue twister repetition task, both AWNS and AWS had breakdown of fluency saying more motoric complexity required for repetition. AWS produced more stuttering like disfluencies compared to AWNS which produced more speech errors. The language effect was seen in both AWNS and AWS, i.e. more errors were found in second language, English.

Implications of the study

- This study gives an insight into the relationship between phonological processing and speech motor control in terms of non-word repetition and tongue twister repetition skills in bilinguals AWS. It highlights the earlier notions about phonological processing problems in PWS.

- With further research in this area it may help augment assessment and management with respect to phonological processing abilities and speech motor control in adults with stuttering.

Limitations of the study

- Due to time constraints subjects could not be studied across genders and severity of stuttering.
- The study could not be carried to see the variation of tongue twister between reading and recitation tasks.
- Small sample size was taken for the study.

Future directions

Further research can be done in the Indian scenario on:

- Non-word and tongue twister repetition skills in the stuttering population across different age groups.
- Non-word and tongue twister repetition skills in the stuttering population across the genders.
- Non-word and tongue twister repetition skills across different severities of stuttering.
- Comparing the non-word and tongue twister repetition skills in the stuttering population across different Indian languages.
- Comparing tongue twister repetition skills across reading and recitation task.

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APPENDIX-I

Hindi bi-syllabic true and non-words

Hindi true words- bisyllabic	Hindi non-words- bisyllabic
κΘ®τΣι (कैंची)	κι®τΣΘ (कींचै)
τ5HA⌉λι (थाली)	τ5HιλA⌉ (थीला)
τ5oτ5A (तोता)	τ5Aτ5o (तातो)
/ατ5Hι (हाथी)	/ιτ5Hα (हीथा)
κυτ5τ5α (कुत्ता)	κατ5τ5υ (कात्तु)
δZHυλA (झुला)	δZHα⌉λυ (झालु)
πΘσα⌉ (पैसा)	πα⌉σΘ (पासै)
σο⌉φα (सोफ़ा)	σα⌉φο (साफ़ो)
ρακHι (राखी)	ρικHα (रिखा)
μυτΣHε® (मुछें)	με®τΣHυ (मेछुं)

Hindi tri-syllabic true and non-words

Hindi true words- trisyllabic	Hindi non-words- trisyllabic
m∂τΣH∂λι (मछली)	m∂λιτΣH (मलीछ)
m∂t∂kα⌉ (मटका)	m∂kα⌉t (मकाट)
d5∂rϖa⌉ζ8α (दरवाजा)	d5∂rζ8αϖa⌉ (दरजावा)
σΙπαηι (सिपाही)	σΙηιπα (सिहीपा)
d5∂ψαλY (दयालु)	d5∂λYψα (दलुया)
τΣ∂μΕλι (चमेली)	τΣ∂λιμΕ (चलीमे)

κ∂π∂δ8α (कपडा)	κ∂δ8απ (कडाप)
τΣΙδ8Ιψα (चिडिया)	τΣΙψαδ8Ι (चियाडि)
κΥληαδ8ι (कुल्हाडी)	κΥλδ8ιηα (कुल्डीहा)
γΥββΑρα (गुब्बारा)	γΥραββΑ (गुराब्बा)

English bi-syllabic true and non-words

English true words - bisyllabic	**English non-words- bisyllabic**
ωΙνδο (windo)	ωονδΙ (wondi)
πΕνσΙλ (pencil)	πΙνσΕλ (pinsel)
μ∂νκι (monkey)	ΜινκΑ⌉ (minka)
φΕλ⌉ο (yellow)	φολΕ⌉ (yolle)
συγ∂ρ (sugar)	σ∂γυρ (sagur)
σολζ8∂ρ (soldier)	σ∂λζ8ορ (salzor)
π□κΕτ (poket)	πΕκ□τ (pekot)
λιγ∂λ (legal)	λ∂γιλ (lagil)
προδΖΕκτ (project)	πρΕδΖοκτ (prejokt)
τα⌉ργΕτ (target)	τεργα⌉τ (tergaat)

English bi-syllabic true and non-words

English true words - trisyllabic	English non-words- trisyllabic
φ□ρμυλα (formula)	φ□ρλα⌉μυ (forlamu)
σΙμιλ∂ρ (similar)	σΙλ∂ρμι (silarmi)
κ∂νζ8ςμ∂ρ (consumer)	κ∂νμ∂r ζ8ς (kanmaerzu)
φιλ□σφι (philosphy)	φιφιλ□σ, (phiphilos)
κ□μπονΕ®τ (component)	k□μνΕ®∫τπο, (comnentpo)
σ∂μ∂ρι (summary)	σ∂ριμ∂, (sarima)
σΙμβ□λΙκ (symbolik)	σΙμλΙκβο, (symlikbo)
δΙνοτΕδ (denoted)	δΙτΕδνο, (detedno)

τΘλιφον (telephone)	τΘφονλι ,(tephonli)
π□λισι (policy)	π□σΙλι, (posili)

APPENDIX-II

English tongue twisters

1. βλΘκ βΘγραΥνδ βραΥν βΘγραΥνδ **(black background brown background)**
2. Σηι⌉να λι⌉δσ Σι⌉λα νι⌉δσ **(sheena leads sheela needs)**
3. ρΕδ λ□ρι φΕλο⌉ λ□ρι **(red lorry yellow lorry).**

Hindi tongue twisters

1. πΙτ5∂λ π∂τ5Ιλα π∂πΙτ5α πιλα (**पितल पतिला पपिता पीला**)
2. κΑτΣα⌉ παπ∂δ8 πΑκκα παπ∂δ8 **(कच्चा पापड पक्का पापड)**
3. γοπΕ γοπαλ γοπαλγ∂μ δ8ασ **(गोपे गोपाल गोपाल्गम दास)**