Phonological Encoding in Persons with Stuttering through Phoneme Monitoring Tasks

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CERTIFICATE

This is to certify that this dissertation entitled "**Phonological Encoding in Persons with Stuttering through Phoneme Monitoring Tasks**" is a bonafide work submitted in part fulfillment for the degree of Master of Science (Speech-Language Pathology) of the student (Registration No: 13SLP004). This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any Diploma or Degree.

Mysore
May 2015

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DECLARATION

This is to certify that this dissertation entitled "**Phonological Encoding in Persons with Stuttering through Phoneme Monitoring Tasks**" is the result of my own study under the guidance of Dr. Swapna.N, Reader in Speech Pathology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier to any other University for the award of any Diploma or Degree.

Mysore **Register No: 13SLP004**

May, 2015

To Sumukh,

- My nephew. The epicenter of happiness in family ☺

And

To Swapna ma'am.

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Chapter 1

Introduction

Stuttering is a communication disorder involving the disruption in the fluency of verbal utterances. According to Yairi and Ambrose (2005) stuttering is characterized by involuntary disruptions in the flow and rhythm of speaking even though the individual knows exactly what he/she wants to say. These uncontrolled interruptions in producing speech include sound prolongations, syllable repetitions and silent blocks which are either brief or last for many seconds.

Various studies have been conducted to identify the cause of stuttering but however it still remains unknown. Stuttering is often considered to be associated with both linguistic and motoric deficits. According to Peters and Starkweather (1990), stuttering is believed to be associated with a lack of balance between the linguistic and the motoric systems involved in speech production. Bloodstein (2002) emphasized on the fact that stuttering is basically a disorder of language development. Such notions motivated the researchers to extensively study the relation between stuttering frequency and the different linguistic variables. There are a number of studies that have investigated the effect of different linguistic variables on the frequency of stuttering. These linguistic factors include lexical retrieval (Bloodstein & Gantwerk, 1967; Helmreich & Bloodstein, 1973; Jayaram, 1983; Howell, Au-yeung & Sackin, 2000; Dayalu, Kalinowski, Stuart, Holbert, & Rastatter, 2002; Santosh & Arunkumar 2006; Sindhupriya, 2012), morphological structure of the words, syntactical complexity (Hannah & Gardner, 1968; Wells, 1979; Brundage & Ratner, 1989) and phonetic complexity (Brown, 1938,1945; Hahn, 1942; Hejna, 1955; Quarrington, Conway, & Siegal, 1962, Geetha, 1978). This suggests that there is indeed a strong relationship between the linguistic factors and stuttering.

A number of theories in this line of research have been proposed to explain this disorder. Some of the theories propose that one of the potential cause for stuttering is the deficits in phonological encoding. According to Levelt (1989) phonological encoding is defined as the processes involved in retrieving or building a phonetic or articulatory plan from each lemma or word and the utterance as a whole. He proposed that this process involves three components: generation of segments that constitute words, integration of sound segments with word frames and assignment of appropriate syllable stress. This process of phonological encoding is considered to be an interlink between lexical processing on one hand and motor speech production on the other hand (Levelt, 1989; Levelt, Roelofs, & Meyer, 1999). Levelt (1989) also stated that phonological encoding is a process that occurred prior to the activation of the speech motor system. Later, as a part of the WEAVER++ model (Levelt et al., Roelofs, 2004), phonological encoding was defined as a phenomenon wherein the phonological code (i.e., phonemes or syllables) of a word is retrieved and reassembled in an incremental, just-in-time manner to allow for the efficient construction of phonological words. This indicates that the phonological encoding is embedded within the language formulation process, thereby making it difficult to isolate from the rest of the language processes.

There are mainly four psycholinguistic theories that emphasize on the relationship between phonological encoding and stuttering. These theories are Fault Line hypothesis (Wingate, 1988), which proposed that stuttering occured due to a delay in the retrieval and encoding of a syllable rhyme during speech production resulting in a fault-line created at the point of integration of the syllable onset with its rhyme; the Neuropsycholinguistic theory (Perkins, Kent, & Curlee, 1991), which outlined that temporal asynchrony between linguistic i.e., lexical, phonological and suprasegmental planning and time pressure were crucial elements in the causation of stuttering; the Covert Repair Hypothesis (CRH, Postma & Kolk, 1993) which proposed that stuttering occurs as a result of the covert corrections of speech plan errors that occurred due to the delay in the process of selection and retrieval of speech sounds; and Execution Planning model (EXPLAN, Howell, 2004) according to which, failure in the fluency was due to the temporal asynchronies between linguistic planning and speech execution. These theories of stuttering have motivated the researchers to conduct extensive research to assess the phonological encoding in persons with stuttering (PWS).

Though these theories of stuttering speculate phonological encoding to be the possible cause for stuttering, it is obscured from direct observation (Coles, Smid, Scheffers, & Otten, 1995). Evidences are present suggesting that phonological encoding may not be efficient or effective in PWS, and some of these findings are equivocal (Wijnen & Boers, 1994; Bosshardt & Fransen, 1996; Burger & Wijnen, 1999; Weber-Fox, Spencer, Spruill, & Smith, 2004; Sasisekaran & De Nil, 2006; Sasisekaran, De Nil, Smyth, & Johnson, 2006; Hennessey, Nang, & Beilby, 2008). Hence, more detailed investigation of the role of phonological encoding in stuttering is essential. One constraint pertaining to this is that the experimental paradigms available to assess phonological encoding in production are limited with respect to the fact that the process of phonological encoding is obscured from direct observation and requires paradigms that does not involve any overt speech production process so as to evaluate this covert mechanism of phonological encoding.

Several paradigms involving the overt speech production process have been used to investigate phonological encoding in PWS and children with stuttering (CWS). One of the paradigm used is the phonological priming paradigm proposed by Wijnen and Boers (1994). They used an implicit priming paradigm to evaluate the phonological encoding abilities in PWS in a set of five word pairs in Dutch with the same phoneme in the consonant only and consonant-vowel condition. Their study revealed that there was a delay in encoding stress bearing nucleus of a syllable (vowel) and this delay was eliminated or reduced using a consonant vowel prime. But in a follow up study by Burger and Wijnen (1999), replication of the findings could not be established. Such a priming paradigm was also used by Melnick, Conture, and Odhe (2003) to investigate segmental, phonological priming effects in CWS wherein the reaction times in three picture naming conditions was investigated and was correlated with articulation mastery. It was found that there was a higher variability exhibited in the naming reaction time by children with stuttering, and no correlation between the reaction time and articulation mastery was found following which they concluded that the lack of such a correlation between the two tasks was attributable to the phonological knowledge and processing difficulties. Another study using the same paradigm was conducted in children by Byrd, Conture, and Odhe (2007) wherein, they found that picture naming was facilitated by end related phonological primes when compared to onset related primes in typically developing children and a reverse pattern was found in CWS.

Since phonological encoding is embedded within the language formulation process, researchers have investigated it by analyzing the phonological processing ability which is related to the phonological encoding (Wagner, Torgesen, & Rashotte, 1999). The phonological processing is considered as an umbrella term which includes phonological memory, which is evaluated using the nonword repetition tasks, phonological awareness which is assessed through tasks involving sound matching, phoneme blending, phoneme segmentation and phoneme elision and rapid automatized naming (RAN) which refers to the ability of the individual to retrieve the phonetic information rapidly by converting the orthographic symbols or the pictures into a meaningful string of phonemes.

A few studies have been carried out using these paradigms such as non word repetition, phonological awareness and RAN to evaluate the phonological encoding abilities. Hakim and Ratner (2004) investigated nonword repetition skills (2 to 5 syllables) with the stress on the first syllable, in children with and with no stuttering. They found that across the two groups, CWS exhibited more errors for three syllable words and both groups had higher percentage of errors across the four and five syllable nonwords. It was concluded that there was a link between stuttering and phonological encoding. Somy (2008) conducted a study to investigate the nonword repetition skills (2-3 syllables) in CWS as opposed to the children with no stuttering (CWNS). It was found that both CWS and CWNS performed poorly on nonword repetition tasks as opposed to word repetition tasks. But however, it was found that trisyllabic nonword repetition task was a good indicator to differentiate CWS from CWNS as the performance of CWS was much poorer for this set of stimuli. Spencer and Weber-Fox (2014) investigated whether receptive and expressive language, phonological, articulatory, and/or verbal working memory proficiencies contribute in determining recovery or persistence of stuttering. The study was conducted on CWS and CWNS in the age range of 4–6 years. Stuttering behaviors of CWS were assessed in subsequent years, forming groups whose stuttering eventually persisted or recovered. A comparison of the scores obtained for the receptive, expressive, phonological, articulatory and verbal working memory tasks with the scores obtained at the initial testing was done for each group. It was found that the performance of CWS was significantly poorer in the measures of articulation and non word repetition in children who persisted with stuttering. Thus it was concluded that phonological and speech articulation abilities can serve as sensitive measures in the preschool years to predict the development of chronic stuttering.

Packman, Onslow, Coombes and Goodwin (2001) found that the performance of PWS was much poorer as opposed to that of the persons with no stuttering (PWNS) in reading passages with and without nonwords. It was found that the PWS exhibited more stuttering events when reading the passages with nonwords than when reading passages with real words. They attributed this difference to the lexical retrieval deficits in PWS. Later, an attempt was made by Au-Yeung and Howell (2002) to reinvestigate the nonsense passage reading and meaningful passage reading in PWS. The study revealed that there was a higher percentage of disfluencies in the nonsense passage reading tasks in PWS and attributed this to phonological encoding deficits and not to the deficits in lexical retrieval process as non word reading eliminates the component of lexicalization process.

A study was conducted by Sweta (2012) to investigate phonological processing and speech motor control in bilingual PWS using a nonword repetition (bi and trisyllabic words) in both Hindi and English (L2). Results revealed that the PWS had greater problems when repeating trisyllabic nonwords. Moreover, the reaction time and total duration was also greater.

Pelczarski (2011) investigated the phonological processing abilities in PWS using the phonological awareness tasks, phonological memory and rapid automatic naming task for both word and nonwords. The study revealed significant group differences for tasks employing the nonwords only, and overall, the differences in phonological processing revealed subtle linguistic differences. Hence they concluded that the PWS had only subtle issues in phonological encoding abilities. Phonological encoding abilities have also been studied in young CWS (Pelczarski & Yaruss, 2014) using the phonological awareness tasks. The study revealed that young CWS had subtle, yet robust differences in terms of phonological encoding and they considered this to be a factor contributing to an unstable language planning system in CWS.

Studies in specific to evaluate rapid automatic naming are considered mainly to evaluate lexical retrieval in PWS. Newman and Bernstein Ratner (2007) investigated lexical retrieval in PWS as opposed to PWNS by considering the naming speed, accuracy and fluency of response by taking into account word frequency, neighborhood density, and neighborhood frequency. It was found that there was no significant difference in the lexical retrieval between the groups but however, PWS exhibited a reduction in naming accuracy. Also, stuttering rate was influenced only by the word frequency and not the other factors .Using a similar paradigm, Bernstein Ratner, Newman, and Strekas (2009) investigated the lexical retrieval in CWS which also revealed similar findings but however, there were no differences in terms of accuracy of the response in both CWS and CWNS. It was concluded that the PWS can have deficits in lexical retrieval but however, it cannot be at the level of the abstract phonological representation of the word.

Another paradigm considered for the investigation of the phonological encoding was the rhyme monitoring paradigm and semantic monitoring paradigm. The rhyme monitoring paradigm required the individuals to monitor whether the word presented rhymed with that of the target word, whereas, the semantic monitoring paradigm required the individuals to judge whether the word presented was semantically related to that of the target word. Bosshardt and Fransen in 1996 investigated the rhyme monitoring and semantic monitoring abilities during the silent prose reading task in adults with stuttering. It was found that there was no difference in the rhyme monitoring task but differences were present in the semantic monitoring task. Bosshardt, Balmer, and De Nil in 2002 studied the phonological and semantic processing abilities in PWS and found that they performed poorly in both semantic monitoring as well as rhyme monitoring tasks.

Several studies have also employed the experimental manipulations of phonological complexity and its effect on task performance in PWS (Logan & Conture, 1995; Prins, Main, & Wampler, 1997; Watkins & Yairi, 1997). However the findings of these studies remain equivocal. Au-Yeung and Sackin

(2000) evaluated the effect of late emerging consonants and the consonant clusters on percentage of disfluencies in the conversation task across the three age groups (3-11 years, 12-18 years and >18 years). It was found that stuttering frequency was greater in late emerging consonants and consonant clusters, in function words than in content words in younger age groups. A greater percentage of disfluencies was noted when the late emerging consonants and consonant clusters occurred in the word initial position compared to the final position in the older age group.

Another similar study was conducted in PWS by Postma, Kolk, and Povel in 1990. The task included silent, lipped and overt production of tongue twisters and control sentences. The study revealed that PWS were slower to a greater extent in overt conditions and smallest differences were present in silent condition, that is, slowness was also present in silent naming task but was lesser as opposed to that of the overt and lipped tasks. This indicated the probability for the presence of phonological encoding deficits in PWS as the task of silent naming requires a minimal to negligible motor planning and execution. However, they stated that such a conclusion should be made with caution as the speech conditions used in the study involved a variety of different cognitive processes i.e., semantic, syntactic, and phonemic encoding and motor speech planning.

Another paradigm employed to assess the phonological encoding in some of the recent studies is the phoneme monitoring paradigm. Studies using this paradigm in the silent naming task in PWS were conducted by Sasisekaran, De Nil, Smyth, and Johnson (2006) wherein the participants were instructed to silently name the pictures without making any lip or tongue movements and thus monitor for the presence of the target phonemes in the names of the picture. This revealed that PWS were significantly slower compared to the PWNS in monitoring the phonemes in a set of bisyllabic words in silent naming though they were comparable for response speed across the auditory monitoring, picture naming or simple motor tasks. The results indicated a specific deficiency at the level of phonological monitoring rather than a general monitoring or auditory monitoring deficit.

Using a similar phoneme monitoring paradigm, a study was carried out by Sasisekaran and De Nil (2006) considering the noun phrases and compound words as the target items. The task involved silent naming and auditory perception of these target items using the phoneme monitoring paradigm. The performance was compared across the two tasks. The results revealed that the PWS were significantly slower in silent naming as opposed to PWNS but no such differences were found in the auditory perception task. Also, the reaction times were comparable in monitoring the phonemes in the silent naming as well as the auditory perception task for both noun phrases and compound words in both the groups. Thus, they ruled out a general monitoring deficit in PWS and concluded that PWS are slower in encoding of segmental, phonological units during silent naming.

Garnett and Ouden (2013) using the phoneme monitoring paradigm that PWS performed significantly slower in silent naming task than in the auditory perception task. This, study also revealed a significant difference in the accuracy for silent naming task. They concluded that in addition to a delay, there is also an increase in the number of errors in PWS thus supporting the CRH (Postma & Kolk, 1993) and Vicious circle hypothesis (VCH, Vasic & Wijnen, 2005) as

PWS exhibited a delay as well as errors in monitoring the phonemes. The VCH supports the fact that in PWS the self monitoring system is highly sensitive even for small deviations in speech because of which they often interrupt and repair the errors which thus results in moments of stuttering.

Sasisekaran, Brady, and Stein in 2013 conducted a study to investigate the phonological encoding skills in CWS wherein the task was to monitor the target phonemes in the syllable onset and offsets of bisyllabic words. Performance was then compared with the auditory tone monitoring abilities of the individual. It was found that CWS became progressively slower in monitoring the phonemes in the bisyllabic words but no such a difference was found in auditory tone monitoring tasks. Also, with respect to the analysis of errors, no significant difference was present between the two tasks in either of the groups. This indicated that CWS experience temporal asynchronies in one or more processes leading to phoneme monitoring. Another study by Sasisekaran and Byrd (2013) investigated the segmentation and rhyme abilities in CWS using two tasks i.e., phoneme monitoring and rhyme monitoring in silent naming. In both the tasks, the participants had to monitor the singletons and consonant clusters. The study revealed no significant differences across the groups in monitoring tasks but only slower monitoring of the consonant clusters was found in CWS. Thus, it was concluded that there was no deficits in segmentation and rhyming in CWS, however, difficulties in segmentation may be more pronounced with the increase in the phonological complexity of the stimuli.

Need for the study

A look into the literature revealed that the findings from the studies reported with regard to phonological encoding difficulties in PWS are equivocal. But there is atleast partial evidence that suggests that phonological encoding deficits or delay may be present in PWS which inturn might lead to the breakdown in fluency. Most of these studies have involved spoken responses which would have failed to eliminate the motor speech execution deficits present in PWS. Therefore, a systematic investigation of the nature and extent of phonological encoding difficulties is essential by choosing an appropriate paradigm and baseline tasks that would isolate the process of interest. Such studies would provide an insight into the etiological variables for an enigmatic disorder like stuttering which would further contribute to our understanding of the various psycholinguistic theories of stuttering and finally approving or disproving them.

Further majority of these studies have been conducted in the western context, in individuals who are native speakers of English and none are available in the Indian context in general and Kannada language in particular. In addition, there is no study reported in the Western or in the Indian context that contributes to explain how the position of the target phonemes within a word is affected by the process of phonological encoding using phoneme monitoring paradigm. Since each language has its own linguistic structure, the influence of linguistic factors on stuttering may vary from one language to another (Dworzinski, Howell & Natke, 2003; Dworzinski & Howell, 2004). Some cross linguistic studies across different languages like German, Spanish, African, Igbo, Kannada and Mandarin languages have revealed that stuttering frequency varies either with respect to phonetic complexity (Dworzinski & Howell, 2004), lexical category (content vs. function words), word length, clausal beginnings, vowel initiated words, and at the initiation of verbs (Bernstein, Ratner, & Benitez, 1985). Therefore differences in the language can influence the frequency of stuttering. Moreover there are certain differences in phonological aspects between English and Kannada, like differences in phonotactics, differences also in terms of rhythm. English being a stress timed language and Kannada being a syllable timed language and rate of speech, which are important factors influencing the fluency in either of the languages. Thus, India being a country known for its innumerous number of languages spoken by the people, a study in one such Indian language, Kannada will be worthy as such a study has not been conducted in any other language of the country.

This will be the first study to be conducted in Kannada, and first study conducted to assess the phonological encoding abilities in PWS taking into account the position of the phonemes in words using the phoneme monitoring paradigm. Keeping this in view, the present study was planned.

Aim of the study: The aim of the present study was to investigate the phonological encoding abilities in adults with stuttering using a phoneme monitoring paradigm in silent naming task and auditory perception task. The specific objectives of the study were

- To compare the reaction time and accuracy in silent naming and auditory perception tasks between persons with and without stuttering.
- To compare the reaction time and accuracy across silent naming and auditory perception task in persons with stuttering.

- To compare the reaction time and accuracy across silent naming and auditory perception task in persons with no stuttering.
- To assess the influence of the position of the target phonemes in silent naming and auditory perception task between persons with and without stuttering.

Chapter 2

Review of Literature

Various definitions have been proposed to define stuttering since several decades. This reflects the complexity of the disorder. Stuttering is considered to be an enigma. Among the various attempts made by the researchers to define this condition, one of the most frequently cited definition is the one put forth by Wingate in 1964. According to him, stuttering means disruption in the fluency of verbal expression, which is characterized by involuntary, audible, or silent repetitions or prolongations in the utterance of short speech elements, namely sounds, syllables, and words of one syllable. These disruptions usually occur frequently or are marked in character and are not readily controllable. Sometimes the disruptions are accompanied by accessory activities involving the speech apparatus, related or unrelated body structures, or stereotyped speech utterances. These activities give the appearance of speech-related struggle. Also, there are not infrequent indications or reports of the presence of an emotional state, ranging from a general condition of "excitement" or "tension" to more specific emotions of a negative nature such as fear, embarrassment, irritation, or the like Wingate further stated that the immediate source of stuttering could be some incoordination expressed in the peripheral speech mechanism; the ultimate cause, however was presently unknown and may be complex or compound. Yairi and Ambrose (2005) defined stuttering as being characterized by a disruption in the flow and the rhythm of speech, though the individual knows exactly what he/she wants to say. These disruptions during the speech production process is perceived as sound prolongations, syllable repetitions, and silent blocks, which can be for a brief duration or lasts for several seconds.

The speech behaviors of the individuals with stuttering are referred to as the core behaviors (Van Riper, 1971, 1982). These behaviours are considered to be involuntary and out of control. Repetitions are considered to be one among the basic core behaviours of stuttering. Individuals with stuttering can simply exhibit a sound, syllable or part word repetition. It appears as though the speaker is stuck on a sound and continues to repeat it until the following sound can be produced. Prolongation is another core behavior which occurs when the sound or the air flow continues but the movement of the articulators stop. These prolongations can vary between half a second to several minutes (Van Riper, 1982). The presence of prolongations and repetitions is considered to be the core behavior of stuttering in advanced stutterers. Block is considered to be another core behavior of stuttering. It occurs when there is a sudden stop of flow of air or voice and the movement of the articulators as well. This can occur at any level along the respiratory, phonatory or at the level of articulatory subsystems. There are certain evidences which support the fact that the blocks occur due to inappropriate activity at the level of laryngeal system. (Conture, McCall, & Brewer, 1977; Freeman & Ushijima, 1978). PWS differ from each other in terms of the nature and frequency of the core behaviors they present. These core behaviors also vary with respect to the different situations and individuals. Stuttering is also characterized by the presence of other disfluencies. This includes pauses which is characterized by the presence of a gap in the ongoing flow of speech which can be silent (duration of silence greater than 250 ms) or a filled pause with extraneous sounds. Hesitations, interjections, broken words, phrase revisions, incomplete phrases, dysrhythmic phonation (prolongations and broken words) and tense pauses are the other disfluencies found in the speech of persons with stuttering. There is a considerable overlap in the type of disfluencies produced by individuals with stuttering with a lesser severity of stuttering in comparison with the disfluencies found in the speech of fluent speakers. Therefore in order to identify the core behaviors better and thus identify the individuals with stuttering, an attempt was made by Yairi and Ambrose (1993) to classify stuttering behavior into stuttering like disfluencies (SLDs) and other disfluencies (ODs). SLDs included repetitions (monosyllabic repetitions and part word repetitions), prolongations and blocks/articulatory fixations and ODs included polysyllabic word repetitions, phrase repetitions, interjections and revisions. The frequency of occurrence of SLDs in comparison with ODs contributes towards the diagnosis of stuttering.

In addition to these disfluencies, stuttering is also associated with the presence of certain secondary behaviors. PWS do react to their core behaviors by trying to end these core behaviors quickly if they are not able to avoid them. Such behaviors develop into a obvious struggle and then into a very well established patterns. Secondary behaviors could be either divided escape behavior or avoidance behaviors (Guitar, 2006). Escape behaviors refers to the phenomenon wherein the person with stuttering stops stuttering and finishes the word. It is characterized by eye blinks, head nods, and interjections. Avoidance behavior refers to the condition wherein the person with stuttering remembers the negative emotions associated with previous experience of stuttering. Therefore, in order to escape from having such a negative experience associated with stuttering, the individual tries to escape by resorting to using certain behaviors that he had used earlier to escape from stuttering like changing the word he was planning to produce. It is considered that these avoidance behaviors enable the person in the early stages by providing a great deal of relief, but however, it gradually becomes a habit which is resistant to change. Avoidance includes postponements, substitutions and use of starters.

The recent reports with reference to incidence and prevalence of stuttering by Yairi and Ambrose (2013) revealed that the life span incidence and prevalence of stuttering was 8% and 0.72% respectively in the world. Further research has also revealed that stuttering is more common in males and tends to run in families. It was also found that about 1 or more of every five children with stuttering will continue to stutter into late childhood and beyond. This revealed that about four out of five children with stuttering recover from stuttering whether intervention is provided or not (Guitar, 2006).

Stuttering in most cases begin in childhood and is referred to as developmental stuttering. The quality and the quantity of stuttering changes as the child grows old, becomes teenager, and finally an adult. That is a person with severe stuttering can have longer durations of prolongations but however, during the childhood, the same adult could have had shorter instances of stuttering and had lesser degree of audible manifestations of physiological tension when compared to the stuttering as being an adult. This indicates that though the problem begins in childhood, it changes in both form and frequency over a period of time. Thus, stuttering is considered to be equally predictable in its occurrence.

Attempts have been made by the researchers to determine whether stuttering is a disorder of speech or language. In order to explain the relationship between stuttering and language, studies have shown that adults frequently stutter on a) consonants b) sounds in word-initial position c) in contextual speech d) nouns, verbs, adjectives and adverbs e) longer words f) words at the beginning of sentences and g) stressed syllables (Brown, 1937, 1938 a, 1938 b, 1938c, 1943, 1945; Brown & Moren, 1942; Johnson & Brown, 1935). This supports the notion that disfluencies are influenced by linguistic factors. Following this, studies were conducted on CWS with the same premise. Researchers found that the very young CWS stuttered more frequently on pronouns and conjunctions and not on nouns, verbs, adjectives and adverbs as opposed to adults with stuttering. In children with stuttering, it was found that there was mainly part word repetitions and repetition of single syllable words in the sentence initial position (Bloodstein, 1995; Bloodstein & Gantwerk, 1967). Based on the finding that stuttering mainly occurred at the beginning of the syntactic units, researchers indicated that the task of linguistic planning and preparation was a key ingredient in the occurrence of disfluency (Bernstein Ratner, 1997; Bloodstein, 2001, 2002).

The finding that stuttering is predominantly seen in a particular position of the word in the speech of PWS was investigated by Brown (1938). The basis for the occurrence of stuttering in the word initial position was explained by taking into account the stress effect. This phenomenon i.e. the stress effect is influenced inturn by the word initial – effect which refers to stuttering being predominantly occurring along the first syllables of the word especially in a language like English wherein the stress usually occurs in the initial position of the word. The stress effect is also affected by the grammatical class i.e. content words versus function words. Studies have reported that a higher number of stuttering frequency for content words than the function words in PWS (Dayalu, Kalinowski, Stuart, Holbert, & Rastatter, 2002) which is inturn due to the differences in the stress patterns across the two grammatical categories. Another attempt was made by Natke, Sandrieser, Melanie van Ark, Pietrowsky & Kalveram in 2003 to investigate whether there is a relationship between linguistic stress and stuttering in CWS. The study was conducted on twenty – two CWS (German as native language), (fourteen boys and eight girls) in the age range of 2 to 5 years were considered. The study involved the recording of the speech samples of the children individually during the interaction with the investigator in the presence of their parents. Speech samples were recorded in two sessions, one recording done per week. The speech samples of the children obtained were analysed orthographically and using CHILDES Project: Tools for analyzing talk (MacWhinney, 1991).Overall, a total of 1000 syllables obtained for each child was obtained and analyzed. CLAN was designed such that it could identify disfluencies and code for them accordingly. The stress rating of the analyzed sample was done using a 9 point rating scale, (1-lowest stress and 9- highest stress). It involved the measurement of both position effect and grammatical class effect in CWS. Results revealed that 97.8% of stuttering events occurred on first syllables of words and 76.5% on the first sound of syllables, thus clearly indicating a word-initial effect. Stuttering frequency on first syllables of function words was significantly higher than the frequency of stuttered first syllables of content words. They concluded that stuttering was predominantly seen along the initial position of the word.

Etiology of stuttering

Though various studies have been conducted to identify the cause of stuttering, it still remains unknown. Stuttering is often considered to be associated with both linguistic and motoric deficits. According to Peters and Starkweather (1990) stuttering is believed to be associated with a lack of balance between the linguistic and the motoric systems involved in speech production. Bloodstein (2002) emphasized on the fact that stuttering is basically a disorder of language development. Such notions motivated the researchers to extensively study the relation between stuttering frequency and the different linguistic variables. There are a number of studies that have investigated the effect of different linguistic variables on the frequency of stuttering. These linguistic factors include lexical retrieval (Bloodstein & Gantwerk, 1967; Helmreich & Bloodstein, 1973; Jayaram, 1983; Howell, Au-yeung & Sackin, 2000; Dayalu, Kalinowski, Stuart, Holbert, & Rastatter, 2002; Santosh & Arunkumar 2006; Sindhupriya, 2012), morphological structure of the words, syntactical complexity (Hannah & Gardner, 1968; Wells, 1979; Brundage & Ratner, 1989) and phonetic complexity (Brown, 1938,1945; Hahn, 1942; Hejna, 1955; Quarrington, Conway, & Siegal, 1962, Geetha, 1978). This suggests that there is indeed a strong relationship between the linguistic factors and stuttering.

Several theories were proposed to explain stuttering, such as biological, psychological and behavioral. These theories try to answer the predisposing, precipitating and perpetuating factors for stuttering. Off the several theories proposed to explain the cause for stuttering, one set of theories are the psycholinguistic theories of stuttering. These theories consider stuttering to be a disorder of language. Psycholinguistics refers to the study of the psychological processes underlying language use. According to the psycholinguistic theories of stuttering, stuttered speech results from minute deficiencies in the psychological processes essential for transforming the words selected into integrated patterns of suprasegmental and segmental gestures of speech. These theories of stuttering do not posit that individuals with stuttering are lacking in their knowledge of phonology or vocabulary of their language but rather propose that they have issues with reference to the retrieval and integration of these elements. One such process that is embedded within the language formulation system that is considered to be the possible loci for stuttering according to these psycholinguistic theories is phonological encoding. It is essential to understand the difference in phonological encoding between normal speakers and PWS in order to explain it as the cause for stuttering.

Phonological Encoding in Normal Speech

Phonological encoding is defined as the process involved in the generation of the sound segments that constitutes the word from the mental lexicon, retrieval of these segments and arrangement of these within an appropriate syllable frame and application of the appropriate syllable stress prior to the initiation of the articulation of speech segments (Levelt, 1989). This process of phonological encoding requires the speakers to monitor their own speech much before it is overtly produced. However speakers can monitor even after it is produced which means that speakers can monitor their speech via dual routes. As a result of the process of phonological encoding and monitoring process, speech flows fluently and if disrupted, it can be corrected by the speaker. This indicates that there is indeed an interaction that exists between phonological encoding and monitoring.

Majority of such monitoring processes happens much before the overt speech production. This signifies that much of the overt speech output is due to the results of phonological encoding and monitoring processes. However in individuals with stuttering, excessive disfluencies are present due to the result of deficits within the language formulation mechanism and interactions between these components and the self monitoring system which safeguards the quality of speech output.

A psycholinguistic model of language comprehension and production was proposed by Levelt (1989). To explain the process of language formulation and production, he divided the language production system into three major components: conceptualizer, formulator and articulator. Conceptualizer acts as an interface between the thought and language. This conceptualizer has an access to the intentions of the speaker, speakers knowledge of the world, the physical and social context and a model of the current state of the discourse. In order to speak, the speaker will formulate a pre-verbal message. The formulator uses this pre verbal message to construct a sentence representation. The formulator is divided into two sub components: the first component is concerned with the grammatical encoding, which is responsible for selecting the words from mental lexicon and then assigning the grammatical functions to these words and then construct a phrasal representation in a linear order. The second component is phonological encoding, which is responsible for determining the prosody of the sentence, and the retrieval of phonological form of the words, i.e., spelling out the “phonological segments” in the words, determining the metrical structure of the words. The representation thus obtained is phonological in nature and hence for the realization of the utterance, there is a need to convert it into the language of motor control. Thus the third component of the model is the articulator which is involved in motor programming and motor execution. According to the model in the figure 2.1, along the right side, there is the component of speech comprehension which is divided into auditory processing of overt speech and speech comprehension proper which is inturn responsible for word recognition, syntactic analysis, and mapping syntactic representation onto meaning. The resultant representation is referred to as “parsed speech” which is inturn fed into the conceptualizer. Thus, the model indicates that the overt speech is fed into the conceptualizer through the speech comprehension system. In addition to the overt speech, there is another feedback channel, wherein the speakers can listen to their own speech before the speech is actually articulated, this is referred to as the inner speech. This channel is represented as a connection between the articulatory buffer, which is involved in the temporary storage of the speech plan while it waits for articulation, and the language comprehension system. Both of these feedback loops are fed back to the conceptualizer, wherein a comparison is made to check whether our own “parsed speech” matches the intended speech of the speaker.

The proposition of the presence of two channels is because it is believed that there is a division of labour between the two channels. Few errors will be detected by one channel and few by the other channel. It is also proposed that the process of monitoring takes place at the level of conceptualizer. For the detection of errors in the parsed speech, a comparison is made between the parsed speech and the intended speech. Following the detection of error, the speaker will interrupt and thus correct the error. According to Levelt’s proposition, the coordination between the two processes is governed by the “main interruption rule”. The speaker interrupts quickly after the error detection and halts all the components of the language production. Thus, the overt speech is interrupted momentarily. This moment marks the “editing phase”, during which the repair is planned. However few researchers (Blackmer & Mitton, 1991; Oomen & Postma, 2001) identified that the process of repair begins immediately at the moment of interruption. Thus, the modified interruption rule was proposed which conceives that the process of interruption and repair as two parallel processes that both start immediately after error detection (Hartsuiker & Kolk, 2001).

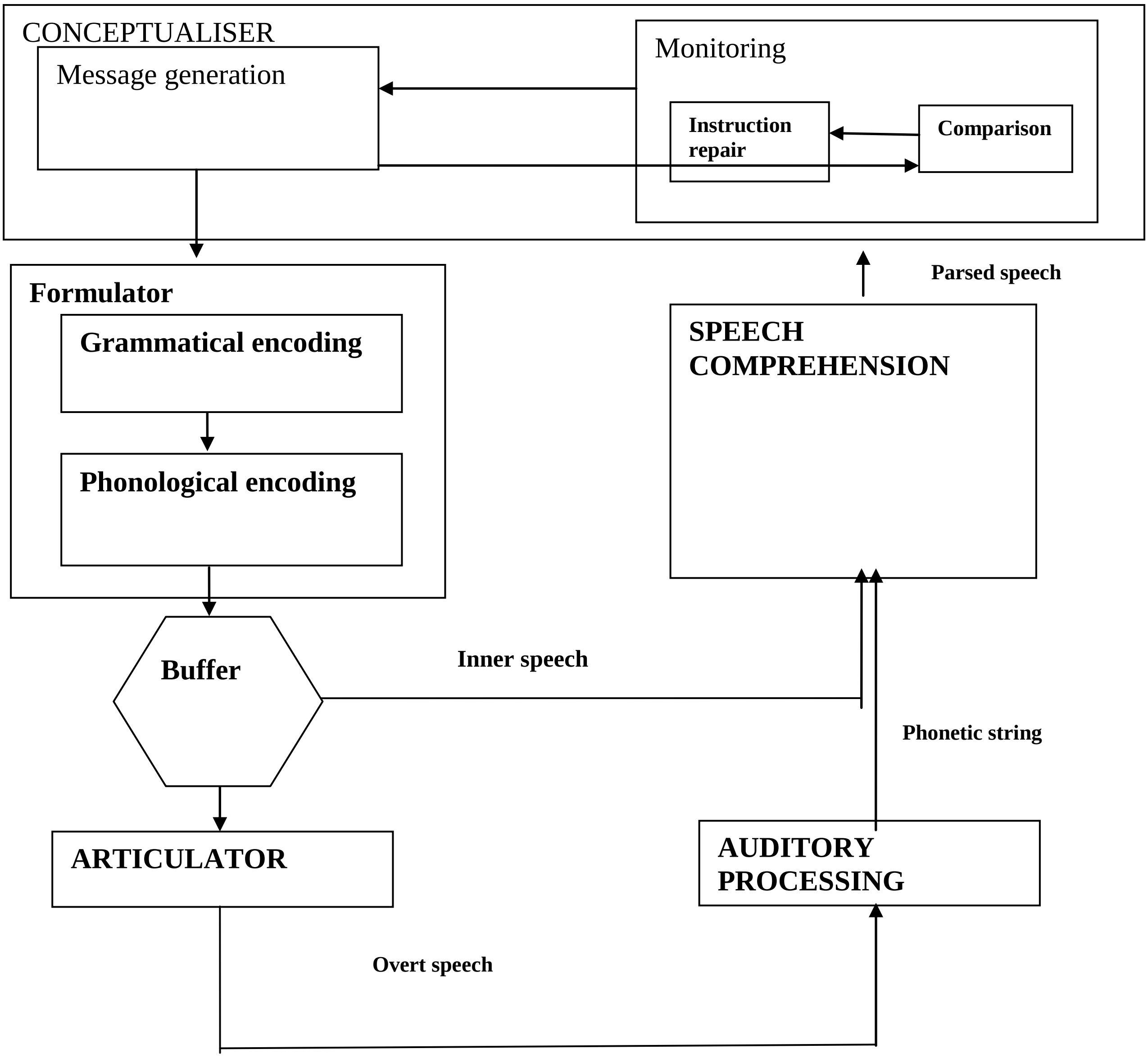

Figure 2.1: Blueprint of the speaker- Levelt (1989). Source: Phonological encoding and monitoring in normal and pathological speech, psychology press.

In order to determine that the speakers do monitor the phonological words and not the articulatory programs or the string of segments, a study was conducted by Levelt and Wheeldon (1995).The study was conducted on the Dutch speakers who had good proficiency in English. The task required the participants to monitor for the target speech segments in the Dutch translation equivalent of visually presented English words. For instance, they had to indicate by a button press (yes/no) whether the segment /n/ is a present in the translation equivalent of the English word WAITER. The Dutch word is *kelner,* which has the segment /n/, thus requiring a yes response. The position of the segments was manipulated, i.e., it could be present along the onset, coda of the first syllable, or along the onset or the coda of the second syllable. Monitoring latencies gradually increased with the serial position of the segments within the word. In order to evaluate that it is the phonological words that was monitored by the speakers rather than the articulatory programs, the participants also had to perform a segment monitoring task while simultaneously counting aloud which is considered to suppress the maintenance of the phonetic representation. The results revealed that in the monitoring task, the latencies increased thus indicating that it is the phonological rather than the phonetic representation that is monitored by the speakers. In addition, in order to determine that it is the syllabified segment that is monitored rather than the string of segments, the participants were required to monitor for the presence of target syllables. The target syllable corresponded to the first syllable of the Dutch word or it was larger or smaller. The results revealed that the syllable targets were detected much earlier when they exactly matched the first syllable of the words than when they were smaller or larger, thus revealing that it is the phonological words that are monitored rather than the string of elements.

Later, Levelt, Roelofs, and Meyer (1999) explained phonological encoding using the WEAVER++, which is a computational model of spoken word production that explains the interplay between planning, comprehending and monitoring explicitly. The model can be explained overall as involving three important processes: 1) Conceptual preparation, 2) Lemma retrieval, 3) Word form encoding which further includes morphological, phonological and phonetic encoding (Roelofs, 1992, 1997a).

The unit ‘conceptual preparation’ is involved in selecting a lexical concept and a goal concept and identifying it as goal concept (The concept of ‘cat’ in naming a picture ‘cat’). The ‘lemma retrieval’ involves activation and selection of a lemma from memory which is involved in the representation of a word which is used in sentences (e.g., The lemma of the word ‘cat’ says that it is a noun). The ‘word form’ encoding involves activation of selected lemma and selecting the form properties from memory (e.g., for ‘cat’, the morpheme <cat> and the segments /k/, /ae/ and /t/ are activated and selected). Following this the segments are incrementally syllabified, which yields a phonological word representation. Finally, a motor program for /cat/ is generated; the articulatory system executes the motor program thus resulting in the production of overt speech.

An illustration of the functioning of the WEAVER++ model is explained in the Figure 2.2. For production of the word ‘cat’, the information is retrieved from the network by the process of spreading activation. For instance, the perceived object i.e. ‘cat’ activates the corresponding concept node. The activation then spreads in a linear activation rule through the network. Each of the node sends its activation to the nodes to which it is connected to i.e. ‘cat’ sends the activation to ‘Dog’ and also to the lemma node ‘cat’. Following this ‘cat’ gets selected as it is the goal concept and has greater level of activation when compared to other lemmas. The actual moment of firing is dependent upon the ratio of level of activation of lemma node and the sum of activation of all other lemma nodes. Following this a morphological rule is applied to the morpheme nodes that are connected to the selected lemma (<cat> for cat). The phonological production rules are then applied to the morphemes thus selected and a phonological word representation is thus obtained. Ultimately, the phonetic production rules are applied which result in the generation of the motor programs that are in turn connected to the syllabified segments i.e., [kaet].

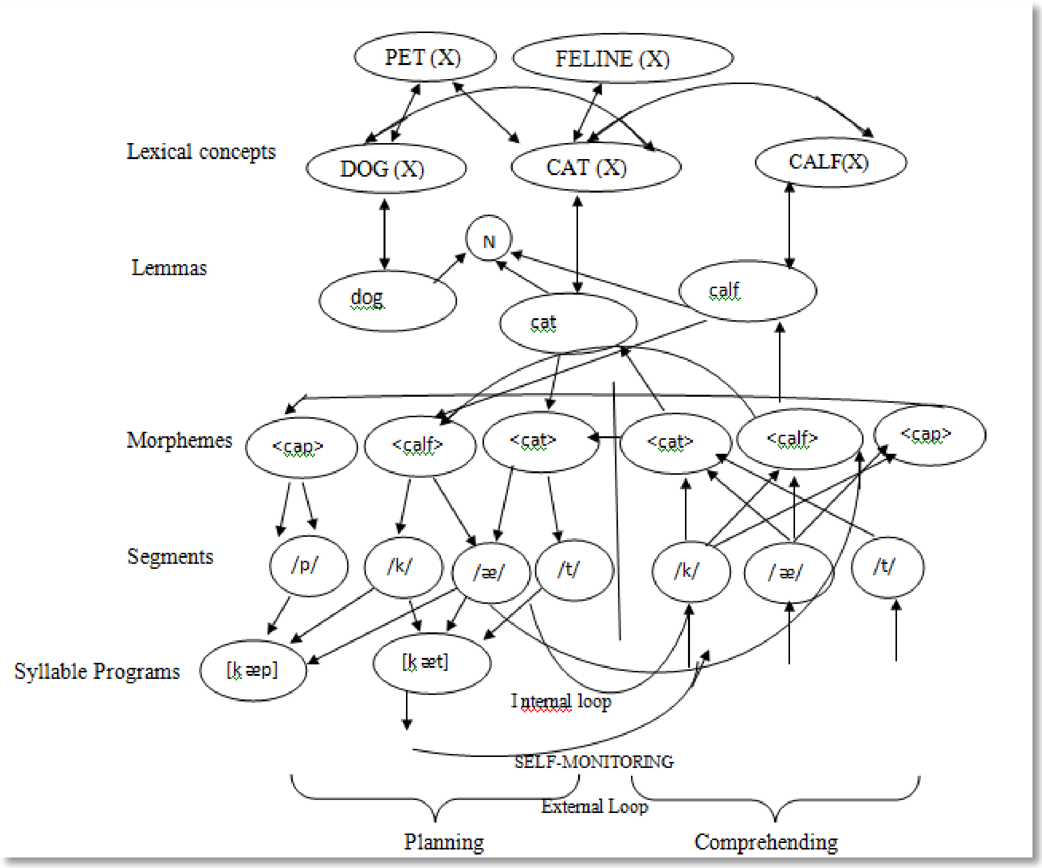

Figure 2.2: An illustration of the production and comprehension networks of WEAVER++ model. Source: Phonological encoding and monitoring in normal and pathological speech, Psychology Press.

The process of phonological encoding in specific using the WEAVER++ model is explained in the figure 2.3 (memory representations are depicted with circles and the processing of information is depicted with arrows). For the encoding of the word "tiger", the two important memory representations TIGER at the lexical concepts and the lemmas (tijger), are not the aspects of the actual phonological encoding but serve as inputs to the process. For the production of this word, there is activation at the lexical level. The word form marks the beginning of the actual phonological encoding process. Majority of the theories proposed suggest that encoding the word form is divided into two separate processes: a) one process which involves retrieving the phonological segments and the other process which involves retrieving the structure of the words i.e, identifying the number of syllables and which is the syllable bearing stress. This is thus referred to as the process of phonological encoding.

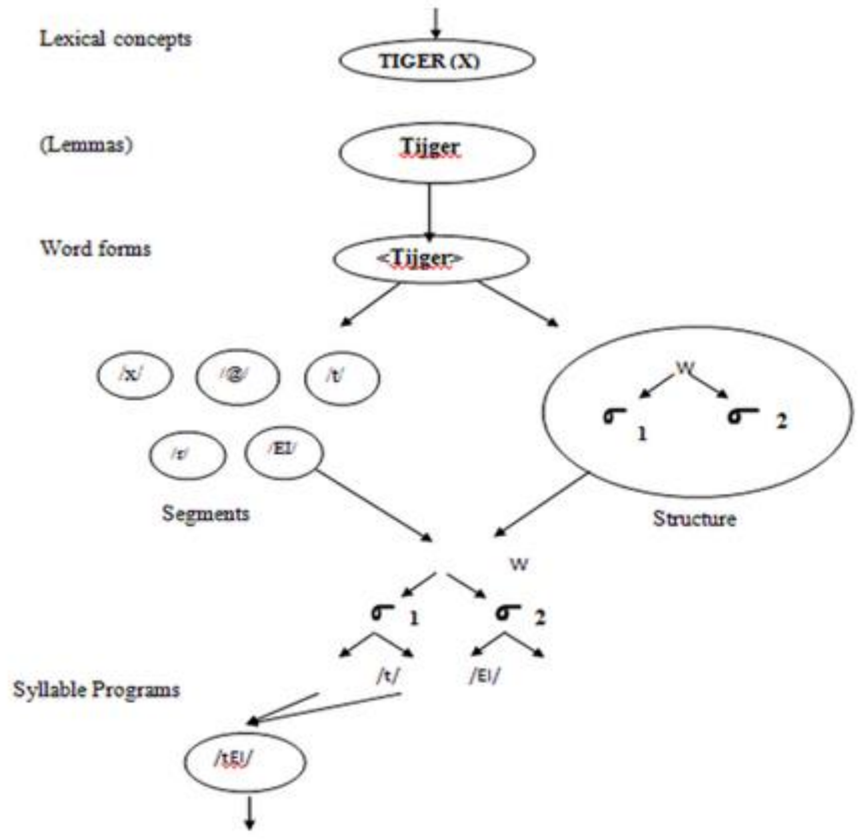

Figure 2.3: Illustration of the process of phonological encoding based on WEAVER++ model. Source: Phonological encoding and monitoring in normal and pathological speech, Psychology Press.

Though WEAVER++ is an influential model to explain the language formulation. It contributes to explain language processing from thought through to the speech output, but the process of phonological encoding requires more than just the output stage of the process involved in language processing. These tasks require the individual to hear the stimuli, perform some sort of identification or manipulation depending upon the task and then provide the speech output. Thus, WEAVER++ only contributes to explain only one half of the process involved in the phonological encoding tasks i.e. it only contributes to explain how the phonological encoding takes place for a self generated speech. Thus, a model that includes speech perception and speech production will provide a framework to examine the phonological encoding abilities of an individual for the speech generated by self and others.

Therefore Ramus, Peperkamp, Christophe, Jacquemot, Kouider, and Dupoux (2010) proposed a “general model” of speech perception and speech production which was based on theories of language formulation like WEAVER++. They included the components of WEAVER++ along with other additional components to obtain a comprehensive understanding of the phonological encoding tasks. The illustration of the functioning of the “general model” is provided in figure 2.4.

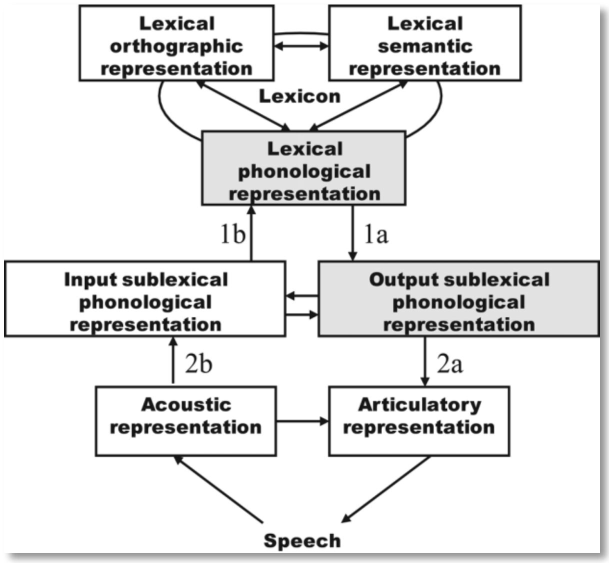

Figure 2.4: An information processing model of speech perception and production (Ramus et al., 2010). Source: Laboratory Phonology 10: Variation, Phonetic Detail and Phonological Representation (pp. 311-340). Berlin: Mouton de Gruyter.

According to this model, during the performance of tasks involving phonological processing like the phonological awareness task, there are two routes that get activated, a lexical route and a phonological route. The lexical route utilizes the information present in the lexicon in order to give a speech output and gets activated on receiving the word from an external source. This is achieved by the retrieval of the acoustic representation and the decoding of the acoustic signal into a specific phonological code at the level of input sublexical phonological representation (via arrow 2b). The lexicon is then accessed in an attempt to match the auditorily presented phonological word with that of the stored lexicon (via arrow 1b). This lexicon consists of orthographic, semantic and phonological representations which is similar to that of the lexemes found in WEAVER++. Thus at the level of the lexicon, the meaning is derived and the response is formulated. For the formulation of the response, the phonological code is retrieved from the lexical phonological representation (via 1a) and then travels down via the output sublexical phonological representation. This output phonological representation acts as the phonological encoding loop of the Levelt's model. Thus phonological code thus formed is delivered as the phonetic code to the articulatory representation (via 2a) resulting in speech production. Thus there is a bidirectional loop that involves sharing the information between the input and output sublexical phonological representations that permits an individual to listen to the auditorily presented item and repeat it back without requiring any contributions from the lexicon (Ramus et al., 2010).This route was basically proposed to explain what happens during the performance of phonological processing tasks using the non words. This indicates that for processing the nonwords, the process of lexical retrieval is not present as the input received is directly routed from the input sublexical phonological representation towards the output sublexical phonological representation. Thus this model contributes to explain phonological processing for an individuals' own speech as well as for the speech input received from the environment.

Phonological Encoding in Persons with Stuttering

Based on the understanding of the psycholinguistic models proposed to explain language comprehension and production (Levelt, 1989; Levelt, Roelofs, & Meyer 1999), one can assume that disruptions in the normal speech or in the pathological speech occur due to dysfunction of the mechanisms involved in speech planning and due to interactions between these processes with that of the self monitoring system of an individual.

Some of the theories proposed to explain the etiology for stuttering have signaled a deficit of phonological encoding as one of the potential cause for stuttering. One such psycholinguistic theory is the **Fault line hypothesis by Wingate (1988).** He hypothesized that stuttering occurs as a result of lack of synchrony in the assembly of linguistic elements, that is, it occurs at the "fault line" of phonological formulation, the point where initial consonant and the vowel are joined. These elements are "utilized" for the generation of syllable stress. Therefore, stuttering indicates the failure to merge the prosodic and phonologic aspects of speech (Perkins, Kent & Curlee, 1991; Wingate, 1988). According to Wingate, the specific sounds which are the loci for repetitions or hesitations are usually well articulated, thus the difficulty is not in the production of the sounds but in moving from one phonetic element to the next phonetic element. He considered stuttering as a "phonetic transition defect" in which the speaker has trouble connecting speech elements rather than with producing the elements themselves. He insisted that this fault line for stuttering has its origin at central rather than at peripheral level of speech production processes and the common loci for stuttering is that they occur on stressed syllables. He explained that the execution of stress is primarily a phonatory function requiring laryngeal adjustments for pitch and loudness. This interference, combined with the view of stuttering as transition defect, led Wingate to conclude that stutterers have a general difficulty to produce stressed vowels, with the implication that the central processing difficulty leads to a failure to make the neurophysiological adjustments necessary for speech.

Another psycholinguistic theory which emphasized on the fact that stuttering occurs when sounds are not inserted at an appropriate time into the syllables during speech production is the **Neuropsycholinguistic Model by Perkins, Kent, and Curlee (1991)**. According to this theory, stuttering occurs when the articulatory rate exceeds the rate at which segments can be synchronously integrated into their syllable frames. There are two neural processes involved in this insertion process. They are the symbol system which is concerned with linguistic processing and the signal system which is responsible for providing the syllable frames which is vulnerable to cognitive deficits.

The dyssynchrony in the functioning of these two systems which inturn affects the speech output is due to the discrepancy in the arrival of the syllable frames which contain the slots into which speech segments are inserted. This dyssynchrony occurs due to self expressive uncertainty and inefficient neural resources due to genetic constraints, brain injury or competition for processing capacity (Perkins et al., 1991). They refer to stuttering resulting from a delay in linguistic processing as linguistic stuttering which can be the result of segmental processing inefficiency or due to ineffective activation of the components that contribute to the final act of speaking.

According to another theory by Postma and Kolk (1993), stuttering occurs as a response to errors or flaws in the speaker’s phonetic plan i.e., the phonological encoding of an utterance. Such errors will make the plan more vulnerable to phonemic or phonetic distortions. As a result the speaker makes covert attempts to correct these errors in plan. These covert attempts affect the smooth flow of speech. This theory was referred to as the **covert repair hypothesis (CRH)**. This theory considered the psycholinguistic models of speech production (Dell, 1988; Levelt, 1989) in order to explain the phenomenon of covert repair and the occurrence of overt disfluencies in speech.

In PWS, there is difficulty in the selection of the correct phoneme, thus these individuals produce more errors. But these errors are obstructed by the self monitoring system and thus the covert repair is done, thus the error is removed from the speech plan. But this process of error detection causes interruptions. Depending upon the time taken for this process of correction, the execution of the speech plan is interrupted leading to disfluencies (Postma & Kolk, 1993; Kolk & Postma, 1997).

The theory does not propose that PWS have impaired self monitoring or poor error detection abilities than the fluent speakers nor that the phonetic errors which these individuals make are different from that of normal speakers. But it emphasizes on the fact that the errors in their plan are more when compared to that of normal speakers. Hence the need to make such covert corrections is more than that of normal speakers and the sound and syllable repetitions made indicate the attempts made by the speakers to correct or reduce the errors. The repetitions are a response to the detection of an error wherein the sound or syllable is restarted. Restarting supposedly reduces the chances of making further encoding errors. Hence stuttering is a ‘normal’ repair reaction to an abnormal phonetic plan. Kolk and Postma (1993) used the model of language comprehension and production by Levelt (1989) to explain the occurrence of disfluencies in the speech of PWS. Based on the Levelt’s model, they proposed that speech and language production involves three important aspects: the internal monitoring of speech, the consequent detection of errors and the speaker’s attempt to correct or repair these errors. This process of error detection is achieved by the role of two loops an internal loop and an external loop as depicted below in the figure 2.5.

Levelt's Monitoring Loops

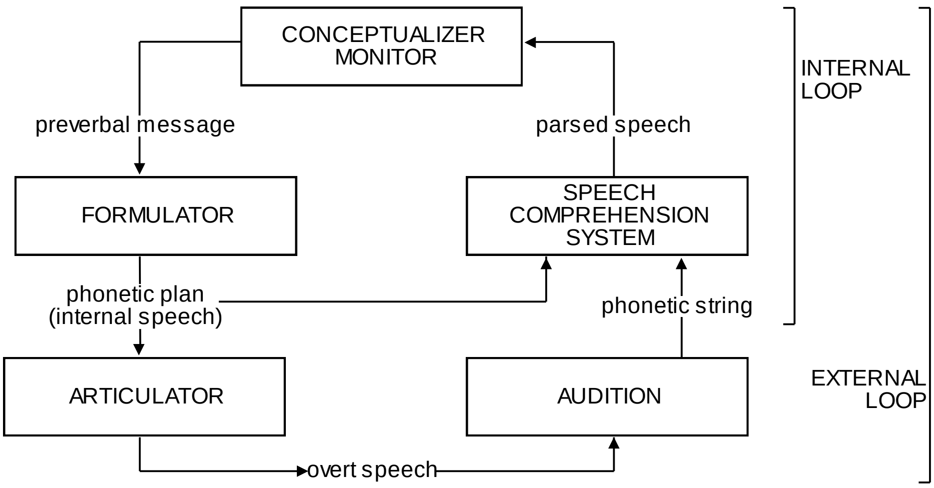

Figure 2.5: An illustration of the Levelt's monitoring loops. Source: Phonological encoding in normal and pathological speech, Psychology Press.

The internal loop contains the conceptualizer, before preverbal message is generated and after phonetic plan is generated by formulator (covert speech) and an external loop: after speech is articulated (overt speech). During the normal course of speech production, errors do occur and are followed by attempts to repair them. The moment an error is detected, flow of speech gets interrupted and the speaker pauses and uses fillers such as 'uh' or 'um' or 'I mean' which were referred to as "editing" by Levelt and the repair begins after the pause. The editing term serves to help the listener understand that a repair process is going on. These self repairs can be either overt or covert. Overt repairs are those corrections made after the execution of the articulatory plan/actual speech. The covert repairs are those corrections which are made at a pre articulatory stage i.e. the errors are detected prior to actual speech. Hence the program is corrected before speaking. But, this repair of errors in the pre articulatory stage does not happen easily, rather it is argued that it produces another type of observable effect i.e., it can hamper the progress of an utterance, can halt the execution of forth coming utterances, and can also result in the repetition of one or more already uttered units. These effects are seen due to the fact that an erroneous plan is already sent to articulators and drastic intervention is needed and repairing of some part of plan, temporarily leaves the correct parts also unavailable. In order to execute a covert repair, there must be a mechanism available to enable the speaker to detect the error before it is called in speech production. Indeed, Kolk and Postma (1997) describe that the process of prearticulatory editing allows the speaker to repair the error before it is produced.

Kolk and Postma (1997) also used spreading activation models by Dell (1986) and Dell and O'Seaghdha (1991) to explain the more number of phonological errors in the speech of PWS. According to this model, during the speech production, a metrical frame of the utterance to be produced is first created and then the phonological elaboration of this frame is achieved through the activation of appropriate phonological segment nodes in a neural network as indicated in the figure 2.6. Those nodes which have the highest level of activation at the moment when speech planning starts are the ones which fill in the frame formed. Postma and Kolk (1993) hypothesized that PWS have slower activation of phonological segment nodes i.e., the time taken for the activation of the nodes to reach a level of activation is more when compared to that of other competing nodes. Therefore, when the rate of speech is normal, inappropriate phonological nodes are selected for the frames they generate resulting in misselection of sounds. But, when the rate of speech is slower, the appropriate nodes get activated and the correct phonemes are inserted into the frames generated thereby ensuring that the phonetic plan is error free.

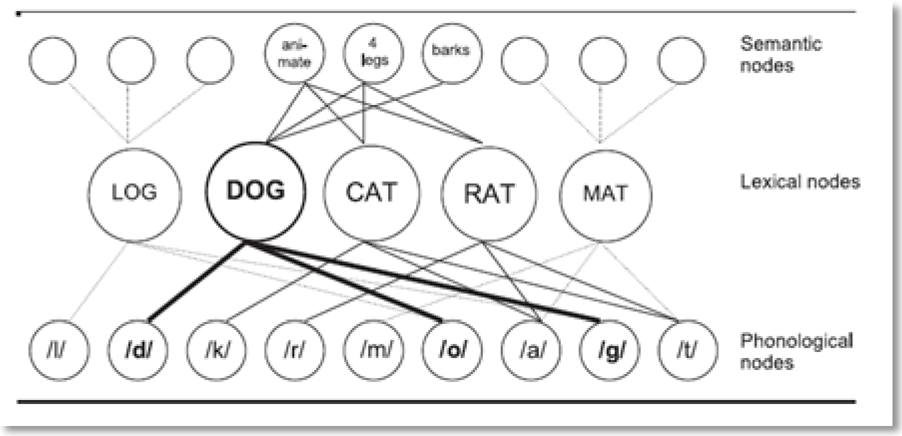

Figure 2.6: Lexical access model by Dell & O'Seaghdha, 1991.Source: Phonological encoding in normal and pathological speech, Psychology Press.

According to Postma and Kolk, a combination of both the factors, i.e., fast rate of speech and slower activation rate contributes to instances of stuttering. Thus, for people who stutter, activation of intended sounds or target (sound) units are delayed or slow to activate than for people who don't stutter. This is thought to result in a longer period of time during which their intended sounds are in competition with other sounds. That is, people who stutter experience a longer period of time during which the sound they intended to select is in competition for selection with other sounds.

The problem arises for the PWS, when the person initiates or maintains speech at a rate faster (i.e. tries to select sounds more rapidly) than the rate at which the slow to activate phonological encoding system makes available appropriate phonological target. This 'mismatch' increases the chances that speech sound selection errors will be made (i.e. sounds other than those intended will be selected). According to this theory, if these errors are detected by the person who stutters, such a detection will result in a self repair or correction, which in turn is perceived by listener as stuttering.

CRH makes use of a monitoring device that checks for the accuracy of speech. But this monitoring takes place as a central or internal function rather than at the output level in the form of auditory or proprioceptive sensory feedback (hence different from feedback models). In this model, monitoring takes place during the formulation of the phonetic plan and prior to the implementation of articulatory commands.

The model proposes that all speakers are able to detect errors in their internal phonetic plan as they internally prepare what they want to say. When errors in the phonetic plan are detected, the speaker interrupts the planning of the phonological sequence in order to make a repair. As a result of this covert repair of errors prior to their production, fluency break occurs. This is the case for any speaker. It is proposed however, the speakers who stutter are impaired in their ability to encode phonological sequences. To summarize, CRH explains that phonological encoding is the process that uses a syntactic representation to derive a phonetic plan that is specific enough to serve as a set of instructions for the articulators (Kolk & Postma, 1997). Thus phonologic encoding is a prearticulatory stage of speech production.

Though there are evidences that support the CRH, Vasic and Wijnen in 2005 stated that the evidence for the CRH is inconclusive. They proposed that the increase in the number of phonological errors errors in PWS is due to something beyond the covert repair of the errors. They attempted to explain the etiology of stuttering using the Levelt's model by proposing the **"Vicious Circle Hypothesis" (VCH).** According to them, as per the Levelt's model, one can assume that the process of monitoring of speech produced by an individual requires attention. Levelt (1983) also stated that repairing of an error is likely to be much higher towards the end of a phrase. The explanation given was that the realization of an utterance requires less attention and hence more resources are thus available to monitor for the errors towards the end of the phrase. This indicates that the amount of attention invested in self monitoring process can vary.

Therefore, Vasic and Wijnen proposed that there are three parameters of attention that are essential for the process of monitoring. They are effort, focus and threshold. Effort refers to the amount of resources available that contribute to monitoring, focus refers to the selective aspect of monitoring and threshold refers to the criteria that the output needs to satisfy in order to be acceptable. In PWS, the effort, focus and threshold are inappropriately set i.e. greater effort is invested in monitoring the speech than is actually required, and that the monitor mainly focuses on temporal fluctuations and discontinuity in speech. Also the threshold for acceptable output is set so high that even the normal and unavoidable discontinuities and temporal fluctuations are also perceived as disfluencies. Therefore, the hypothesis emphasizes on the fact that PWS monitor more vigilantly for the errors in speech and have a lesser threshold for instigating repairs. Such an hyper vigilant monitoring system results in recurrent repairs of even minor sub-phonemic irregularities resulting in unnecessary reformulations of the speech-plan ultimately resulting in a "vicious circle".

Another psycholinguistic theory of stuttering is the **EXPLAN theory by Howell, (2004)** which assumes that speech production involves independent planning and execution processes. Fluency failures such as repetition of prior words, prolongation, pausing and repetitions of parts of the current word occur when the word to be spoken is not ready by the time the execution of the previous word is completed. The theory contributes to explain the behavior of both fluent speakers as well as the speech of persons with stuttering. There are two factors leading to the discrepancy between the planning and execution process, it includes the execution time of the prior word and the planning time of the current word. This theory emphasizes that planning and execution processes reflect the linguistic and motoric aspects involved in speech production. Thus a lack of synchrony between the planning and execution process leads to failure in fluency. The time taken to generate a plan determines whether the speech will be fluent or not. According to the theory, fluent speech will be produced when the execution time is long enough for allowing the plan for the following word to be ready, only then the speech flows in a sequence. But, any problem at the prosodic, lexical or other levels increases the planning time thus affecting the production of fluent speech, i.e, fluency failure occurs mainly because of two reasons: a) The inherent properties of linguistic segments make their planning slow, b) Speech is executed at a high rate. It follows from the EXPLAN account that speakers need more time to prepare the next word when fluency fails. To overcome this problem, a speaker has to gain more time before attempting, or while attempting, a difficult word. One possible way of getting the extra time is to repeat the word before the one that is incomplete (that has already been planned and has just been executed). This assumes that the speaker still has the plan for this word available (Blackmer & Mitton, 1991). Related ways of gaining time would be the repetition of more than one word, or hesitation (using filled or unfilled pauses). Thus, this theory contributes to explain how language combines with speech in fluency control.

Assessment of Phonological Encoding

The theories mentioned above motivated the researchers to investigate the phonological encoding in individuals with stuttering so as to provide an explanation for the probable etiology for the condition. A number of paradigms have been used to investigate the phonological encoding abilities. The paradigms include priming, non word repetition task, phonological awareness tasks, rapid automatic naming tasks experimental manipulation of the phonological complexity of the words, rhyme monitoring paradigm and the phoneme monitoring paradigm. These paradigms have been discussed below.

Priming paradigm

Priming (to prime refers to prepare or to instruct in advance) constitutes a cognitive phenomenon that can be predicated on the establishment of context-based associations between a stimulus and a response. Hence, priming and its modes of operation resemble the mechanisms of classical conditioning, wherein a previously presented stimulus (the prime) cues a response as soon as an associated prime (then called target) is presented to the subject at a second test run. By definition, priming originates in an associative link between two events, whereby an event A increases the probability of the occurrence of an event B. The paradigm requires the participants to read through syllables or words or sentences following which it involves the presentation of successive pairs of test items where the first member of the pair is the prime and the second is the target.

The prime activates the representation in the memory and spreads the activation to the other concepts in the representation. The structure of representation is inferred from the pattern of response latencies of targets compared to the control words. Facilitatory effect is reflected by a shorter latency of the target than for neutral items and longer latencies reflect inhibition.

Priming is not only a cognitive phenomenon reverberating the subconscious information processing and its effects on the brain, but is also implemented as a tool in cognitive science, psychology and psycholinguistics. In these disciplines priming functions as a methodology rendering subliminal mental processes visible and thus, enabling a thorough scientific investigation. However, the paradigm fails to explain the reasons behind the activation for a particular target, and it is also difficult to distinguish between the level of activation and the memory strength. It is so possible that the activation may be too quick to distinguish to be detected by online methods. The task also demands considerable division of labour that is, the person has to read or hear the stimuli and then respond only to the target, which requires a great deal of excitation and inhibition of response. Among the different priming paradigms, most commonly used priming paradigm to evaluate the phonological encoding abilities is the phonological priming paradigm. Several studies have been conducted to assess phonological encoding by employing this paradigm. Some studies have been carried out in both CWS and PWS, some only on CWS and some only on PWS. A few of these studies have been described below:

Studies using the priming paradigm in children and adults with stuttering

Brooks and McWhinney in 2000 conducted a study to investigate developmental changes in the phonological encoding component of the word generation process by studying the phonological priming effects in children and adults using a cross-modal picture-word interference task. Ninety children 30 each in the age range of 4-4.11 to 5-5.11, 6-6.11 to 7-7.11 and 9.5 to 11.9 years and 30 adults were considered. Two experiments were conducted. Pictures of familiar objects were presented on a computer screen and the interfering words were presented via headphones. These interfering words were phonologically related, unrelated, neutral or identical to the target word. Two experiments were conducted. In both the experiments, the reaction times (RTs) for pictures paired with phonologically-related interference words were compared with the RTs for pictures paired with phonologically-unrelated interference words to evaluate the phonological priming effects. In experiment 1, the phonologically related interference words shared onset consonant or the consonant cluster with the names of the target pictures. In Experiment 2, the phonologically related Interference words rhymed with the names of the pictures. In Experiment 1, participants at all ages showed strong onset-based phonological priming at the stimulus onset asynchronies (SOAs) of 0 and +150. However, the SOA yielding the maximum priming effect was delayed in five-year-olds, in comparison to older children and adults indicating that young children required more time to encode interference words before they could impact picture naming. In experiment 2, only the five and seven year old children were influenced strongly by the rhyme based priming, thus indicating that the older children and adults begin to articulate so quickly that the rhyme has little effect. On the other hand, the younger children were still engaged in phonological encoding while they are processing the rhyme of the interference words. The disappearance of the rhyme priming effect with age may reflect the gradual emergence of the onset as an organizing structure in speech production. Thus, it was concluded that the greater weightage to the onset can be viewed as one component of a just-in-time, incrementalist approach to speech production that allows adults to speak more fluently than children. It was also concluded that such a paradigm to be effective in controlling the effect of speech motor planning and execution as the participants verbal utterances remained identical across the conditions.

Studies in children with stuttering using the priming paradigm

Melnick, Conture, and Ohde (2003) conducted a study to evaluate the phonological priming on the speech RT of CWS and CWNS using a picture naming task. Eighteen children in each group in the age range of 3-5 years with stuttering were matched for age and gender with eighteen children with no stuttering. The task required each child to name the white-on-black line drawings of common, age-appropriate objects as quickly as possible in three conditions: a) no prime, b) related prime, c) unrelated prime condition for which the naming latency were obtained. Results revealed that all the children exhibited shorter reaction times in related prime condition compared to no prime condition. Also, the reaction time improved with advancing age for all the children i.e, the 5 year old children had lesser reaction times when compared to 3 year old children. Also, CWNS had a negative correlation between articulatory mastery and reaction time as opposed to CWS, thus indicating that the CWS may have comparatively less developed articulatory systems as opposed to CWNS.

Pellowski and Conture in 2005 conducted a study to investigate the influence of lexical/semantic priming on the reaction time in young CWS and CWNS using a picture-naming task. Twenty three CWS and CWNS in the age range of 3-5.11 years matched for age were considered. The task was naming the 28 pictures presented in three different conditions (a) no-prime condition, (b) related-prime condition, and (c) unrelated-prime condition. The results revealed that the reaction time was shorter in related prime condition when compared to no prime condition in CWNS but an increased reaction time was found in CWS. It was also found that CWNS with higher receptive vocabulary scores had faster reaction times but no such relationship was found in CWS. The study indicated that CWS may exhibit subtle difficulties in lexical encoding and that this difficulty with speech-language planning may be one variable that contributes to childhood stuttering.

In order to investigate the influence of conceptual and perceptual properties of words with respect to speed and accuracy of lexical retrieval of CWS as opposed to CWNS, a study was conducted by Hartfield and Conture in 2006, using a picture naming task. 13 CWS and CWNS in the age range of 3-5 years were considered. The task required each child to name the white-on-black line drawings of common, age-appropriate objects as quickly as possible in four auditory priming conditions: (a) a *neutral* prime consisting of a tone, (b) a word prime *physically* related to the target word, (c) a word prime *functionally* related to the target word, and (d) a word prime *categorically* related to the target word for which the reaction time were measured. Results revealed that CWS were slower than CWNS across all the priming conditions than CWNS and also the speed of lexical retrieval in CWS were more influenced by the functional rather than perceptual aspects of target pictures. It was concluded that CWS tend to organize lexical information functionally more so than physically and that this tendency may relate to difficulties establishing normally fluent speech and language production.

Anderson and Conture (2006) conducted a study to investigate the syntactic processing abilities using a sentence-structure priming paradigm in CWS and CWNS. 16 CWS and 16 CWNS in the age range of 3.3 to 5.5 years matched for age and gender were considered. The task required the children to describe the black on white line drawings of children, adults and animals performing activities that could be appropriately described using simple active affirmative declarative sentences (e.g., "The man is walking the dog"). The prime sentences were counterbalanced for order. Reaction time was measured from the onset of the picture presentation to the onset of the child's verbal response in the absence and presence of priming sentences. Results revealed that CWS had slower reaction times in the absence of priming sentences and greater syntactic-priming effects than CWNS. It was concluded that CWS have difficulty in planning and retrieving sentence-structure units, which contributed to their inabilities to establish fluent speech-language production.

Certain studies have revealed that CWS use an immature form of phonological encoding i.e, holistic processing than the more mature incremental processing. Holistic processing refers to processing at a syllable as the global unit of speech form (Charles-Luce & Luce, 1990; Walley, 1988) whereas incremental processing is defined as the processing the word as individual sounds from beginning to the end of the word (i.e, left to right). Byrd, Conture and Ohde in 2007 conducted a study to investigate the holistic versus incremental phonological encoding processes in young CWS. Twenty six CWS and twenty six CWNS in the age range of 3-5 years matched for age and gender were considered. The task considered was a picture-naming auditory priming paradigm. The children named the pictures in three auditory priming conditions: neutral, holistic and incremental. Speech reaction time was measured from the onset of picture presentation to the onset of participant response. The results revealed that CWNS performed significantly faster in incremental priming condition along with faster reaction times in holistic priming condition whereas CWS had faster reaction times in holistic than in incremental processing task. It was thus concluded that pre-school children CWS appear delayed in making the developmental shift in phonological encoding from holistic to incremental and thus may require additional acoustic-phonetic information to plan and produce faster naming responses as they grow than CWNS.

Studies in adults with stuttering using the priming paradigm

Wijnen and Boer in 1994 conducted a study to investigate the phonological encoding abilities using a phonological priming paradigm in adults with stuttering (AWS). Nine Dutch persons with stuttering (PWS) and nine persons with no stuttering (PNS) in the age range of 20 to 30 years participated in the study. The experiment was divided into two blocks, one in which the initial consonants were primed and one in which the initial consonant and the subsequent vowel were not primed. The task was that the subjects had to utter a prescribed response word following the visual presentation of a cue word. In each block, 5 sets of 5 words sharing the initial consonant or the initial consonant vowel (CV) string respectively were selected as responses. All selected response words were bisyllabic, with primary stress on the first syllable.

Sets of cue-response pairs in which the response words were phonologically similar were called homogeneous sets. Within a homogeneous set, the response words were as phonologically dissimilar as possible, except for the shared initial part, and semantically unrelated. Five heterogeneous sets of five cue-response pairs for each block were constructed by taking one pair from each homogeneous set. Thus, the response words in the heterogeneous sets were phonemically entirely unrelated. The experiment was divided into runs of 25 trials in which words from one set of cue-response pairs were tested. Thus, within a run, each cue-response pair from a particular set occurred five times. Results revealed that PNS had shorter speech onset latencies in the homogeneous conditions than in the heterogeneous conditions, and the difference was larger for the words sharing both consonant and vowel than for the words sharing the initial consonant only. In most PWS, a reduction of speech onset occurred only when the words shared both consonant and vowel. Thus the results indicated that in persons with stuttering the encoding of non initial parts of syllables is delayed and that the SLDs like repetition and prolongation of the initial segments occur as a result of attempting to execute a syllable prior to the incorporation of correct vowel information into the articulatory plan.

Hennessey, Nang, and Beilby (2008) conducted a study to investigate linguistic encoding abilities in PWS. 18 PWS and 18 PNS were considered in the age range of 22 to 65 years. Auditory priming paradigm was considered during picture naming and word vs. non-word comparisons during choice and simple verbal reaction time (RT) tasks. During picture naming, PWS did not differ significantly from normally fluent speakers in the magnitude of inhibition of RT from semantically related primes and the magnitude of facilitation from phonologically related primes. PWS also did not differ from controls in the degree to which words were faster than non-words during choice RT, although PWS were slower overall than controls. Simple RT showed no difference between groups, or between words and non-words, suggesting that differences in speech initiation time do not explain the choice RT results. The findings were consistent with PWS not being deficient in the time course of lexical activation and selection, phonological encoding, and phonetic encoding.

Burger and Wijnen in 2009 conducted a study to test the hypothesis that stuttering occurs as a result of phonological encoding deficit. They attempted to replicate the above study by Wijnen and Boer on a larger group of subjects and new set of stimulus words. The results showed that PNS responded faster than PWS, as they did in the above experiment. Furthermore, the homogeneous condition yielded faster RTs than the heterogeneous condition. Moreover, response words with identical initial CVs primed better than response words with identical initial Cs. The reaction times as a function of the interaction between prime type and condition showed the same pattern in PWS and PNS. Both subject groups benefited from C priming and, to a larger extent, from CV priming. These findings did not support the hypothesis that stuttering is the result of a phonological encoding deficit. This idea underlies the CRH, and thus this hypothesis is not corroborated by this study. In conclusion, in this experiment no evidence was found for the hypothesis that stuttering is specifically related to a difficulty in the phonological encoding of the stress-bearing part of the syllable.

Vincent, Grela, and Gilbert (2012) conducted a study to evaluate the phonological encoding abilities in PWS. Fifteen PWS and age and gender matched fifteen PNS in the age range of 18 to 36 years were considered. Speech onset latency was obtained for both groups and stuttering frequency was calculated for PWS during three phonological priming tasks: (1) heterogeneous, during which the participants' single-word verbal responses differed phonemically; (2) C-homogeneous, during which the participants' response words shared the initial consonant; and (3) CV-homogeneous, during which the participants' response words shared the initial consonant and vowel. Response words containing the same C and CV patterns in the two homogeneous conditions served as phonological primes for one another, while the response words in the heterogeneous condition did not. During each task, the participants produced a verbal response after being visually presented with a semantically related cue word, with cue-response pairs being learned beforehand. Results revealed that PWS had significantly longer speech onset latency when compared to PNS in all priming conditions. Priming had a facilitating effect on word retrieval for both groups, and there was no significant change in stuttering frequency across the conditions for PWS. Thus they concluded that phonological encoding may play no role, or only a minor role, in stuttering.

In order to determine whether the persons with stuttering have issues with their lexical retrieval, a study was conducted by Sindhupriya (2012) conducted a study with the objective of comparing the percentage of syllable stuttered across the two languages Kannada (L1) and English (L2) and the lexical access in bilingual adults with stuttering (BAWS) and without stuttering (BAWNS). They also evaluated the relation between percentage of syllable stuttered and lexical access scores. The study was conducted on fifteen Kannada –English speaking bilingual adults with stuttering and fifteen Kannada-English bilingual adults who did not stutter in the age range of 18 to 26 years, were matched for age, gender and proficiency in L2.The severity of stuttering was determined in both the languages in Kannada and English. The percentage of syllable stuttered was determined in both spontaneous speech and reading tasks, in both the languages. Lexical access was investigated using cross modal priming paradigm in two experiments. The first experiment, the lexical access was investigated within each language wherein, the auditory prime as well as the expected target response was in the same language. Within this experiment, three conditions were included: neutral, related and unrelated priming condition. In the second experiment, the influence of the cross linguistic priming task on lexical access was evaluated using the cross linguistic priming paradigm which involved two order conditions i.e., Kannada to English and English to Kannada. In the first condition, the prime was in L1 and the expected target response was in L2 and in the second condition, it was vice-versa. Totally, three priming conditions were included in both the language orders: translation equivalent, related and unrelated. DMDX software was used to control the presentation of the target picture and auditory prime, and the reaction time was recorded in ms. Randomization and counter balancing of the stimulus presentation was also incorporated. The results revealed that there was a statistically significant difference in frequency of disfluency in L1 and L2 in spontaneous speech task with BAWS stuttering more in L2 than in L1 but such a significant difference was not present in reading task. In experiment1, there was no significant difference in mean speech reaction time (SRT) between BAWS and BAWNS and also there was no significant difference in mean SRT between both the languages and in three priming conditions. In terms of the results obtained in experiment 2, it was found that there was a statistically significant difference in mean SRT between two language orders with L2-L1 language order having a lower mean SRT when compared to L1-L2 language order. The results also revealed that there was no significant relationship between lexical access and percentage of syllable stuttered. Based on the results obtained, it was concluded that BAWS do not differ in terms of their lexical access from BAWNS and thus the deficits may be at the level of syntactic encoding or phonological encoding.

Non word repetition, phonological awareness and rapid automatized naming paradigm

According to Wagner, Torgesen, and Rashotte, (1999) phonological encoding is embedded within the language formulation process and it is very difficult to isolate this process from the rest. Therefore, it is essential to understand and analyze the related processes that serve as a parallel form for the assessment of phonological encoding. Thus according to Wagner et al., (1999), this phonological encoding can be investigated by evaluating the phonological processing abilities of the individual. This process of phonological processing is an umbrella term which in turn includes the following skills: a) phonological awareness b) phonological memory and c) rapid automatized naming (Wagner, Torgesen, & Rashotte, 1999).

Phonological awareness refers to the ability of an individual to combine or break the sounds of the words and can be assessed using tasks such as like phoneme blending, elision, segmentation and phoneme reversal tasks.

Phonological memory refers to the ability of the individual to store the phonological code within the short term memory of the individual prior to the retrieval and can be assessed using a nonword repetition task. It requires the activation of the phonological route for the production of the output and not the lexical route as there is no access to the lexicon required during this task as the lexicon is devoid of phonological, orthographical and semantic information for the non words. Thus, the task requires adequate phonological memory for the storage of the phonemes prior and during the course of production of the non words which is inturn an important aspect influencing the phonological encoding abilities of the individual. Rapid automatized naming which refers to the ability of the individual to retrieve the phonetic information rapidly by converting the orthographic symbols or the pictures into a meaningful string of phonemes.

Several studies have been conducted to assess phonological encoding by employing these paradigms in isolation or in combination in CWS and on PWS. Some of these studies are described below.

Studies in children and adults with stuttering using the non word repetition tasks

Hakim and Ratner (2004) conducted a study to evaluate the nonword repetition abilities in eight CWS and matched eight CWNS in the age range of 4 to 9 years. The stimuli were selected from Children's Test of Nonword Repetition (Gathercole et. al.1994), the nonwords were varying in length (two to five syllables) that had stress on the first syllable. In the four-syllable nonwords, the stress pattern was altered to study the effect of stress position on task performance. The results revealed that CWS performed poorly when compared to CWNS in nonword repetition task which was significant only at three syllable level .Both the groups demonstrated more errors at four and five syllable nonword repetition task as opposed to two and three syllable nonword repetition task. Thus they concluded that the unfamiliar stress patterns considered in the study might have had contributed to the diminished performance in 4 syllable nonword in CWS. Hence they supported the link between phonological encoding and stuttering and highlighted the need for further examining the influence of word stress on phonological encoding in PWS.

A study was conducted by Somy (2008) which aimed at studying the nonword repetition skills in 5-6 year old Kannada speaking CWS and CWNS. The study further aimed at evaluating how the young CWS differ from CWNS in the number of phonemes correct and the number of correct responses produced across both the tasks and also to determine the fluency of responses during the word/ nonword repetition task as the word length increased. The language abilities and the articulatory skills was also studied in order determine whether there exists a relationship between language performance and non word repetition skills and between phonological/phonetic development and nonword repetition skills. Therefore, both the groups were tested for language, articulation, word and nonword repetition skills by the administration of Speech Language Assessment Checklist (Geetha, Jayaram & Swapna, 2007), list of bi-syllabic and tri-syllabic words (comprising of all the base phonemes in the initial position of words taken from Kannada Articulation Test (KAT; Babu et al., 1972), list of bi-syllabic and tri-syllabic nonwords (based on words from KAT) and the responses were transcribed. The results revealed that CWS had poorer scores than CWNS in both articulation and language abilities. In terms of the number of correct responses and in terms of number of phonemes correct, scores obtained by CWS was poorer than CWNS. Overall, it was found that CWS and CWNS had difficulty in nonword repetition task as opposed to word repetition task. It was found that the trisyllabic nonword repetition task was a good indicator to differentiate CWS from CWNS as well as between the severities of stuttering.

Byrd, Vallely, Anderson, and Sussman (2012) conducted a study to evaluate the phonological working memory of PWS by using a nonword repetition and phoneme elision task. Fourteen PWS and matched fourteen PNS in the age range of 17 to 50 years with the mean age range of 28 years were considered. The task was repeating a set of 12 nonwords across four syllable lengths (2-, 3-, 4-, and 7 syllables) constituting a total of 48 nonwords. In the phoneme elision task, same set of nonwords were considered but requiring a particular target phoneme eliminated. Results revealed that PWS were less accurate in the repetition of longest nonwords and required more number of attempts as opposed to PNS in order to produce the nonwords accurately. In the phoneme elision tasks, it was found that both the groups performed poorly as the length of the nonwords increased but there was no interaction between group and syllable length. Thus they concluded that there was a need for additional research for understanding how phonological working memory contributes to the difficulty PWS have in establishment and maintenance of fluent speech.

Spencer and Weber-fox in 2014 conducted a study to investigate the factors that would enable to predict the eventual recovery and persistence of stuttering in CWS. The participants considered were 40 CWS and 25 CWNS in the age range of 3.9 years to 5.8 years. The measures evaluated were the receptive and expressive language abilities, phonological and articulatory proficiencies. The verbal working memory abilities were also investigated. At the initial testing, for both the groups, the receptive and expressive language abilities were determined using Test of auditory comprehension of language, 3rd edition (TACL-3, Carrow-Woolfolk, 1999), and Structured Photographic Expressive Language Test, 3rd edition (SPELT-3, Dawson, Stout, & Eyer, 2003) respectively. In order to determine the articulatory proficiency and the phonological abilities, Bankson–Bernthal Test of Phonology-Consonant Inventory subtest (BBTOP-CI; Bankson & Bernthal, 1990), Nonword Repetition Test (NRT; Dollaghan & Campbell, 1998) were administered. In order to investigate the verbal working memory, Test of Auditory Perceptual Skills-Revised (TAPS-R; Gardner, 1985) auditory number memory and auditory word memory subtests were administered. The assessment of these factors were done in the subsequent years on the groups which persisted with stuttering (children with stuttering persisted, n=19) and recovered from stuttering (children who recovered from stuttering, n= 21). A comparison of the scores obtained on all the measures with that of the scores obtained during the initial testing stage were done on CWS persisted and children who had recovered from stuttering with that of CWNS. The results revealed that CWS persisted performed much poorer than the CWS recovered and CWNS on the measures of articulatory proficiency and nonword repetition task. However, the scores obtained in the receptive, expressive language abilities and verbal working memory tasks did not show much of a difference between CWS persisted and CWS recovered. Based on the binary logistic regression analysis, it was concluded that BBTOP-CI scores and overall NRT proficiency scores can predict the recovery from stuttering. Thus, the study emphasized on the need to assess the articulatory proficiency and the nonword repetition abilities in the preschool years as a part of comprehensive risk assessment for the development of chronic stuttering.

Studies in children with stuttering using phonological awareness tasks

In order to determine the possible factors influencing the persistence of stuttering in the school going CWS, a study was conducted by Yashaswini (2010).The study was conducted with the aim of determining whether there exists a difference in the performance of CWS and CWNS across linguistic and metalinguistic tasks. The study was conducted on thirty CWS and twenty eight CWNS in the age range of 8-12 years which was further divided into four groups: 8-9 years, 9-10 years, 10-11 years and 11-12 years in order to obtain the information about the developmental pattern. The steps involved in the study were determining the severity of stuttering by administering SSI-3 (Riley, 1994). In order to determine the severity in reading task, the reading passage in Kannada was taken from Kannada Articulation Test (KAT) (Babu, Ratna, & Betageri, 1972), for determining the severity in the picture description task, pictures were selected from LPT, to evaluate the linguistic abilities of the children, Linguistic Profile Test (LPT, Karanth, 1980) was administered, and the metalinguistic abilities was assessed by the administration of the subtest Test of Metaphonological skills from Reading Acquisition Profile in Kannada (RAP-K) (Prema, 1997) which included rhyme recognition, syllable stripping, syllable oddity (words), syllable oddity (Non-words), phoneme stripping and phoneme oddity. The study revealed that there was statistically significant difference between CWS and CWNS. CWS performed significantly poorer than CWNS in

10- 11 year age range. There was no statistically significant difference between the CWS and CWNS in the semantic section of LPT.In the metalinguistic tasks, CWS performed poorer when compared to CWNS in 8-9 year age group. In the metaphonological tasks, it was found that CWS in the age range of 8-9 years performed poorer in phoneme stripping and there was a poor performance in syllable oddity in 11- 12 year age group. Overall, it was found that CWS performed significantly poorer on all the metaphonological tasks except in rhyme recognition and phoneme oddity. Thus, it was concluded that CWS performed significantly poorer in syntactic judgement tasks and metaphonological skills.

Pelczarski and Yaruss in 2014 conducted a study to evaluate phonological encoding abilities in five to six year old children with stuttering. Ten CWS and ten CWNS matched for language abilities, gender and maternal education were considered. The tasks included were multiple measures of phonological awareness abilities that is sound matching, phoneme blending and elision tasks. In addition, receptive and expressive vocabulary and articulation were also considered. The phonological awareness subtests from the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotte, 1999) was considered. Based on this, the phonological awareness composite score which is a combination of the standard scores of three subtests: sound matching subtest, blending words subtest, and elision subtest was calculated. The receptive vocabulary was determined by administering Peabody Picture Vocabulary Test–III (PPVT-III, Dunn & Dunn, 1997), the expressive vocabulary ability was determined by administering Expressive Vocabulary Test (EVT, Williams, 1997 and the speech sound abilities was determined by Goldman-Fristoe Test of

Articulation–2 (GFTA-2, Goldman & Fristoe, 2000). Results revealed that CWS performed significantly poor than CWNS in elision and blending tasks. No group differences were seen in sound matching tasks or in any other language measures. Thus, it was concluded that, CWS have subtle, yet robust differences in certain aspects of phonological encoding which inturn contributes to an unstable language planning system.

Studies in adults with stuttering using rapid automatized naming tasks

Newman and Bernstein Ratner (2007) conducted a study to investigate lexical access in adults with stuttering. Twenty five AWS and twenty five adults with no stuttering (AWNS) (8 females and 17 males) with the mean age of 38.2 years and 37.8 years respectively were considered. The participants were matched for age, gender and education. The task mainly aimed at assessing the role of word frequency, neighborhood density and neighborhood frequency in the naming speed, accuracy and fluency. Three sets of word lists were prepared. The first set included two lists of words which differed in word frequency, the second set included two lists of words differing in neighborhood density (number of items in the lexicon that is similar to the target word), the third set included two lists of words that differed in neighborhood frequency (the frequency with which the neighbors are encountered). All the three sets of stimuli were presented in a random manner on the computer screen. Majority of the stimuli considered were nouns and only few were verbs. The participants were required to name the pictures using a single word or to describe the pictures if it were verbs as quickly as possible following the presentation of the stimuli. The verbal responses were recorded and the reaction time was also obtained, and the stuttering episodes were also determined based on the recorded response obtained. Coding of the responses was done to determine the accuracy. The results revealed that there was same effect of lexical factors in naming in AWS as that of AWNS, but however, AWS performed much poorer in terms of the accuracy of responses. It was also found that the stuttering rate was influenced by word frequency and not the other factors. Thus based on the results obtained it was concluded that AWS had a fundamental deficit in lexical retrieval, however this could not be attributed to deficits at the level of the word's abstract phonological representation.

Bernstein Ratner, Newman, and Strekas (2009) used a paradigm similar to the one used by them previously in 2007 to evaluate the lexical retrieval abilities in AWS. The study aimed at investigating how the lexical factors i.e. word frequency, neighborhood density and neighborhood frequency contribute to affect the naming latency, accuracy and fluency. The study was conducted on fifteen CWS and fifteen CWNS (3 females and 12 males in each group) in the age range of 4 years to 16 years matched for age and gender were considered. The stimuli considered for the study were three sets of word lists. The first set included two word lists which differed in word frequency, the second set included two lists which differed in neighborhood density and the third list included two lists which differed in neighborhood frequency. Majority of the stimuli considered were nouns and only few were verbs. The children were required to name the pictures using a single word or to describe the pictures if it were verbs as quickly as possible following the presentation of the stimuli. The verbal responses were recorded and the RT was also obtained, and the stuttering episodes were also determined based on the recorded response obtained. Coding of the responses was done to determine the accuracy. The results revealed that there was same effect of lexical factors in naming speed and fluency. Unlike the previous study it was also found that there was no difference seen even in terms of the accuracy of responses between the two groups. Thus based on the results obtained in the current study and the previous study it was concluded that there is no involvement of atypical phonological organization in individuals with stuttering.

Studies in adults with stuttering using all the three paradigms viz. phonological awareness, non word repetition and rapid automatized naming

Pelczarski in 2011 conducted a study to evaluate the phonological processing abilities of persons with stuttering. Nineteen PWS and nineteen PWNS matched for age, gender and education were considered. The tasks employed in the study included: phonological awareness tasks, tasks to assess phonological memory and rapid automatized naming. These tasks were included with the assumption that phonological encoding abilities in PWS can be evaluated using these three tasks. Therefore, phonological awareness was evaluated using phoneme elisions, blending, phoneme reversals and word segmentation tasks from Computerized test for phonological processing (CTOPP, Wagner, 1999). In this task, only accuracy of responses was considered. In addition to evaluate the phonological awareness in the absence of lexical knowledge, phonological awareness tasks with non word stimuli which included blending and segmenting non words were considered. In order to evaluate non verbal phonological awareness abilities, silent phoneme blending was included, wherein both RT and accuracy were obtained. Phonological memory was evaluated using two subtests from CTOPP viz. memory for digits and non word repetition task. Rapid automatic naming was evaluated using rapid object, color naming, letter naming and digit naming. Results revealed that performance of PWS was comparatively reduced in the phonological awareness tasks which was actually getting masked with the real word stimuli but was obvious with the non word stimuli. With respect to the phonological memory, PWS performed significantly poorer than the control group on the non word repetition tasks compared to the digit naming task, thus indicating that PWS have a over reliance on the lexical knowledge to complete the phonological memory tasks. In rapid automatic naming tasks, PWS performed significantly poorer for color and object naming tasks but not for digit and letter naming tasks. It was found that though there were differences present between PWS and PWNS in the phonological processing tasks, these differences were not statistically significant that is majority of the scores did lie within the normal limits across both the groups. Thus it was concluded that phonological encoding in PWS may be just one of the contributing factor among the various other factors i.e., speech motor planning, temperament and various other linguistic factors for stuttering that can in turn lead to an unstable speech system.

Experimental manipulation of phonological complexity of the words

Such a paradigm requires the participants to produce words or sentences which are usually controlled for number of syllables or words, length of the utterance and the syntactic structure. Such a paradigm enables one to evaluate the process of phonological encoding in a more structured manner. That is, one can gain an understanding as to how the process of selection and retrieval of the phonemes happens when the stimuli is controlled without any other intervening variables like sentences of varying length, words with highly variable structures, words with different stress patterns and its effect on the performance of the individual. Such a stimuli would inturn affect the performance but will make the results obtained being highly variable.

Such paradigms have thus been employed by various researchers to indirectly investigate this obscure aspect of phonological encoding abilities of the individual. The paradigms do contribute to draw inferences regarding the probable role of phonological encoding in general but not in specific as it involves the production of speech overtly which inturn is the outcome of several underlying processes like lexical retrieval, phonological and grammatical encoding, and articulation. Thus it fails to explain at what level exactly within the language formulation system there is phonological encoding but it gives rather a more holistic view. That is there are various other factors which can influence the production of the language output like lexical retrieval, word familiarity, frequency effects and motoric execution of speech at the level of articulators.

Thus employing such paradigms to evaluate phonological encoding in specific might not really give a true picture of the process. Especially when it comes to evaluating the speech of individuals with obvious deficits at the level of execution like stuttering, one fails to demarcate whether the performance of the individual has deteriorated due to deficits in language in general and phonological encoding in specific from those due to deficits at the level of speech execution. A few studies have been conducted to evaluate phonological encoding in CWS and PWS through the experimental manipulation of phonological complexity and their effect on the task performance has been analyzed. Some of these studies are described below.

Studies using experimental manipulation of phonological complexity in children and adults with stuttering

Postma, Kolk, and Povel (1990) conducted a study to evaluate the importance of speech planning and execution process in speech of persons with stuttering. Nineteen PWS (16 males and 3 females) in the age range of 20 to 42 years and nineteen PNS (16 males and 3 females) were considered in the age range of 21 to 47 years. The severity of stuttering ranged from moderate to severe. The task considered was reading ten control sentences which were matched for number of words, syllables and syntactic structure and ten tongue twisters in three tasks, that is, overt, lipped and silent reading of these sentences. The sentences were presented on the computer screen and each sentence had to be repeated quickly and accurately for 5 times i.e., they had to press the mouse button after each repetition. Time between the presses was registered by the computer and was taken as an estimate of how long the individual takes to complete each of these sentences. The participants were explicitly instructed to not move their articulators, and to keep their mouths closed and their tongues still during the silent reading task. The experimenter checked whether no movement was indeed visible. The sentences were counterbalanced over subjects within each group. Results revealed that PWS were slower in silent reading as opposed to lipped and overt reading task indicating that PWS require increased speech planning times. Further their performance was much slower in lipped and overt speech tasks when compared to PNS indicating that they had an extra amount of difficulty with respect to the motor execution task. They concluded that silent speech is the task which involves phonological encoding (Dell, 1980; Locke, 1978; McCutchen & Perfetti, 1982; Smith, 1986) thus a deficit in this process can be assumed in PWS. The differences in lipped speech task which differed primarily from overt speech task in terms of reduced phonatory functioning indicated that in PWS, even in the absence of phonation, disfluencies do exist and thus the performance in the overt speech task will be definitely reduced due to deficits in speech motor execution. It was suggested that the results of the study has to be interpreted with caution as the three tasks i.e., silent, lipped and overt reading tasks involved a variety of cognitive processes like semantic, syntactic and speech motor planning.

Yet, in another study, Howell, Au-yeung, and Sackin (2000) investigated the effect of phonologically complex sounds such as consonant clusters (CC) and late emerging consonants (LEC) on the frequency of stuttering across different age groups. The study considered fifty-one English speaking participants in the age range of 3-11 years, 12-18 years, and > 18 years. Detailed evaluation was carried out to assess the frequency of usage of LEC and CC over age groups depending on whether and where these factors occurred in the content words. All nine combinations of no LEC, word-initial LEC, non-initial LEC with no CC, word-initial CC, and non-initial CC were examined. Usage of certain of these nine categories varied over age groups. Results revealed that in the younger age groups, greater frequency of stuttering on LEC and CC in function words when compared to older age groups. The percentage of disfluencies was more in the older age group when both LEC and CC occurred in the word initial position as opposed to the other positions. The results of this study revealed two important factors, i.e., the LEC and CC have an impact on the likelihood that a word will be stuttered or not and the effect thus depends on the age of the speakers who stutter. It also indicated that such an effect can only be seen in content words and at word initial positions but not in function words. It also supported the fact that why CWS have more problems with function words as opposed to AWS.

A study was conducted by Sweta (2012) in order to determine the phonological processing and speech motor control in bilingual adults with stuttering and to compare it with age matched adults. The tasks included a, non word repetition and tongue twister repetition task. The study was conducted on fifteen Hindi-English speaking BAWS and BAWNS in both the groups in the age range of 18 to 30 years. The study aimed at determining how the adults with stuttering differed from adults with no stuttering in reaction time and total duration on non word repetition compared to word repetition task of bi and trisyllabic lengths in Hindi (L1) and English (L2). The study also aimed at comparing the number of correct responses, speech errors, stuttering like disfluencies and other disfluencies produced on non word as opposed to true word repetition task. The additional objectives of the study were to determine the differences in the correct responses and fluency of response as the word or the non word length increased in either of the languages in the tasks of word and non word repetition. Tongue twister repetition task in both the languages was also considered and the number of errors and frequency of errors was also determined to evaluate whether there exists any possible relationship between phonological processing/ speech motor control and non word repetition/ tongue twister repetition skills. The study included two experiments. In the experiment 1, both the groups were tested for word and non word repetition skills, wherein the reaction time and accuracy and total duration was determined by transcribing the response and experiment 2 involved tongue twister repetition task wherein frequency of errors in both the languages was determined. The study revealed that in the word and non word repetition task, in terms of the fluent response, the performance of AWS was poor when compared to AWNS in the number of correct responses. With respect to the lengths, types of words and the language, both AWS and AWNS had problems in repetition of trisyllabic compared to bisyllabic words and non words when compared to words. No language effect was seen in this task. It was thus concluded that the trisyllabic non word repetition task to be good indicator for the phonological processing and speech motor control across both the groups. In the tongue twister repetition task, both the groups had a breakdown in fluency with the increase in motoric complexity. AWS produced more stuttering like disfluencies compared to AWNS who produced more speech errors. More number of errors were found in L2 than in L1 thus indicating a language effect.

Rhyme monitoring paradigm

Another paradigm which can account for phonological encoding is the **rhyme monitoring paradigm.** The paradigm requires the participants to judge whether the cue word they listened prior, rhymes with that of the target word. It uses the terminal segments of the words serving as a cue to decide on the rhyming aspects of the target word. It is a paradigm commonly used in the investigation of auditory word recognition. It provides the information regarding how the lexical information is accessed, however the results are affected by the phonological priming effects. This is because the judgement is made depending upon whether the final segment of the cue word is phonologically identical to that of the final segment of the target word. Because of this, the paradigm can be used to evaluate phonological encoding abilities of the individual. Few studies have also been conducted to evaluate phonological encoding using the rhyme monitoring paradigm which have been described below.

Studies using the rhyme monitoring paradigm in adults with stuttering

Bosshardt and Fransen (1996) conducted a study to investigate whether during silent reading task, PWS encode phonological and semantic information more slowly when compared to PWNS. They also investigated how the syntactic context of the stimulus sentences influenced the speed of coding. Fourteen PWS and fourteen matched PNS were considered for the study. A self paced word by word reading experiment were considered and during the silent prose reading task. The participants had to monitor the target words which were specified before the presentation of the text. This cue word (in upper case letters) was briefly displayed on the screen before starting and participants were asked to monitor the text that appeared one word at a time in lower case letters. The target words to be monitored were phonologically similar, categorically related, or identical to the cue word. For instance, monitoring for semantic categories (e.g., fruits) while silently reading prose (e.g., At the market there is much to find. A women gives a pear to a little girl). The influence of syntactic information on the word-monitoring reaction time was studied by presenting the text either as a normal prose, in a syntactically correct but semantically anomalous condition or in a random word order. Therefore, judgements thus included the translation of graphemic representations into corresponding phonological forms and identifying whether they rhyme with the target or accessing the meaning of words. The results revealed that the two groups were not different with respect to the speed of identical word identification and made similar number of errors. No significant differences were present in identifying the rhyming target words but it was found that PWS were significantly slower in the semantic monitoring task when compared to PNS. Hence, they concluded that both the groups were equally efficient at lexical access and phonological encoding and that the PWS were slow at semantic processing. However there was a considerable overlap between the two groups in terms of the recognition time scores for semantically similar words. Thus they concluded that delayed phonological or semantic processing can be considered as an important factor for stuttering.

Weber-Fox, Spencer, Spruill, and Smith (2005) conducted a study using rhyming paradigm combining event related potentials (ERPs) and behavioural measures to examine the phonological processing in adults with stuttering. Eleven PWS and matched eleven PNS were considered for the study. The task required the participants to judge whether the pair of words presented orthographically rhyme or not. Pairs of orthographically presented words were either orthographically similar (e.g., wood–hood) or dissimilar/incongruent (e.g., cone–own); half rhymed and half did not. ERPs, judgment accuracy, and RTs were obtained. Results revealed that PWS and PNS exhibited similar phonological processing abilities as indexed by the ERPs, response accuracy and reaction times. But relatively longer reaction times for PWS indicated their greater sensitivity to the increased cognitive loads imposed by phonologic/orthographic incongruency. Also, unlike the normally fluent speakers, the PWS exhibited a right hemisphere asymmetry in the rhyme judgment task, as indexed by the peak amplitude of the rhyming effect (difference wave) component. Thus they concluded that these findings do not support the theories of stuttering which propose a deficit in phonological processing abilities and rather suggest that these individuals are more prone to increased cognitive loads and display greater right hemisphere involvement in late cognitive processes.

In addition to the above paradigms, another paradigm that is considered to be effective in evaluating the phonological encoding abilities is the phoneme monitoring paradigm.

Phoneme monitoring paradigm

Whether it is spoken/written language comprehension, there are several levels of analysis involved in the process which include recognition of phonemes, recognition of the words created, syntactic processing and comprehension of the sentences and finally the integration of the sentences into coherent messages. One of the reaction time measures that is involved in the spoken language recognition/ written language recognition is the phoneme monitoring paradigm. This is a dual task paradigm which is mostly used to study the attentional processes. This paradigm is based on the assumption that a) individuals have a limited processing capacity and b) different cognitive activities make use of different resources. For instance, participants can be made to read sentences while listening to a tone. If the response time gets slower, then it indicates that both the tasks draw the same cognitive resources and the rate of slowness in the performance in turn indicates the degree of resource usage. In the phoneme monitoring paradigm, the participants have to monitor for the presence of certain target phonemes in the words or the sentences presented auditorily. Thus, this task in turn requires the participants to perform two tasks; they are comprehending the word/ sentence and then detecting the presence of target phoneme by pressing a button. Such a paradigm has been predominantly used in evaluating the syntactic processing abilities, lexical ambiguity and the attentional issues.

Such a paradigm was used to study the phonological encoding abilities in persons who do not stutter (Wheeldon & Levelt, 1995; Costa, Sebastian- Galles, Pallier, & Colome, 2001; Wheeldon & Morgan, 2002) and in CWS (Sasisekaran et al., 2006, 2013 & 2014). The assumption behind the paradigm is that the participants rely on prearticulatory monitoring of the output of phonological encoding to provide a phoneme monitoring response (Levelt, 1989; Wheeldon & Levelt, 1995). Phoneme monitoring task is undertaken to study phonological encoding in PWS as the studies in the past have revealed that the time course for phoneme monitoring task in the silent speech parallels the time course of phonological encoding (Wheeldon & Levelt, 1995; Costa et al., 2001; Wheeldon & Morgan, 2002) supporting a left to right incremental encoding process (Levelt, 1989; Levelt et al., 1999). Moreover silent naming eliminates the overt speech production which is beneficial for persons with stuttering wherein the overt speech motor processes would otherwise interfere with the interpretation of the results. Several studies have been conducted to assess phonological encoding by employing this paradigm. Some of these studies have been in CWS and some in PWS which have been described below.

Studies using phoneme monitoring paradigm in children with stuttering

Sasisekaran and Byrd in 2013 conducted a study to investigate segmentation and rhyme abilities which are considered critical for phonological encoding in children with stuttering (CWS). Nine CWS (8 males and 1 female) and matched CWNS in the age range of 7 to 13 years were considered. The tasks performed by the participants were verbal monitoring tasks: phoneme monitoring and rhyme monitoring tasks in silent naming. Mainly, the experiment was divided into four tasks, 1) picture naming, (2) phoneme monitoring, (3) rhyme monitoring, and (4) tone-sequence monitoring. The picture naming task involved the presentation of the target pictures (twenty-eight monosyllabic high frequency nouns were the target items) which were black and white line drawings on the computer screen and it was conducted to familiarize the participants with the target stimuli. In phoneme monitoring task, the participants had to monitor for the presence of the target phoneme in the picture of the target word presented by pressing the button as quickly as possible to indicate whether the phoneme was present or not in the target word. Further, the complexity of the phoneme monitoring task was varied such that participants had to monitor for singletons vs. consonant clusters. Similarly, in the rhyme monitoring task, a nonword was presented auditorily following which the picture of the target word was presented and the participants were expected to judge whether the two stimuli rhymed or not by pressing the button as quickly as possible. The tone monitoring task involved presentation of two tones auditorily via the headphones and judging whether the two tones were same or different. The results revealed that there were no group differences in all the three monitoring tasks but however it was found that there was slower monitoring for consonant clusters in CWS as opposed to CWNS. Thus they concluded that there was no deficit in terms of segmentation or rhyming abilities in CWS though there was some preliminary evidence of segmentation difficulties with increasing phonological complexity of the stimuli in CWS.

Sasisekaran, Brady, and Stein in 2013 conducted a study to investigate phonological encoding abilities in CWS. Nine CWS age and gender matched with nine CWNS in the age range of 10 to 14 years were considered. The experiment consisted of four tasks: simple motor task, a picture familiarization and naming task, a phoneme monitoring task, and an auditory tone monitoring task. Familiarization task was conducted before the phoneme monitoring task wherein the target pictures (twelve bisyllabic nouns (CVC(C) CVC, CVCCCV) were the stimuli for the picture naming task. All target words had the stress placed on the first syllable and carried target consonants at the onset and offset of each syllable. The pictures were presented in the form of black and white line drawings on the computer screen and the participants had to name them overtly as quickly and accurately as possible. This was done with the premise of confirming that they use an appropriate target name to monitor the phonemes in the phoneme monitoring task. In the phoneme monitoring task, the participants were expected to monitor for the presence of target phonemes (/t/, /k/,/d/,/n/,/f/,/l/, and /r/) in the target pictures presented by manually pressing a button as quickly and accurately as possible. The simple motor task was done with the premise of understanding how quick the participants were in the execution of a simple motor response. Here, a 500 Hz pure tone of 550 ms duration was presented with varying inter stimulus interval of the blank screen, the task was that the participants had to press the button as quickly as possible the moment they hear the target tone. Finally, the auditory tone monitoring task was done with the rationale of ruling out any general auditory tone monitoring deficits in both the groups. In this task, a sequence of four pure tones were presented such that the 1 KHz tone occurred in 4 different positions in a sequence of 4 pure tones of which the remaining three stimuli were tones of 500 Hz. The overall length of each tone sequence was matched to the average length of the target bisyllabic words in the experiment as produced by a native English speaker and measured using PRAAT. The participants were required to give a "yes" or "no" response for the presence and the absence of the target tone in the sequence respectively as quickly as possible through manually pressing a button. Results revealed that CWS were significantly slower in the reaction time as opposed to CWNS in the phoneme monitoring task. But the two groups did not differ in terms of their reaction time and accuracy of responses in simple motor task and auditory tone monitoring task. Thus they concluded CWS do have temporal asynchronies in one or more processes leading to phoneme monitoring and hence they supported the theory on etiology of stuttering that it occurred as result of deficits in phonological encoding.

Studies using phoneme monitoring paradigm in adults with stuttering

Sasisekaran and De Nil in 2006 conducted a study to investigate the phonological encoding skills in adults with stuttering. Ten PWS age, gender and handedness matched with twelve PNS in the age range of 18 -48 years were considered with the mean age of PWS and PNS being 31.8 years and 24.3 years respectively. The task included a familiarization task, phoneme monitoring in silent and phoneme monitoring in auditory perception task. The stimuli considered in the study were words of different levels of phonological complexity i.e, two types of stimuli: compound words (e.g., /greenhouse/, stress on first syllable) and noun phrases (e.g., /green house/, primary stress on second syllable and secondary stress on first syllable) and a total of seven compound words and seven noun phrases were bisyllabic (CVCCVC) and balanced for the positions in which the target phonemes were located were considered. The target phonemes to be monitored occurred in either the first or the second syllable offset position of all target items. Familiarization task was conducted before the phoneme monitoring task and the target pictures in the form of black and white line drawings were presented on the computer screen and the participants had to name them overtly as quickly and accurately as possible. This was done with the premise of confirming that they use an appropriate target name to monitor the phonemes in the phoneme monitoring task. In the phoneme monitoring through silent naming task, the participants were expected to monitor for the presence of target phonemes in the target pictures presented on the computer screen by manually pressing a button as quickly and accurately as possible. In the phoneme monitoring in the perception task, the participants were expected to monitor for the phonemes in the same target words presented auditorily via the headphones. This task was conducted with the premise of ruling out any general monitoring deficits in both the groups. Results revealed that PWS were significantly slower than the PNS in phoneme monitoring in silent naming, but no such difference was found in the perception task. The groups were also comparable in the response time to phoneme monitoring within compound words and noun phrases in both silent naming and perception. The findings suggested that PWS were slower in the encoding of segmental, phonological units during silent naming. Furthermore, absence of such differences in perception ruled out a general monitoring deficit in PWS. Thus they concluded that phonological encoding and/or monitoring is a causal variable in stuttering.

Sasisekaran, De Nil, Smyth and Johnson in 2006 conducted a study to investigate the phonological encoding skills in the silent speech of PWS. Ten PWS and age, gender and handedness matched ten PNS in the age range of 18 to 49 years with mean age of PWS and PNS being 30.4 years and 30.1 years respectively were considered. The stimuli considered were 14 single morpheme, bisyllabic (CVCCVC) words chosen from the Ku era and Francis database (1967). All target words with the stress placed on the first syllable were considered. The words were depicted as black and white line drawings, which were shown to all participants in the picture naming and phoneme-monitoring tasks. The tasks considered were a familiarization task, an overt picture naming task, a task of self-monitoring target phonemes during concurrent silent picture naming, a task of monitoring target pure tones in aurally presented tonal sequences, and a simple motor task requiring finger button clicks in response to an auditory tone. Familiarization task was conducted before the phoneme monitoring task and the target pictures in the form of black and white line drawings were presented on the computer screen and the participants had to name them overtly as quickly and accurately as possible. This was done with the premise of confirming that they use an appropriate target name to monitor the phonemes in the phoneme monitoring task. In the phoneme monitoring through silent naming task, the participants were expected to monitor for the presence of target phonemes in the target pictures presented on the computer screen by manually pressing a button as quickly and accurately as possible. Phonemes to be monitored occurred in one of four target positions, C1VC2C3VC4 (e.g., b1as2k3et4) within each of the 14 bisyllabic words. In auditory tone monitoring task, a sequence of four pure tones were presented such that the 1 KHz target tone occurred in 4 different positions in a sequence of 4 pure tones of which the remaining three stimuli were tones of 500 Hz. The participants were required to give a “yes” or “no” response for the presence and the absence of the target tone in the sequence respectively as quickly as possible through manually pressing a button. This task was included so as to rule out any general monitoring deficit in the two groups. The simple motor task was done with the premise of understanding how quick the participants were in the execution of a simple motor response. Here, a 500 Hz pure tone of 550 ms duration was presented with varying inter stimulus interval of the blank screen, the task was that the participants had to press the button as quickly as possible the moment they hear the target tone. Results indicated that PWS were significantly slower in phoneme monitoring compared to PNS. No significant between-group differences were present for reaction time during the auditory monitoring, picture naming or simple motor tasks, nor did the two groups differ for percent errors in any of the experimental tasks. Thus they concluded that there is specific deficiency at the level of phonological monitoring, rather than a general monitoring, reaction time or auditory monitoring deficit in PWS.

Garnett and Ouden in 2013 conducted a study to investigate the phonological encoding abilities in PWS and persons with cluttering (PWC) using the phoneme monitoring paradigm. The participants considered were seven PWS, fourteen PWC and nineteen controls in the age range of 25years to 30 years. Participants were matched for age. The participants had to perform three tasks i.e. phoneme monitoring, auditory monitoring and simple motor task. The phoneme monitoring task required the participants to monitor a particular phoneme among the following target phonemes: /p/, /t/, /k/, /b/, /d/, /g/, /m/, /n/, /s/, /ʃ/, /r/, /l/, /f/, /v/ in the name of the picture presented by silently naming the picture. A set of 28 bisyllabic words were considered with the target phoneme occurring in one of four positions C1VC2C3VC4. Prior to the silent naming task, a familiarization task was also conducted. Auditory tone monitoring task required the participants to monitor for the target pure tone in the sequences of 4 tones presented so as to evaluate the general auditory monitoring abilities of the individual. A simple motor task was also conducted which required the participants to press the spacebar as soon as possible on hearing the tone so as to rule out differences in basic motor responses. The results revealed that the reaction time in phoneme monitoring task was longer in PWS but however there was no difference in the reaction times in PWC and controls. In terms of accuracy, PWS made significantly more errors than controls and PWC. The performance of all the three groups with respect to reaction time and accuracy for auditory tone monitoring task and simple motor task were comparable. Based on the results obtained, it was concluded that PWS do have a deficit in phonological encoding. Since both the reaction time and accuracy of responses was poorer in phoneme monitoring task in this group, they supported both covert repair hypothesis and vicious circle hypothesis of stuttering. They also concluded that PWC do not have a deficit in phonological encoding.

Thus, a thorough review of the literature in order to evaluate the relation between the linguistic aspects and stuttering in general indicates that there is indeed a significant relationship between the two factors. The findings of the various studies evaluating the phonological encoding abilities in individuals with stuttering in an attempt to understand the psycholinguistic theories of stuttering have yielded mixed results in both children and adults with stuttering. Several paradigms have been used to assess the phonological encoding abilities of an individual. Among these paradigms, studies using the priming paradigm to evaluate the phonological encoding abilities in CWS have supported the fact that there is a deficit in phonological encoding in CWS. However, the use of the same paradigm, in adults with stuttering has yielded mixed results. Such inconclusive findings are consistent with the investigations done using other paradigms like rhyme monitoring and non word repetition tasks in adults with stuttering. None of these paradigms have pin pointed the presence of phonological encoding deficits as the cause for stuttering but rather identified phonological encoding to be one among the various other factors to be contributing to stuttering. Such a finding is also found using the phonological awareness tasks. But majority of these paradigms fail to evaluate the phonological encoding abilities in specific. However, one of the paradigm, the phoneme monitoring paradigm tries to specifically target the phonological encoding abilities in these individuals and the results of the studies using this paradigm have supported the fact that there is a phonological encoding deficit in adults with stuttering. Thus, in order to determine whether the same is true with respect to the Indian context in general, and Kannada speakers in particular, the phoneme monitoring paradigm was used and the present study was conducted. The study contributes to unravel, the information regarding the causal variables for stuttering. This will also help in providing the information regarding the linguistic factors that influence stuttering. The results of the study would enable to support or disprove the psycholinguistic theories of stuttering. The study also would help direct future Evidence Based Practice (EBP) by allowing the clinicians to assess and treat the areas of weakness and utilize strengths in phonological encoding abilities.

Chapter 3

Method

The current study was designed to investigate the phonological encoding abilities in adults with stuttering using the phoneme monitoring paradigm. The study was undertaken in two phases:

Phase I: Preparation of the stimulus material

Phase II: Administration of the material developed on both the groups

Participants: Twelve adults with stuttering in the age range of 18-25 years, 11 males and 1 female with native language Kannada participated in the study. They formed the clinical group. They were diagnosed as ‘stuttering’ by experienced speech-language pathologists based on the ratings obtained on the Stuttering Severity Instrument (SSI Version 3, Riley, 1994). The severity was calculated based on frequency (included job task and reading task), duration of disfluencies (duration of three longest blocks) and physical concomitants exhibited by these adults. Among them two had mild degree of stuttering, 6 had moderate degree and 4 had severe degree of stuttering. They were screened for problems in voice, articulation, and language. Oral mechanism examination and hearing screening was also carried out to rule out any abnormality. The participants were recruited from the Department of Clinical services, All India Institute of Speech and Hearing, Mysore. Table 3.1 depicts the demographic details of the clinical group considered for the study.

Inclusion criteria for the clinical group:

- Individuals who were right handed with no neurological, intellectual, sensory (vision and hearing) or other communication disorders.
- Individuals with developmental stuttering.

Twelve age and gender matched persons with no stuttering comprised the control group. They were matched with the clinical group for their socioeconomic status using the NIMH socioeconomic status scale developed by Venkatesan (2009). The scale has sections such as occupation, education, annual family income, property, and per capita income to assess the socioeconomic status of the participants. All the participants considered had Kannada as their mother tongue and were randomly recruited from both urban and semi urban areas around Mysore. Individuals who were right handed with no history of sensory, neurological, communicative, academic, cognitive, intellectual or emotional and orofacial abnormalities were included in the control group.

To rule out the group differences in vocabulary and short term memory, vocabulary subtest from Manual for Adult Aphasia Therapy in Kannada (MAAT-K, Goswami, Shanbal, Navitha,Chaitra & Ranjini, 2011) and working memory subtests from Cognitive Linguistic Assessment Protocol For Adults (CLAP, Aruna Kamath, 2001) were administered as a part of screening procedure. To screen for their phonological knowledge, subtests to assess metaphonological skills from Reading Acquisition Profile-Kannada (RAP-K, Prema, 1997) were administered for persons in both the groups. Those individuals who passed the screening tests in all the aspects mentioned above, were only included in the study.

Ethical procedures were considered to select the participants, that is, the participants were explained about the purpose and the procedures of the study and an informed verbal consent was also obtained.

Table 3.1: *Demographic details of the clinical group.*

Clinical group	**Age/Gend**	**Severity stuttering**
S1	18 y /M	Mild stuttering
S2	19 y/M	Moderate stuttering
S3	20y/M	Moderate stuttering
S4	20y/M	Moderate stuttering
S5	21y/F	Severe stuttering
S6	21 y/M	Severe stuttering
S7	21y/M	Moderate stuttering
S8	21y/M	Moderate stuttering
S9	22y/M	Mild stuttering
S10	24 y/M	Severe stuttering
S11	25 y/M	Severe stuttering
S12	25y/M	Moderate stuttering

Phase I: Preparation of the stimulus material

a) **Stimulus preparation:** The target phonemes considered for the study were /p/,/t/,/k/,/b/,/s/,/m/,/t/, /r/ and /h/ which were finalized through a review of case files of adult Kannada speakers with stuttering who reported to the Department of clinical services, All India Institute of Speech and Hearing, Mysuru with the presence of phoneme specific disfluencies in their speech. Using these phonemes, 27 trisyllabic (CVCVCV) picturable words in Kannada were selected which formed the target words. All these words had the target phonemes in the initial, medial or in the final position of the word. Each target word was picturized. These pictures were given for validity check to five experienced SLPs. They were asked to check the validity of the pictures on the basis of naturalness, size and representation of the target word. A three point rating scale was used to obtain the feedback in which '0' represented no similarity of the picture with the target word, unnatural and of inappropriate size and '2' represented complete similarity with the target word, very natural and of appropriate size. Following the validity check, two pictures received a score of 0, twelve pictures received a score of 1, and thirteen pictures received a score of 2. The fourteen pictures which received a score of 0 and 1 were replaced based on the suggestions provided by the SLPs. The final list of target phonemes and words have been provided in the appendix.

b) **Instrumentation:** For recording the target phonemes and words used, a native Kannada adult male speaker was selected. The phonemes and the words were recorded in PRAAT software (Version 5.3) in a sound treated room at an appropriate intensity. For the presentation of the target pictures, phonemes to be monitored, and the recording of the manual responses in the computer, DMDX software (Version 4) was used.

c) **Design of the experiment:** In the present study, a phoneme monitoring paradigm was considered. Using this paradigm the following, two experiments were designed.

Experiment 1: Phoneme monitoring in silent naming and

Experiment 2: Phoneme monitoring in auditory perception

The experiment 1 was primarily designed to investigate the phonological encoding abilities whereas; the experiment 2 was conducted with the premise of identifying deficits in auditory perception in either of the groups.

Experiment 1: Phoneme monitoring in silent naming

The main purpose of this experiment was to evaluate the phonological encoding abilities by measuring the reaction time (in ms) and accuracy in monitoring the phonemes in target words during the silent picture naming. Here, the phonemes to be monitored occurred in one of the three target positions (initial, medial and final) in each of the 27 trisyllabic words. The target words were assigned in two blocks. In each block, each target word occurred twice (once with the target phoneme, thus requiring a ‘yes’ response and once without the target phoneme requiring a ‘no’ response) for a total of 54 per block. Thus, the total number of phonemes a person heard in this experiment was 108. Within and across the blocks, the target words and pictures were randomized. The order of the blocks was also counterbalanced across the participants.

In this experiment 1, prior to the presentation of each picture on the computer screen, the phoneme to be monitored was presented auditorily. This was followed by an inter stimulus interval (ISI) of 500 millisecond (msec) and then by an orienting pure tone of 500 Hz for 500 msec. The target picture followed the orienting tone. This was programmed on the DMDX software. The participant was expected to indicate through a 'yes' response if the target phoneme was present and 'no' if the target phoneme was not present. The following description and pictorial representation indicates the programming of DMDX for this experiment.

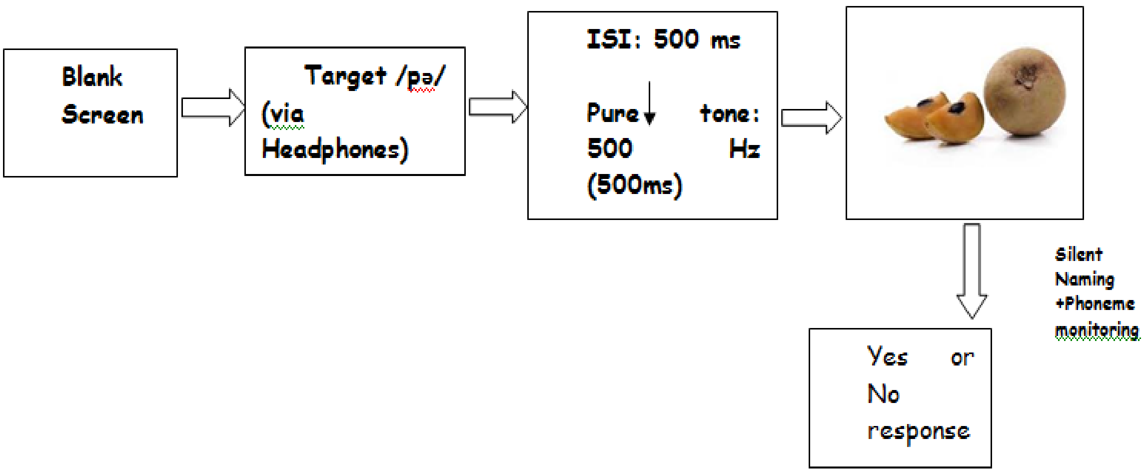

Figure 3.1: Pictorial representation of phoneme monitoring in silent naming.

Experiment 2: Phoneme monitoring in auditory perception

The purpose of this experiment was to assess the average reaction time (in ms) and accuracy of responses in phoneme monitoring for an auditorily presented target word in order to investigate group differences in terms of speech perception. In both the experiments, the target words were the same and were balanced for their position in which the target phoneme had to be monitored.

The target items were counterbalanced. In this experiment, in each trial, prior to the presentation of the target word via the headphones, the target phoneme to be monitored was presented, this was followed by an ISI of 500msec and then by an orienting pure tone of 500 Hz for 500 msec. The auditory presentation of the target word then followed the orienting tone. This was again programmed using the DMDX software. Here the response modality was the same as in experiment 1. The following description and pictorial representation indicates the programming of DMDX for this experiment.

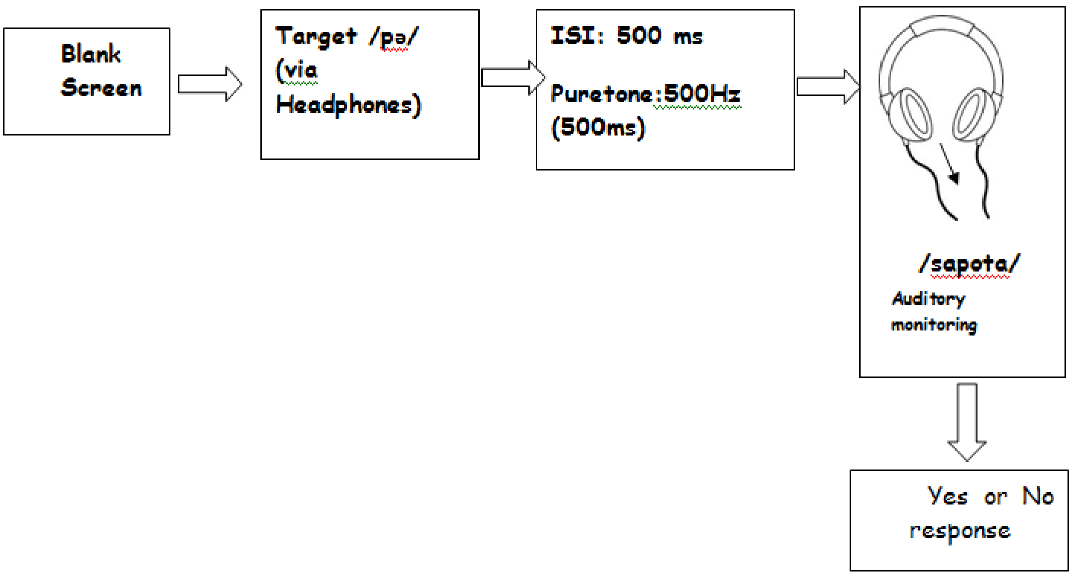

Figure 3.2: Pictorial representation of phoneme monitoring in auditory perception.

d) Pilot study:

Following the programming of both the experiments using the DMDX software, a pilot study was conducted on ten participants from the control group and two participants from the clinical group with the aim of identifying the problems if any reported by the participants during the course of the experiment in terms of clarity of the stimuli recorded. Further, the pilot study also helped in knowing the total duration of the experiment, and in identifying whether any rest period was required during the testing within each of the two trials in either of the experiments. Following the pilot study, a few modifications were incorporated into the final program which is listed below:

- Re recording of bilabials was done as the quality of the pre recorded signal was judged to be poor as by majority of the participants.
- A rest period was included after 4.5 mins in each of the experiments which was predetermined in the program following which they could continue with the experiment by pressing the spacebar once they were ready.

Phase II: Administration of the material developed on both the groups

Procedure: The testing was initiated with the administration of two tasks, they were

1) Familiarization task
2) Overt picture naming task

These tasks were conducted in order to rule out the role of other factors like lexical retrieval and to evaluate whether the participants will monitor for the target phonemes in the intended words only respectively. The details of the tasks are described below.

1) **Familiarization task:** A booklet containing the target pictures and their names were provided to the participants. They were familiarized with the 27 target pictures that were considered for the task.

2) **Overt picture naming task:** Following the familiarization task, participants were instructed to overtly name the same pictures that were shown

during the familiarization task. The pictures were randomly presented on a computer screen. Participants who named atleast 24 of the 27 pictures presented correctly qualified for the Experiment1. In the present study, all the participants qualified for the Experiment 1.

Following the administration of the two tasks, the experiments involving the phoneme monitoring paradigm was carried out. The first experiment tapped on the phoneme monitoring in silent naming, and the second experiment involved the investigation of phoneme monitoring in the auditory perception task.

For the experiment 1, each participant was seated comfortably in front of a 15 inch computer screen in a distraction free environment. The participants were provided with oral instruction, which was as follows: "You will hear a phoneme like /k/ and after a small time gap, a tone will be presented. Following this, a picture will be presented on the computer screen. You have to monitor for the presence of the target phoneme in the name of the picture by silently naming the picture. Do not make any overt lip and tongue movements during the course of silent naming." The participants were instructed to respond by pressing the arrows programmed specifically on the computer keyboard as quickly as possible. The "right" arrow indicated a "yes" response if the target phoneme was present in the name of the picture and "left" indicated a "no" if the target phoneme was not present in the name of the picture. In case there was no manual response within 3sec, from the participant, the next trial would start automatically.

This was followed by experiment 2. The participants were provided with instruction, which was as follows: “You will hear a phoneme and after a small time gap, a tone will be presented. Following this, a word will be presented via the headphones. You have to monitor for the presence of the target phoneme in the word presented auditorily. Do not make any overt lip and tongue movements during the course of monitoring for the target phoneme.” The participants were instructed to respond in a similar manner as in experiment 1.

Both the experiments were carried out in a silent and distraction free environment on each of the participant individually. The total duration to complete all the four tasks was 40 minutes approximately. The time taken to complete each experiment was 18 minutes approximately. Practice trials for a total duration of 2 minutes were also provided to the participants, prior to the initiation of each of the experiment. Following the completion of one complete block (i.e. 54 stimuli), a rest period was given to the participants in both the experiments the duration of which was controlled by the participant i.e. once the participant is ready, he/she could press the spacebar following which the experiment would resume.

Analysis: The reaction time and accuracy of the response was obtained for each participant automatically using the DMDX software. The reaction time for each of the stimuli obtained for each of the participant was averaged in both the groups separately. Similarly, the accuracy was obtained by counting the number of accurate responses for each task and thus a raw score was obtained for a total set of 108 stimuli for each task for both the groups.

In order to evaluate the phoneme monitoring abilities by considering the position of the target phonemes (initial, medial, final) in the target words, the reaction times and accuracy of responses was obtained in a similar manner as mentioned above. However, the total number of stimuli considered for evaluation was 54 in number in each of the task in each group. Only those pictures and the words containing the target phonemes were considered for this evaluation and the total number of words reduced to 54.

Statistical Analysis: Appropriate statistical procedures was applied to compare the reaction time and accuracy of responses for both the experiments between both the groups. The data was analyzed using the SPSS software (Version 16) to determine whether there was any significant difference in reaction time and accuracy of responses within and across both the groups in both the experiments. Repeated measure ANOVA, Wilcoxon signed rank test, paired t test, Mann-Whitney test were carried out. In order to evaluate the position effect, mixed ANOVA, MANOVA and Mann-Whitney test were carried out. Repeated measure ANOVA and Bonferroni's pair wise comparison test was used to compare the reaction time measures across the different positions within each group. The results obtained after statistical analysis have been presented in the next chapter.

Chapter 4

Results

The main aim of the study was to investigate the phonological encoding abilities in adults with stuttering using a phoneme monitoring paradigm in silent naming task and auditory perception task. Specifically, the study aimed at investigating the reaction time and accuracy of responses in both the tasks between and within the two groups, that is, the clinical group (PWS) and the control group (PWNS). Further, the study also aimed at investigating the influence of the position of the target phonemes (initial, medial and final positions) in the trisyllabic words in phoneme monitoring abilities in both the groups. The data thus obtained was averaged, tabulated, and analyzed using certain statistical measures listed. SPSS (Version 16.0) package was used for the statistical analysis.

- Descriptive statistics was carried out to compute mean and standard deviation values in both the groups.
- Shapiro-Wilk's test of normality was used to check for normality in reaction time and accuracy measures.
- Repeated measure ANOVA was used to see the main effect of participants, reaction time and interaction between the two. In addition, this was done to check whether there was any significant difference within and between both the groups in terms of the reaction time.
- Mann-Whitney test was used to find the significant difference in accuracy of responses as well as to compare the effect of the position of

the target phonemes on the accuracy measures across both the groups in both the tasks.

- Wilcoxon Signed Ranks test was used to compare the accuracy of responses between both the tasks in the control group and also to compare the accuracy measures across the different positions within the groups.
- Paired 't' test was used to compare the accuracy of responses between both the tasks in the clinical group.
- Mixed ANOVA was used for comparison of within participant factors i.e. with experiments and position as variables and between participant factors i.e. control and clinical groups being the variables.
- Repeated measure ANOVA and Bonferroni's pair wise comparison test was used to compare the reaction time measures across the different positions within each group.
- MANOVA was used to compare the effect of the position of the target phonemes on the reaction time measures between the clinical group and the control group on the two tasks.

The results obtained are presented in detail below under different sections:

I. Comparison of the reaction time measures across the clinical and the control group in the silent naming and auditory perception task.

II. Comparison of the accuracy of responses across both the groups on both the tasks

III. Comparison of the reaction time in the clinical group across the tasks.

IV. Comparison of the accuracy of responses in the clinical group across the tasks.

V. Comparison of the reaction time in the control group across the tasks.

VI. Comparison of the accuracy of responses in the control group across the tasks.

VII. Comparison of the reaction time measures across the two groups in different positions of the target phonemes on both the tasks.

VIII. Comparison of accuracy measures across the two groups in different positions of the target phonemes on both the tasks.

I. Comparison of the reaction time measures across both the groups on both the tasks (silent naming and auditory perception)

A check of normality was done using Shapiro-Wilk test on the data obtained and it was found that with respect to the reaction time measures, there was normality ($p>0.05$) in both the groups on both the tasks. As a result, parametric tests were done to analyze the significant difference, if any, for the reaction time measures across the two tasks. The p values for both the groups on both the tasks are indicated in the table below.

Table 4.1: *Results of the Shapiro-Wilk test of normality for reaction time for the two groups on both the tasks.*

Tasks	Clinical group	p value	Control Group	p value
Silent naming	0.93	**0.45***	0.95	**0.72***
Auditory perception	0.92	**0.34***	0.95	**0.72***

***p>0.05**

The mean values and standard deviation for the reaction time measures was obtained for both the tasks for both the groups using descriptive statistics which have been depicted in table 4.2. On observation, it was noted that the mean values of the clinical group was higher than the mean of the control group on both the tasks. Further, the mean values of both the groups obtained in both the tasks was subjected to repeated measure ANOVA which revealed a significant difference in the reaction time measures between the two groups on both the tasks [$F= 8.27$, $p<0.05$]. This indicated that the control group outperformed the clinical group in monitoring the phonemes in the silent naming task as well as in the auditory perception task. The F and p values have been depicted in the table 4.2.

Table 4.2: *Mean, standard deviation (SD), F and p values for the reaction time in both the groups on the two tasks.*

Tasks	Clinical group		Control group		F value	p value
	Mean	SD	Mean	SD		
Silent naming	1359.06	112.15	1174.51	176.34	8.27	**0.00***
Auditory perception	1316.44	180.95	1158.70	166.12		

***p<0.05**

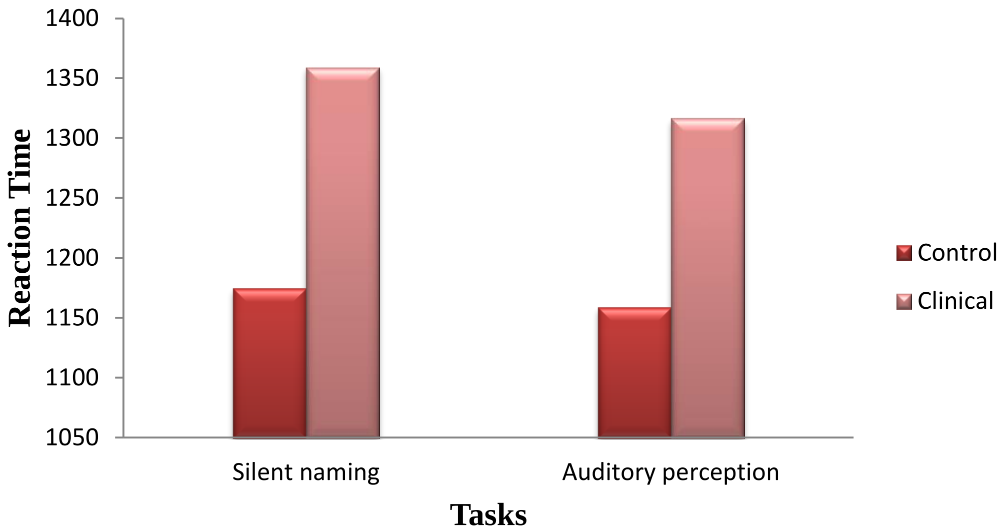

Figure 4.1: Mean reaction time measures for the control and clinical group on the silent naming and auditory perception task.

The performance of the clinical and the control group on both the tasks with respect to reaction time measures is indicated in the Fig. 4.1. It is evident from the figure that the control group performed better than the clinical group as the mean reaction time is lesser in the control group for both the tasks.

II. Comparison of the accuracy of responses across both the groups on both the tasks

A check of normality was done on the data obtained using Shapiro Wilk test and it was found that in terms of accuracy of responses, there was no normality ($p<0.05$) in the control group on both the tasks. However, the data was normally distributed for both the tasks in clinical group. As a result, non parametric test was administered in the control group and parametric test was done in the clinical group to find if there was any significant difference between the two groups. The p values for both the groups in both the tasks are indicated below in table 4.3.

Table 4.3: *Results of the Shapiro-Wilk test of normality for the two groups for accuracy in both the tasks*

Tasks	Clinical Group	p value	Control group	p value
Silent naming	0.91	0.26	0.67	**0.00***
Auditory perception	0.90	0.19	0.81	**0.01***

***p< 0.05**

The mean, median and standard deviation scores across the two groups on the two tasks were obtained using descriptive statistics and compared. On comparison of the median scores, it was seen that the median values of the control group was higher than the clinical group. The median values obtained were subjected to Mann Whitney test which revealed that there was a significant difference between clinical group and control group for accuracy measures in the silent naming task ($p<0.05$), however, there was no significant difference between the two groups for accuracy in the auditory perception task. The |z| and p values have been depicted in table 4.4. The performance of the clinical and the control group with respect to accuracy measures has been indicated in the Fig. 4.2.

Table 4.4: *Mean, standard deviation (SD), median, |z| values and p values for accuracy in both the groups on both the tasks.*

Tasks	**Clinical group**			**Control group**			**|z| values**	**p values**
	Mean	**SD**	**Median**	**Mean**	**SD**	**Median**		
Silent naming	97.42	3.655	97.00	101.50	5.090	103.50	2.33	**0.02***
Auditory perception	101.42	4.420	102.00	104.83	3.070	106.00	1.86	0.06

***p<0.05**

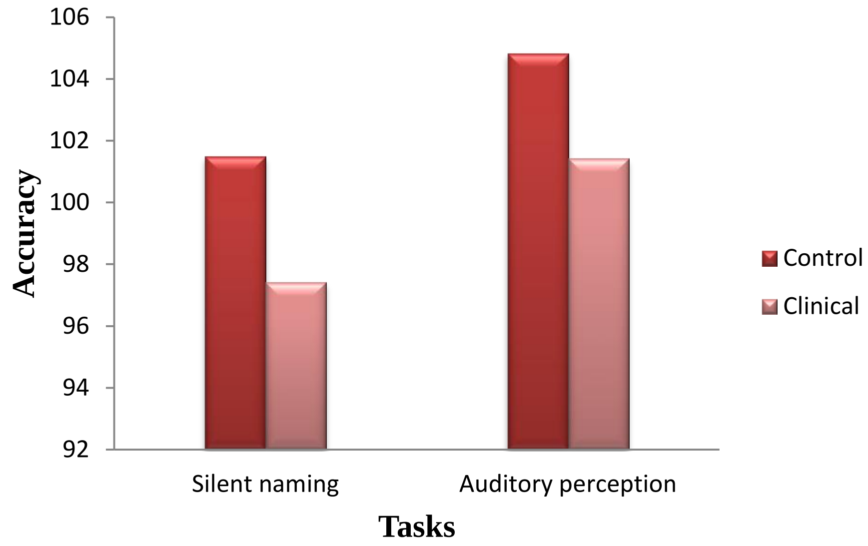

Figure 4.2: Accuracy measures for the control and clinical group on the silent naming and auditory perception task.

III. Comparison of the reaction time in the clinical group across tasks

The mean and standard deviation values for the reaction time of the clinical group in monitoring the target phonemes in silent naming and auditory perception task was computed using descriptive statistics and these values have been depicted in table 4.7. The mean values across both the tasks i.e., silent naming and auditory perception were comparable. This indicated that the performance of the clinical group in silent naming task and auditory perception task was almost similar. The mean values thus obtained were subjected to Repeated measure ANOVA which revealed no statistically significant difference between the two tasks with [$F(1) = 0.22$, $P>0.05$]. The F and p values have been depicted in table 4.5. The performance of the clinical group with respect to reaction time measures on both the tasks is indicated in the Fig. 4.3.

Table 4.5: *Mean, standard deviation (SD), F and p values for the reaction time in the clinical group on both the tasks.*

Tasks	**Mean**	**SD**	**F value**	**p value**
Silent naming	1359.06	112.15	0.22	**0.6***
Auditory perception	1316.44	180.95		

*p>0.05

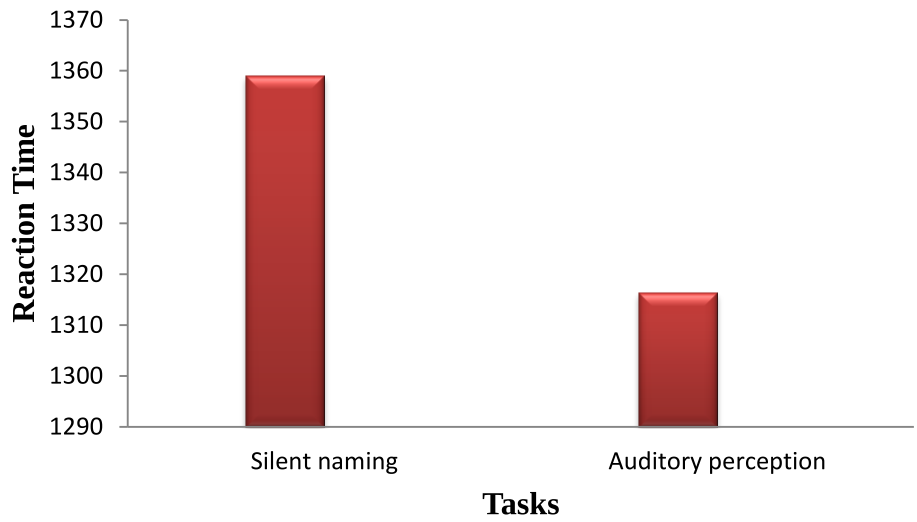

Figure 4.3: Mean reaction time measures for the clinical group across the silent naming and auditory perception task.

IV. Comparison of the accuracy of responses in the clinical group across the tasks

The mean, median and standard deviation values for the accuracy in the clinical group in monitoring the target phonemes in both the tasks was computed using descriptive statistics and these values have been represented in table 4.6. On comparing the mean values across the two tasks, it was seen that the clinical group had a lesser mean for the silent naming task. The data thus obtained was subjected to paired t test which revealed a significant difference between the two tasks ($p<0.05$). This indicated that there was a statistical significance in the accuracy of responses across the two tasks. The t and p values have been depicted in table 4.6. The performance of the clinical group with respect to accuracy measures is indicated in the Fig. 4.4.

Table 4.6: *Mean, standard deviation (SD), median, t value and p value for accuracy of responses in the clinical group on both the tasks.*

Tasks	**Mean**	**SD**	**Median**	**t value**	**p value**
Silent Naming	97.42	3.65	97.00	2.47	**0.03***
Auditory perception	101.42	4.42	102.00		

***p<0.05**

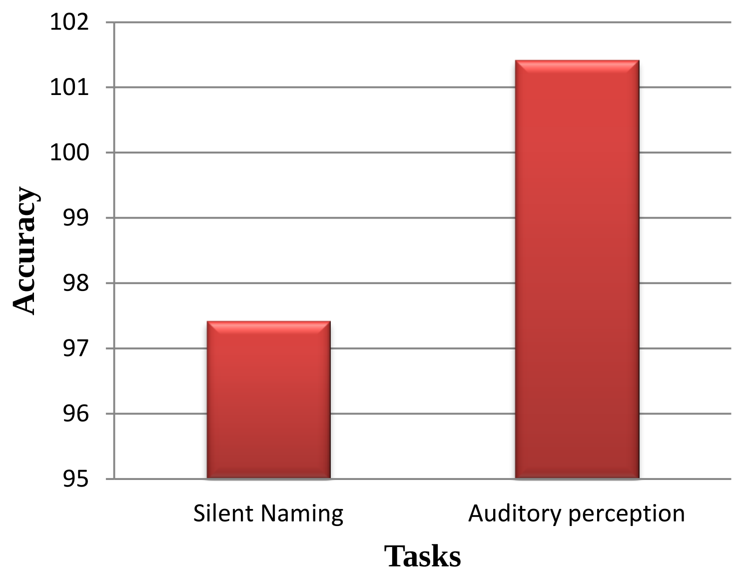

Figure 4.4: Accuracy measures for the clinical group across the silent naming and auditory perception task.

V. Comparison of the reaction time in the control group across the tasks

The mean and standard deviation values for the reaction time of the control group in monitoring the target phonemes in silent naming and auditory perception task was computed using descriptive statistics and these values have been depicted in table 4.7. The mean values across both the tasks i.e., silent naming and auditory perception were comparable. This indicated that the performance of control group in silent naming and auditory perception task was almost similar. The mean values were subjected to repeated measure ANOVA which revealed no statistically significant difference between the two tasks [$F = 1.078$, $p > 0.05$]. The F and p values have been depicted in table 4.7. The performance of the control group with respect to reaction time measures across the tasks is depicted in the Fig. 4.5.

Table 4.7: *Mean, standard deviation (SD) for the reaction time in the control group on both the tasks.*

Tasks	Mean	SD	F value	p value
Silent naming	1174.51	176.34	1.07	**0.31**
Auditory perception	1158.70	166.12		

***p>0.05**

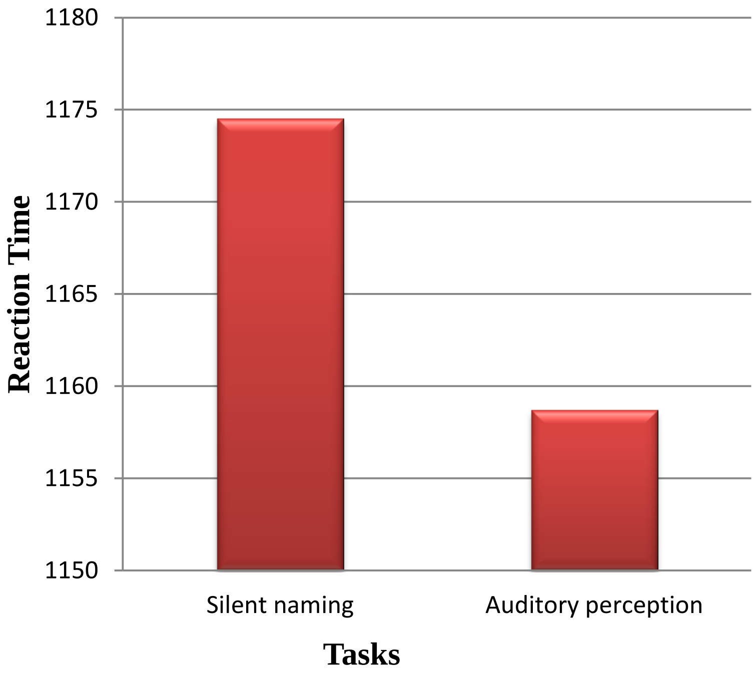

Figure 4.5: Mean reaction time measures for the control group across the tasks.

VI. Comparison of the accuracy of responses in the control group across tasks

The mean, median and standard deviation values for the accuracy in the control group in monitoring the target phonemes in silent naming task and auditory perception task was computed using descriptive statistics and these values have been represented in table 4.8. A comparison of median scores across the two tasks indicated that the control group had better accuracy in the auditory perception task as opposed to in silent naming task. The median values obtained was subjected to Wilcoxon Signed ranks test for further analysis which revealed a significant difference for accuracy between the two tasks ($p<0.05$). The $|z|$ and p values are depicted in table 4.8. The performance of the control group with respect to accuracy measures is indicated in the Fig. 4.6.

Table 4.8: *Mean, median and standard deviation (SD) and |z| and p values for the accuracy of responses in the control group.*

Tasks	**Mean**	**SD**	**Median**	**|z| value**	**p value**
Silent naming	101.50	5.09	103.50	2.39	**0.01***
Auditory perception	104.83	3.07	106.00		

$^*p<0.05$

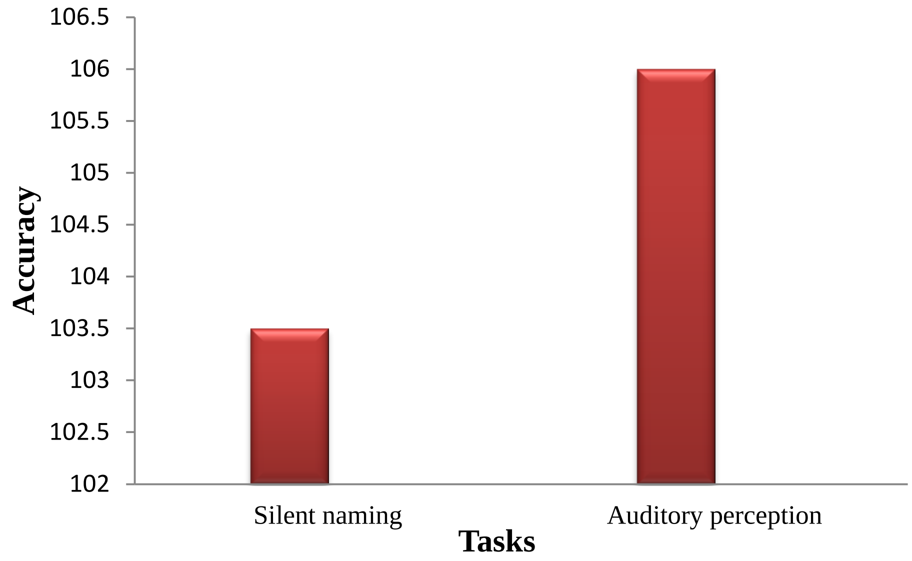

Figure 4.6: Accuracy measures for the control group across the silent naming and auditory perception task.

VII. Comparison of the reaction time measures across the two groups in different positions of the target phonemes on both the tasks.

In order to evaluate the effect of the position of the target phonemes in phoneme monitoring across both the groups in both the tasks, the total number of stimuli considered for evaluation were 54 in number in each of the task in each group unlike 108 stimuli considered for evaluating the phoneme monitoring abilities in both the groups and in both the tasks as in the results discussed above. This discrepancy was because only those pictures and the words containing the target phonemes were considered for this evaluation (with the elimination of false positives and negatives).

The mean and standard deviation values for the reaction time of the control and clinical group in monitoring the target phonemes across the three positions in silent naming and auditory perception task was computed using descriptive statistics and these values have been depicted in table 4.9. The mean values of reaction time measure was lesser for the control group on initial, medial and final position of the target phoneme which indicated that their performance was better when compared to the clinical group in all the three positions in both the tasks. The mean values were the least for monitoring the phonemes in the initial position for both the groups.

Table 4.9: *Mean and standard deviation (SD) values across the two groups across the positions and tasks.*

Tasks		**Clinical group**		**Control group**	
	Position	**Mean**	**SD**	**Mean**	**SD**
Silent naming	**Initial**	1076.70	110.73	939.93	134.46
	Medial	1391.48	167.94	1190.82	218.59
	Final	1362.48	157.99	1188.43	201.14
Auditory Perception	**Initial**	1083.85	162.27	1000.23	137.98
	Medial	1247.73	149.36	1097.07	155.80
	Final	1315.66	179.04	1172.57	165.72

The mean values were subjected to mixed ANOVA with tasks and position as variables across the groups. The results revealed that there was a significant main effect for groups and position. However, no main effect was found for tasks, which indicated no statistical significant difference between the two tasks. A significant interaction effect was seen for tasks and positions, however, no interaction effect was seen for tasks and groups, position and groups and tasks, position and groups. The F and p values have been depicted in Table 4.10.

Table 4.10: *The F and p values for tasks, groups and positions as variables.*

Variables	**df**	**F values**	**p values**
Groups	1	7.66	**0.01***
Tasks	1	2.32	0.14
Tasks* Groups	1	0.771	0.38
Position	2	76.17	**0.00***
Position * Groups	2	1.33	0.27
Tasks * Position	2	9.67	**0.00**
Tasks*Position* Groups	2	0.06	0.94

$^*p < 0.05$

Since the position had statistically significant main effect, Bonferroni's pair wise comparison was carried out to find across which position the reaction time differed significantly. The results revealed that there was a statistically significant difference in monitoring the phonemes only in the initial position and no statistical significant difference was found in monitoring the phonemes in the medial and final position. The p values have depicted in table 4.11.

Table 4.11: *Results of Bonferroni's Pair wise comparison test of the reaction time measures across the positions along with p values.*

Position	**Position**	**Mean Difference**	**p value**
Initial	**Medial**	-250.89	**0.00***
	Final	-248.50	**0.00***
Medial	**Initial**	250.89	**0.00***
	Final	2.38	1.00
Final	**Initial**	248.50	**0.00***
	Medial	-2.38	1.00

*$p<0.05$

Since the groups had a significant main effect, MANOVA was carried out to find in which position there was a significant difference across groups. It was found that there was a statistical significant difference in monitoring the target phonemes in all the three positions between control and clinical group in the silent naming task. On the auditory perception task, no such significant difference was found in monitoring the target phonemes in the initial and final positions. However, there was a statistically significant difference in monitoring the phonemes in the medial position. The F and p values thus obtained have been depicted in table 4.12.

Table 4.12: *The F and p values across the positions and tasks between the control and the clinical group.*

Tasks	Initial		Medial		Final	
	F	**p**	**F**	**p**	**F**	**p**
Silent naming	7.39	**0.01***	6.35	**0.01***	5.55	**0.02***
Auditory perception	1.84	0.18	5.84	**0.02***	4.12	0.05

$*p<0.05$

The performance of the control and the clinical group with respect to reaction time measures across the different positions and tasks has been indicated in the Fig 4.7.

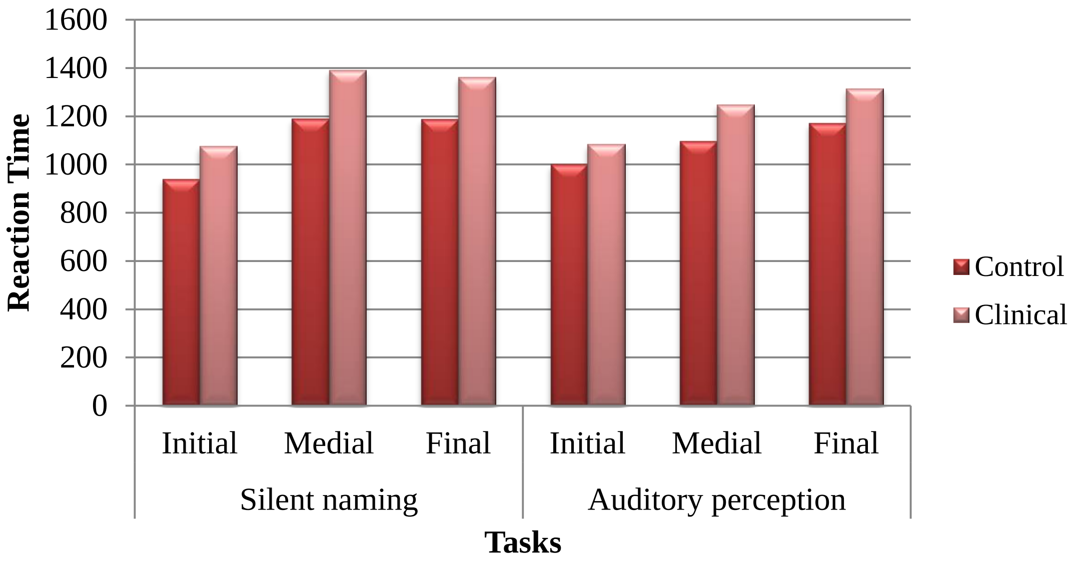

Figure 4.7: Reaction time measures across the control and clinical group in the two tasks across the positions.

Since there was a significant interaction effect seen between tasks and position, the mean values for the reaction time measures obtained in each group across different positions for each task was subjected to Repeated measure ANOVA and Bonferroni's pair wise comparison test was done to compare the positions in which there was a significant difference within the tasks and in each group. The results revealed that for the control group, in the silent naming task, there was a statistical significant difference in monitoring the phonemes in the initial position only. In the auditory perception task, there was a statistical significant difference in monitoring the phonemes across all the three positions. The p values have been depicted in table 4.13. For the clinical group, in the silent naming task and for the auditory perception task, there was a statistical significant difference in monitoring the phonemes in the initial position only. The p values have been depicted in table 4.14.

Table 4.13: *Pair wise comparison of the reaction time measures within the control group across the positions and tasks along with p values.*

		Silent naming		**Auditory Perception**	
Position	**Position**	**Mean Difference**	**p values**	**Mean Difference**	**p values**
Initial	**Medial**	-250.89	**0.00***	-96.83	**0.00***
	Final	-248.50	**0.00***	-172.34	**0.00***
Medial	**Initial**	250.89	**0.00***	96.83	**0.00***
	Medial	2.38	1.00	-75.50	0.01
Final	**Initial**	248.50	**0.00***	172.34	**0.00***
	Medial	-2.38	1.00	75.50	0.01

***p<0.05**

Table 4.14: *Pair wise comparison of the reaction time measures within the clinical group across the positions and tasks along with p values.*

		Silent naming		Auditory Perception	
Position	**Position**	**Mean Difference**	**p values**	**Mean Difference**	**P Values**
Initial	**Medial**	-314.77	0.00	-163.88	**0.00***
	Final	-285.78	0.00	-231.81	**0.00***
Medial	**Initial**	314.77	0.00	163.88	**0.00***
	Medial	28.99	1.00	-67.92	0.24
Final	**Initial**	285.78	0.00	231.81	**0.00***
	Medial	-28.99	1.00	67.92	**0.24***

$*p<0.05$

VIII. Comparison of accuracy measures across the two groups in different positions of the target phonemes on both the tasks.

The mean, median and standard deviation for the accuracy measures of the control and clinical group in monitoring the target phonemes across the three positions in silent naming and auditory perception task was computed using descriptive statistics and these values have been depicted in Table 4.15. On comparison of the median values, it was seen that both the groups had highest values in the initial position indicating that the accuracy is maximum while monitoring for the target phoneme in the initial position. The median thus obtained was subjected to Mann Whitney test to compare the accuracy measures across the two groups with respect to the position of the phonemes on the two tasks. The results revealed that there was a statistical significant difference in the accuracy measures in the medial and final position in the silent naming task between the two groups. However, there was no significant difference in accuracy measures across the two groups in auditory perception task across any position. Thus, the results indicated that control group performed more accurately than the clinical group in monitoring the phonemes in the medial and final position when compared to that in the initial position in the silent naming task and the performance of both the groups was comparable on the auditory perception task. The |z| and p values have also been depicted in table 4.15. The performance of the control and clinical group with respect to the accuracy measures across the different positions and tasks is indicated in the Fig 4.8.

Table 4.15: *The mean, median and standard deviation (SD), |z| and p values for the accuracy measures between the two groups across the positions and the tasks.*

Tasks			**Control group**			**Clinical group**		**|z| value**	**p value**
	Position	**Mean**	**Median**	**SD**	**Mean**	**Median**	**SD**		
Silent naming	**Initial**	17.58	18	0.51	17.00	17.50	1.20	1.02	0.30
	Medial	16.67	17.00	1.92	15.16	15.00	1.19	2.83	**0.00***
	Final	16.08	16.00	1.08	14.33	14.00	2.22	2.14	**0.03***
Auditory perception	**Initial**	17.83	18.00	.38	17.42	18.00	0.79	1.44	0.14
	Medial	17.25	17.00	0.75	16.91	17.00	1.08	0.69	0.48
	Final	16.83	17.50	1.58	16.08	16.00	1.67	1.14	0.25

$*p<0.05$

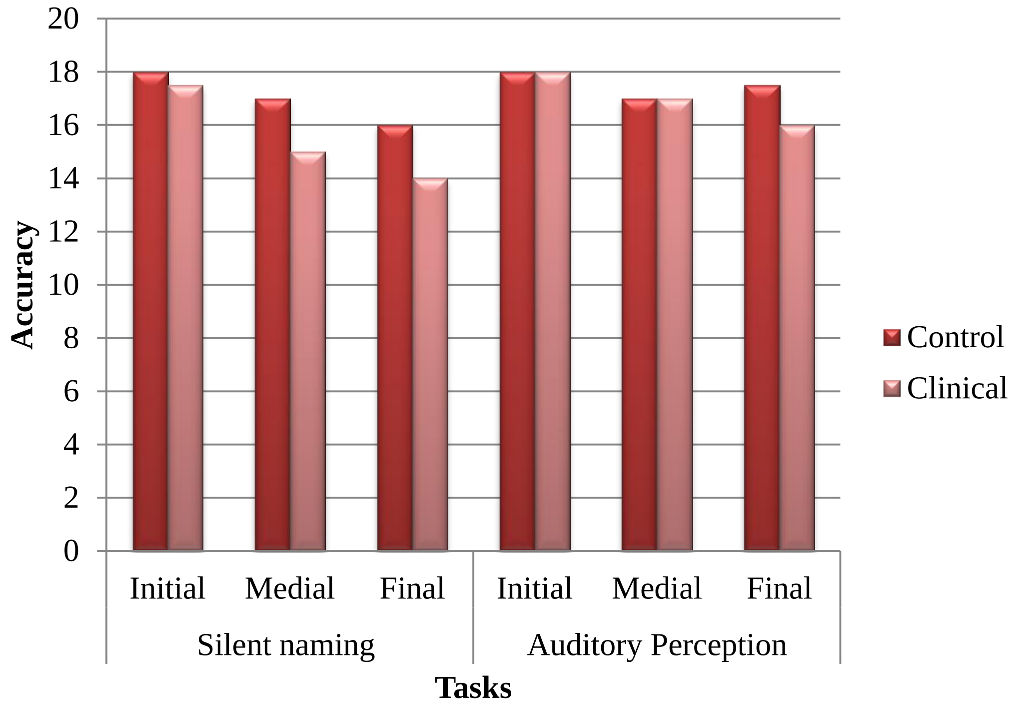

Figure 4.8: Accuracy measures across the control and clinical group in the two tasks across the positions.

Further, a comparison of the accuracy measures within the two groups in both the tasks across the different positions of the target phonemes was done using Wilcoxon's signed rank test. The results revealed that in the control group, there was a statistical significant difference in monitoring the phonemes in the initial and medial position in silent naming task. In the auditory perception task, there was no statistically significant difference in monitoring the phonemes across all the positions. The |z| and p values have been depicted in table 4.16. In the clinical group too, there was a significant difference in monitoring the phonemes in the initial and medial position in silent naming task. In the auditory perception task, there was significant difference in monitoring the phonemes in the initial position. The |z| values and p values have been depicted in table 4.17.

Table 4.16: *Pair wise comparison of the reaction time measures within the control group across the positions and tasks along with |z| and p values.*

		Silent naming		Auditory	Perception
Position	**Position**	**|z| values**	**p values**	**|z| values**	**p values**
Initial	**Medial**	2.11	**0.03***	1.93	**0.05**
	Final	2.71	**0.00***	1.84	**0.06**
Medial	**Final**	1.08	**0.28**	1.09	**0.27**

***p<0.05**

Table 4.17: *Pair wise comparison of the reaction time measures within the clinical group across the positions and tasks along with |z| and p values.*

		Silent naming		Auditory	Perception
Position	**Position**	**|z| values**	**p values**	**|z| values**	**p values**
Initial	**Medial**	2.82	**0.00***	2.12	**0.03***
	Final	2.42	**0.01***	2.22	**0.02***
Medial	**Final**	1.08	0.27	1.44	**0.15**

***p<0.05**

Thus, the results revealed that there was a significant deficit, i.e. a delay as well as a reduction in the accuracy measures in encoding the phonemes in the silent naming task in PWS. However, there was only a significant delay in encoding the phonemes in the auditory perception task in PWS as opposed to PWNS. With respect to position effect, PWS were significantly poorer in monitoring the phonemes in the medial and final positions when compared to PWNS.

Chapter 5

Discussion

The study aimed at investigating the process of phonological encoding in adults with stuttering in the age range of 18-25 years using a phoneme monitoring paradigm in silent naming and auditory perception task. The process of phonological encoding using the phoneme monitoring paradigm was determined using reaction time and accuracy measures. The rationale behind selecting the reaction time measures was that it provided the information regarding the time taken by the individual to identify the phoneme in the name of the picture or in the auditorily presented word. The accuracy measure provided the information regarding the final outcome of all underlying mental processes (cognitive skills) of the individual i.e. how accurate was the individual in judging the phonemes as being present or absent in the stimuli presented. Thus these measures of reaction time and accuracy provided a subjective method of determining the underlying cognitive functions which is influenced by factors such as the arousal, attention, discrimination, perception, identification, judgement, problem solving and motor abilities of an individual.

The reaction time and accuracy are performance based measures. Though they appear simple, they provide tremendous information regarding speed and accuracy of information processing. Thus such measures were incorporated in the phoneme monitoring paradigm which indirectly provides the information regarding the phonological encoding abilities of the individual. Further, the use of such a paradigm is considered to be very advantageous in evaluating the phonological encoding abilities of PWS as the tasks involved i.e. silent naming and auditory perception do not require any overt speech output thus eliminating the role of the speech execution systems and tapping primarily on what happens at the prearticulatory level of language processing (Wheeldon & Levelt, 1995). This assumption is based on the Levelt's model of language comprehension and production (1989) and also on the computational model of language formulation (WEAVER++) by Levelt, Roelofs and Meyer (1999). The thought of evaluating the phonological encoding abilities in PWS comes from the psycholinguistic theories of stuttering which propose that there is a probable delay in the process of retrieval and encoding of the phonemes during the language production in these individuals which leads to instances of stuttering.

Therefore, with this information obtained from psycholinguistic models of language comprehension and production and the psycholinguistic theories of stuttering, the study was conducted with the ultimate desire of investigating the probable etiology of stuttering which would further add to our knowledge about the disorder and would be instrumental in evidence based practice. The study has revealed some fascinating findings with respect to the phonological encoding abilities of PWS.

One of the primary objectives of the study was to evaluate the reaction time and accuracy in silent naming and auditory perception tasks between persons with stuttering (PWS) and persons with no stuttering (PWNS). The results revealed that the performance of PWS was poorer in monitoring the phonemes in the silent naming task as well as in auditory perception task when compared to the performance of PWNS. This was indicated by a statistically significant difference in the reaction time measures between the two groups. With respect to accuracy, there was a statistically significant difference between the two groups only in the silent naming task. The finding of the present study is in contrast to the findings obtained by the study conducted by Sasisekaran and De Nil in 2006 on PWS and PWNS. The latter also conducted the study using the phoneme monitoring paradigm, and they reported that the PWS were significantly poorer than the PWNS in the reaction time measures in the silent naming task, however no such difference was found in the auditory perception task. Further, they reported that the two groups were comparable with reference to accuracy measures in both the tasks. One of the major assumptions of their study was that the silent naming task taps on phonological encoding whereas the auditory perception task assesses the general monitoring abilities. Thus based on these results they concluded that PWS have a delay specifically in phonological encoding and the absence of such a delay in the perception task prompted them to conclude that there was no general monitoring deficits in PWS. Thus they stated that the probable etiology of stuttering is a delay in phonological encoding. Yet another study by Sasisekaran, et al. in 2006 in PWS and PWNS using a similar paradigm revealed that although PWS were significantly poorer than PWNS in phoneme monitoring in silent naming, no such difference was found in the auditory tone monitoring task and the simple motor task. Further, the two groups were comparable for the accuracy measures in either of the tasks. The assumption of this study was similar to their previous study discussed above that the silent naming task provided information regarding phonological encoding and the auditory tone monitoring task assessed the general monitoring abilities of the individual.

These authors also concluded that PWS have a delay in the process of phonological encoding rather than a deficit in general monitoring. The findings of yet another study by Garnett and Ouden (2013) on PWS and PWNS using a similar phoneme monitoring paradigm revealed that PWS performed significantly poorer in silent naming task than in the auditory perception task. Unlike the other studies discussed above, this study revealed a significant difference in the accuracy of responses in the silent naming task. They concluded that in addition to a delay, there is also an increase in the number of errors in PWS. Thus they supported the covert repair hypothesis (Postma & Kolk, 1993) for the delay in the process of encoding of phonemes and also supported the Vicious circle hypothesis (Vasic & Wijnen, 2005) which states that in PWS, the self monitoring system is highly sensitive even for small deviations in speech because of which they often interrupt and repair the errors which thus results in moments of stuttering. According to the assumption of this hypothesis, there are three parameters of attention that play a very important role during the process of monitoring speech. These components include effort, focus and threshold. Effort refers to the amount of resources available that contribute to monitoring, focus refers to the selective aspect of monitoring and threshold refers to the criteria that the output needs to satisfy in order to be acceptable. They state that in PWS, the effort, focus and threshold are inappropriately set i.e. greater effort is invested in monitoring the speech than is actually required, and that the monitor mainly focuses on temporal fluctuations and discontinuity in speech. Also the threshold for acceptable output is set so high that even the normal and unavoidable discontinuities and temporal fluctuations are also perceived as disfluencies. Therefore, the hypothesis emphasizes on the fact that PWS monitor more vigilantly for the errors in speech and have a lesser threshold for instigating repairs. Such an hyper vigilant monitoring system results in recurrent repairs of even minor sub-phonemic irregularities resulting in unnecessary reformulations of the speech-plan ultimately resulting in a “vicious circle”. Based on the findings of all these studies with respect to the reaction time measures, in the present study too, it can be concluded that there were deficits in both phonological encoding as well as in general monitoring.

With respect to accuracy, there was a statistically significant difference between PWS and PWNS only in the silent naming task and not in the auditory perception task with PWS performing poorer than PWNS. This can be attributed to the fact that PWS tend to have more errors in their phonetic plan (Kolk & Postma, 1990) and also are hypervigilant for errors in their own speech (Vasic & Wijnen, 2005) rather than in the speech formulated by others.

The conclusion in the study by Sasisekaran and De Nil in 2006 in PWS that the auditory perception task assess the general monitoring abilities of the individual was proposed based on the study conducted by Postma and Kolk in 1992.The study required the PWS to monitor the errors in their own speech in the normal auditory feedback condition and altered feedback condition which revealed that there was no difference in their performance when compared to PWNS in either of the two tasks in error detection process, however, the PWS performed poorer in the detection of errors in the speech produced by others. Based on this, they concluded that PWS have general linguistic monitoring deficits. The same concept can be applied to the present study as the study involved the monitoring of self generated speech in silent naming task and monitoring for the phonemes in others speech in the auditory perception task. Slower reaction time obtained in both the tasks in the present study indicated slowness in phonological monitoring in self generated and in speech produced by others in PWS. However, they were comparable to PWNS in the accuracy in the auditory perception task which indicates that although slow, they were accurate in monitoring the speech of others. In the silent naming task, the accuracy was affected indicating difficulty in monitoring self generated speech.

Thus, the findings in the current study does account for a delay in the process of monitoring for the target phonemes in silent naming to a delay in phonological encoding abilities in these individuals. In addition an increase in the number of errors (marked by poor accuracy) in silent naming task also supports the psycholinguistic theories of stuttering like the covert repair hypothesis and vicious circle hypothesis (Vasic & Wijnen, 2005) which propose that there is an increase in the errors in the phonetic plan within the covert loop as well as an hypersensitive self monitoring system respectively in these individuals which inturn contribute to the symptoms of stuttering.

The findings with respect to speed and accuracy in monitoring for the target phonemes in silent naming task in PWS can be explained with respect to the following aspects: a) PWS have an increase in the number of errors in their phonetic plan because of poor levels of activation required for activating the specific phonemes b) As a result of the mismatch between the levels of activation and the retrieval of the phonemes, inappropriate phonemes are retrieved c) or there will be a delay in the retrieval of the appropriate phonemes as the thresholds required for activation of the appropriate phoneme may be increased (Dell,1986; Dell & O'Seaghdha,1991). Consequently, it can be concluded that there is a phonological encoding deficit in these individuals rather than a delay based on the findings obtained in the present study.

However, based on the finding that there is a delay in monitoring the target phonemes in the auditory perception task, one cannot assume and conclude that there is a general monitoring deficit in PWS. This is because this task requires monitoring the target phonemes in the words produced by the other speakers. Neither the Levelt's model nor the WEAVER++ contributes to explain this aspect. Though WEAVER++ is an influential language formulation model, it only partially represents the processes required to complete tasks of phonological awareness and phonological memory. WEAVER++ models the journey from a thought or concept through to speech output. However, most phonological processing tasks require more than just the "output" stage of language formulation. These tasks require an individual to hear stimuli, perform some sort of manipulation or identification, depending on the task, and then provide a spoken response. WEAVER++ only describes half of the process that occurs during the completion of phonological processing tasks. As a result, a model that contains aspects of both speech perception and production would contribute specifically in examining phonological processing abilities of an individual. This prompted us to look at the "general model" of speech perception and production proposed by Ramus et al. (2010). This model is based on

WEAVER++ and other similar models. The findings of the current study can be explained, based on the Ramus model. In this study the overt speech which is an acoustical signal, is received by the lexical route following which the listener senses the incoming acoustic signal. In order to make sense of the incoming signal, the lexicon is then accessed to match the input signal with the stored representations. The lexicon contains semantic, orthographic and phonological representations. Thus, in order to understand the incoming signal, both semantic and phonological representations are retrieved from the stored lexicon and then the output is formulated. Based on this model, one can state that the process of selecting, retrieving and arranging the phonemes i.e. phonological encoding also takes place for the perceived auditory signal. Consequently, the delay in monitoring the target phonemes in auditory perception task could be due to delay in phonological encoding. However, the performance of PWS with respect to accuracy in this task has revealed no significant difference from that of the PWNS. This shows the presence of speed accuracy trade off. That is the delay in the monitoring of phonemes in an attempt to give a correct response has resulted in a better accuracy but by compromising on the speed of information processing. Moreover, it is not a possibility that there could have been a delay in lexical retrieval in these individuals since there was a familiarity check conducted at the beginning of the tasks which required the overt naming of the stimuli considered for the study. The main intention behind carrying out the familiarization task was to rule out lexical retrieval deficits if any and to ensure that these individuals do monitor the phonemes in the required target word only.

In order to further justify the results of the current study, support can be drawn from the assumption that phonological encoding can be assessed through the phonological processing abilities. This phonological processing is an umbrella term that includes phonological memory, phonological awareness and rapid automatized naming (Wagner, Torgesen, & Rashotte, 1999). Both the tasks employed in the study i.e. silent naming and auditory perception incorporates phonological awareness. This is because the process of silent naming requires the individual to identify the target phoneme, select, blend and sequence the phonemes for the target word from the mental lexicon appropriately utilizing the lexical route. The auditory perception task also includes the ability to perceive the phoneme, identify the same in the target word, determine the way the target phoneme is sequenced and blended to form the word using the lexical route. Further, the role of phonological working memory is equally significant in both of these tasks. On applying the Baddeley's model of working memory to interpret the results obtained, we can assume that both the tasks required the individual to store the target phoneme presented auditorily as well as the individual phonological codes of the words until the entire word was formed in their phonological loop in their phonological short term memory along with the activation of the visuospatial sketch pad which is an important component contributing to the overall working memory or short term memory of the individual for storing the pictures presented in the silent naming task (Baddeley & Hitch,1974). Though rapid automatized naming is required only in silent naming task but not in perception task, we can thus conclude based on these observations that phonological encoding deficits is present in PWS based on the results obtained in the present study.

The study conducted by Pelczarski (2011) extend support to the current study which was based on the assumption that phonological encoding can be evaluated using the phonological processing abilities. This study revealed that performance of PWS was comparatively reduced in the phonological awareness tasks which was actually getting masked with the real word stimuli but was obvious with the non word stimuli. With respect to the phonological memory, PWS performed significantly poorer than the control group on the non word repetition tasks than with the digit naming task, thus indicating that PWS have a over reliance on the lexical knowledge to complete the phonological memory tasks. In rapid automatic naming tasks, PWS performed significantly poorer for colour and object naming tasks but not for digit and letter naming tasks. It was found that though there were differences present between PWS and PWNS in the phonological processing tasks, these differences were not statistically significant that is majority of the scores did lie within the normal limits across both the groups. Thus it was concluded that phonological encoding in PWS may be just one of the contributing factor among the various other factors i.e., speech motor planning, temperament and various other linguistic factors for stuttering that can in turn lead to an unstable speech system and did not offer complete support to the assumption regarding phonological encoding deficits in PWS. However, a weightage was given to the fact that delay or deficits in phonological encoding could be one of the factors accounting for symptoms of stuttering. But, a direct comparison of the findings of the current study with these studies cannot be done as there are differences in the tasks and paradigms considered in either of the studies.

Support can be drawn to the findings of the present study from the findings of functional imaging studies that reported that PWS differ from PWNS in terms of the areas traditionally considered to be involved in phonological encoding and self monitoring (right frontal operculum and fronto temporal fluency loop) (Fox, Ingham, Hirsch, Downs, & Martin, 1996).

The second objective of the study was to evaluate phonological encoding abilities within the two groups (PWS and PWNS) by comparing the reaction time and accuracy using the phoneme monitoring paradigm across the two tasks. The results revealed that within the PWS, there was no statistically significant difference in reaction time across the two tasks i.e. silent naming and auditory perception task. Similar results were obtained in PWNS. These indicated that the time taken to monitor the target phonemes in words which were presented auditorily and in the names of pictures presented visually in the silent naming task respectively was almost similar. However, on close inspection of the total mean scores in both of the two groups with respect to reaction time revealed that the reaction time was better in the auditory perception task when compared to silent naming task.

This indicated that the silent naming task was cognitively more demanding since it required the activation of the appropriate phonemes, selection, retrieval and organization of the phonemes for the names of the pictures presented and then monitoring the presence of the target phoneme in the name of the picture which the individual formulated covertly. Auditory perception task on the other hand is a task that looked into the ability of the individual to monitor for the target phonemes in the speech produced by other speaker which was less cognitively demanding. Thus, this task did not require great deal of selection, retrieval of phonemes and formation of the word, rather it required the ability of the individual to integrate the perceived information and monitor for the phonemes in the overt speech (i.e., it required spoken word recognition and monitoring in others speech rather than self monitoring).

With respect to the accuracy, the results revealed that in PWS, there was a statistically significant difference across the two tasks. Further the examination of the mean values revealed that the performance of PWS was poorer in silent naming task as opposed to auditory perception task. Similar findings were obtained in PWNS. Therefore, in both the groups, there were certain errors in the activation of the appropriate phonemes so as to monitor for the presence of the target phonemes. Also a significantly better performance with respect to accuracy in the auditory perception task indicated that there was no perceptual deficits in either of the groups. A comparison of the results obtained for the reaction time and accuracy within the groups revealed that there is no speed accuracy trade off in either of the groups in either of the tasks.

Overall, difference in the performance across the two tasks i.e. silent naming and auditory perception task within PWS and PWNS can be attributed to the differences in terms of the task complexity between the two tasks. Silent naming task required visual processing of the picture in the primary stage and then secondarily, the monitoring for the phoneme in the name of the picture presented, whereas, the auditory perception task required auditory processing of information throughout. Since, it is mainly the auditory pathway that plays a major role during the conversation than the visual pathway, we can expect that the silent naming task is much more complex as opposed to the auditory perception task, thus indicating a poorer reaction time in silent naming task though not statistically significant between the two tasks in either of the groups. However, with respect to accuracy measures, there was a statistically significant difference between the two tasks in both the groups. The accuracy was much better in the auditory perception task than the silent naming task, further supporting the fact that silent naming task is more complex as opposed to the auditory perception task.

The third objective of the study was to evaluate phoneme monitoring abilities by considering the position of the target phonemes in the silent naming and the auditory perception task across the PWS and PWNS. An interesting finding was obtained in the current study to explain the position effect in PWS. The findings revealed that with respect to the reaction time measures, PWS were significantly poorer in monitoring the phonemes across all the positions i.e. initial, medial and final positions when compared to PWNS in silent naming task. But in the auditory perception task, the PWS performed significantly poorer in monitoring the phonemes in the medial position, however, the responses were comparable in monitoring the phonemes in the initial and final positions. With reference to the accuracy measures, PWS performed significantly poorer in monitoring the phonemes in medial and final position in silent naming task. There was no significant difference in monitoring the phonemes in either of the positions in the auditory perception task. Further, close inspection of the results revealed that the reaction time measures were the least in monitoring the phonemes in the initial position for both the tasks in both the groups. Whereas, the reaction time measures were almost the same in monitoring the phonemes in the medial and final position. With respect to the accuracy measures, the accuracy was the best in monitoring the phonemes in the initial position as opposed to medial and final positions.

Further, a comparison of the reaction time measures within the two groups across the different positions of the target phonemes on both the tasks revealed that there was a statistically significant difference in monitoring the phonemes in the initial position when compared to the medial and final positions in the silent naming task in both the groups. In the auditory perception task, the PWNS had a statistically significant difference in monitoring the phonemes across all the three positions, whereas, the PWS had a statistically significant difference in monitoring the phonemes in the initial position only. With respect to the accuracy measures, it was found that in PWS, there was statistically significant difference in monitoring phonemes only in the initial position in both the tasks, and in PWNS, there was statistically significant difference in monitoring the phonemes only in the initial position in silent naming task and no significant difference was present in monitoring the phonemes across any of the positions in the auditory perception task.

There are no studies reported in the literature considering the position of the target phonemes for evaluating the phonological encoding abilities in PWS. However, one of the important characteristic feature of stuttering is that the disfluencies are predominantly seen in the initial position of the words (Brown, 1938; Natke, Sandrieser, Melanie van Ark, Pietrowsky & Kalveram; 2003). The reason for the occurrence of stuttering in the word initial position was explained by taking into account the stress effect. It was also stated that the stress effect was influenced by the word initial – effect which refers to stuttering being predominant along the first syllables of the word. These findings are with respect to the studies conducted on the English speaking population. The stress often occurs along the word initial position in English. However, the present study was done on the native speakers of Kannada which is a syllable timed language unlike English which is a stress timed language. Therefore, in the current study, one cannot merely consider the stress effect to be the probable reason for the occurrence of disfluencies along the initial position of the words. As already discussed, both silent naming task and auditory perception task contribute to evaluating the phonological encoding abilities (Levelt, 1989; Levelt, Roelofs & Meyer, 1999; Ramus et al., 2010). However, the silent naming task is the one which is more cognitively demanding as it requires the individual to monitor the target phonemes in their own speech. On the other hand, auditory perception is less cognitively demanding as it assessed the phonological encoding in the others speech. In the current study, it was found that PWS were significantly poorer in encoding the phonemes in all the positions in silent naming task and the accuracy of responses were poorer in encoding the phonemes in the medial and final position only. Thus, there is a presence of speed accuracy trade off in encoding the phonemes in the initial position. That is, though the PWS are slower in encoding the phonemes in the initial position, they compensate for this slowness by being accurate enough in the process of encoding along the initial position. On applying the rationale of covert repair hypothesis (Kolk & Postma, 1997) and the concept of spreading activation model (Dell, 1986; Dell & O'Seaghdha, 1991), one can state that the activation of the initial syllable though slow, will take place appropriately in PWS. But, for the further elaboration of the phonological node by the inclusion of the medial and the final phonemes in the trisyllabic word, the time taken for the activation is slow along with diminished accuracy in the selection process. This can probably explain the reason behind the initial syllable repetition or the prolongation of the initial syllable in PWS i.e. it can be attributed to the fact that the selection of the initial phoneme is appropriate but there is a deficit in encoding the remaining portions of the word while formulating their own speech.

In the auditory perception task, there was comparatively a different finding as opposed to the silent naming task. With respect to the reaction time measures, PWS performed significantly poorer in monitoring the phonemes in the medial position but, the responses were comparable in monitoring the phonemes in the initial and final positions. There was no statistically significant difference in encoding the phonemes with respect to accuracy measures in either of the positions in the auditory perception task in PWS when compared to PWNS. Such a finding can be attributed to the probable assumption about the fact that PWS are very vigilant in monitoring the speech produced by others at the initiation of the utterance but, the degree of vigilance might reduce while monitoring for the phonemes in the medial position. Therefore, we can attribute this explanation to account for the poorer reaction time which is significant statistically between the PWS and PWNS in the auditory perception task. Thus we can conclude that PWS are slower in encoding the phonemes along the medial position of the words in the speech produced by others and but the accuracy with which the encoding is done is comparable with that of PWNS.

To summarize, by considering the position of the target phonemes in the process of phoneme monitoring, it can be concluded that the PWS have deficits in monitoring the phonemes in the medial and final position of the words in self generated speech and slowness only in monitoring phonemes in the medial position of the word for the speech produced by others. Further, the process of monitoring is quicker for the phonemes in the initial position when compared to the other positions. Especially in the silent naming task, which requires monitoring of the phonemes in the self generated speech, the phonemes along the initial position form the loci for encoding i.e. they form the point of initiation of the encoding process. This can be explained based on the significant difference in both reaction time and accuracy measures in monitoring the phonemes in the initial position in both the groups. In perceiving the speech of others, it was found that the ability of the individual to monitor the phonemes in the initial position was much quicker and accurate than in monitoring the phonemes in the other positions.

Chapter 6

Summary and Conclusions

Stuttering is a complex communication disorder. This is evident from the fact that it is one of the most researched communication disorder in the field of speech and language pathology since several decades. In spite of the numerous researches conducted with reference to stuttering, the disorder is still considered to be an enigma. This is due to the mystery that remains with reference to its definition, characteristics and its etiology. Such abstractness in the condition also contributes to complicate the assessment and management of the individuals with stuttering.

Consequently, it is of utmost importance to conduct studies so as to answer the unanswered questions, to solve or to explain the riddle. One of the important aspect that has remained a mystery in understanding stuttering is its etiology. Various studies have been conducted since decades to explain the etiology of stuttering. The rationale behind the search for an etiology is to gain a better understanding of the condition, to take preventive measures if required, to gain a better clinical picture of the individuals with stuttering during the course of the assessment and to take appropriate step towards management of these individuals by incorporating an Evidence based practice (EBP). The EBP paves way to answer an important question i.e. "as professionals, how do we know that what we do really works?" Thus, an attempt was made to understand the etiology of stuttering through this study.

Although researchers have considered that stuttering is a disorder of speech, some have considered it as a disorder of language. With this notion several psycholinguistic theories have also been proposed to explain the etiology of stuttering wherein they try to establish the link between phonological encoding and stuttering. One of the major assumption of these theories was that stuttering occurs due to deficits in phonological encoding. However, one of the major difficulties in evaluating the phonological encoding abilities is that it is a covert phenomenon that occurs prior to the activation of speech execution system. Therefore, a need was felt to select an appropriate paradigm that contributes to investigate phonological encoding abilities in PWS by eliminating the role of speech execution system as the overt speech is obviously expected to be affected in PWS. Since, the phoneme monitoring does not require overt speech production by the participants and involves monitoring of the phonemes at the prearticulatory stage itself, this paradigm is more beneficial in evaluating the phonological encoding in PWS. Thus, this paradigm was selected for the purpose of evaluating the phonological encoding abilities in PWS. Further, it was found that the studies investigating the phonological encoding using such a paradigm in PWS were limited and also none were conducted in the Indian context.

Thus, this study was planned to investigate phonological encoding abilities in PWS in comparison to PWNS using the phoneme monitoring paradigm which involved two tasks designed specifically to assess phonological encoding i.e. silent naming and auditory perception task. Two performance based measures i.e. reaction time and accuracy measures were considered for comparison of the performances within the group and across groups. In addition, the effect of the position of the target phonemes in phoneme monitoring abilities across the two groups was also evaluated.

The study was conducted on twelve PWS and twelve PWNS in the age range of 18 to 25 years. The participants were matched for age, gender and socio economic status. The participants were screened for their short term memory, vocabulary, working memory and phonological abilities prior to the testing. A set of nine phonemes were considered for the purpose of monitoring and consequently 27 trisyllabic picturable words in Kannada with each of these target phoneme occurring in the initial, medial and final position were considered. The pictures representing these words were selected based on the content validity check conducted by experienced speech language pathologists. These trisyllabic words and pictures served as the stimuli for the two experiments in the study i.e. phoneme monitoring in silent naming and phoneme monitoring in the auditory perception task. The phoneme monitoring paradigm was programmed using the DMDX software. The participants were instructed to monitor for the target phonemes in the names of the picture presented on the computer screen in the silent naming task or in the words presented auditorily in the auditory perception task. They were instructed to signal by pressing the “right” arrow for a “yes” and the “left” arrow for a “no” response. The target phonemes were presented in two blocks with a total of 54 times in each block, accounting for 108 times in each of the task. The presentation of the pictures or the words in both of the tasks was randomized. The order of the blocks was also counter balanced. The testing was done individually in a distraction free and noise free environment.

The mean reaction time (in ms) and accuracy of responses were obtained for both the tasks for each participant. The values thus obtained were averaged for each group i.e. PWS and PWNS. The data was then subjected to statistical analysis using the SPSS software (Version 17.0). Descriptive statistics was used to obtain the mean and standard deviation (SD) values with respect to reaction time measures and mean, median and SD values were considered for the accuracy measures for each group for both the tasks. Repeated measure ANOVA was used to see the main effect of participants, reaction time and interaction between the two. In addition, this was done to check whether there was any significant difference within and between both the groups in terms of the reaction time. Wilcoxon Signed Ranks test was used to compare the accuracy of responses between both the tasks in the control group. Paired ‘ t’ test was used to compare the accuracy of responses between both the tasks in the clinical group. Mann-Whitney test was used to find the significant difference in accuracy of responses if any, across both the groups in both the tasks. Mixed ANOVA was used for comparison of within subject factors i.e. with tasks and position as variables and between participant factors i.e. control and clinical groups being the variables. MANOVA was used to compare the effect of the position of the target phonemes on the reaction time across the clinical group and the control group across the two tasks. Mann-Whitney test was used to compare the effect of the position of the target phonemes on the accuracy measures across the two groups on the two tasks.

The overall findings of the study can be summarized as follows:

1. The performance of PWS in monitoring the phonemes in the silent naming task and auditory perception task was significantly poorer when compared to

PWNS with respect to the reaction time measures. Also, the PWS were less accurate in monitoring the phonemes in the silent naming task when compared to PWNS, however, the PWS were as accurate as PWNS in monitoring for the phonemes in the auditory perception task.

2. The performance of PWS was comparable in monitoring the phonemes across the silent naming and auditory perception task with respect to the reaction time measures while with respect to accuracy measures, the PWS performed poorer in monitoring the phonemes in the silent naming task when compared to auditory perception task. A similar finding was found even in PWNS for both reaction time and accuracy measures across both the tasks.
3. The evaluation with respect to the position of the target phonemes in phoneme monitoring tasks revealed that the performance of PWS were significantly poorer in monitoring the phonemes in all the positions in silent naming task with respect to reaction time measures but with respect to the accuracy measures, poorer performance was present only in the medial and the final position when compared to PWNS. In the auditory perception task, it was found that the performance of PWS was significantly poorer in monitoring the phonemes in the medial position only and the reaction time was comparable to PWNS in the initial and final positions. In terms of the accuracy, PWS were comparable to PWNS in monitoring the phonemes across all the positions. Overall, it was found that the phoneme monitoring was comparatively better for the initial position with respect to reaction time as well as the accuracy measures.

Thus based on the findings obtained in the present study it can be concluded that PWS do have deficits in the process of phonological encoding. Also there is indeed an influence of the position of the target phonemes in the process of encoding which can contribute to explain the reason behind the occurrence of certain types of stuttering like disfluencies.

Clinical implications

The theoretical implication of the study is that it contributes to validate the psycholinguistic model of language comprehension and production put forth by Levelt in 1989. The study also validates the computational model of language formulation i.e. WEAVER++ (Levelt, Roelofs & Meyer, 1999) and the "general model" of speech perception and production (Ramus et al., 2010). Overall, the study also contributes to validate the psycholinguistic theories of stuttering.

In addition to the theoretical implications, there are certain clinical implications which have been listed below:

- A comprehensive relationship does exist between language and stuttering i.e. to say that stuttering is not merely a speech disorder. Such an awareness can thus be established in the mind of young clinicians.
- The rationale behind the use of prolonged speech techniques can be viewed from another angle i.e. prolongation of the initial phonemes of the words provides the PWS an extra time to plan and select appropriate phonemes from their mental lexicon in order to produce the fluent speech. This can further add towards counselling PWS.

- The importance of assessing and intervening various tasks assessing the phonological processing abilities in PWS i.e. incorporating phonological awareness tasks, rapid automatized naming tasks wherein, both the tasks involve phonological memory should be carried out rather than restricting to narration and reading tasks in different situations which is traditionally carried out in therapy programs for PWS.
- Further the knowledge regarding the etiology of any condition contributes towards planning a comprehensive assessment and management, thus this study paves way for the same as it supports the psycholinguistic theories of stuttering.

Limitations of the study

Though, the findings are in agreement with the psycholinguistic theories of stuttering to predict the etiology of stuttering, there are certain short comings in the study which needs to be taken into account prior to concluding several aspects based on the findings of the study. These include the following:

- A major assumption of the study was that the phonological processing skills reflect phonological encoding abilities. However, it cannot be assumed that phonological processing is reflective of phonological encoding, rather further indepth investigation of the nature of phonological processing skills as evidence of phonological encoding abilities is required.

- The study was conducted on limited number of participants in both clinical as well as the control group; hence the generalization of the results is questionable.

Future directions

This study though has resulted in conclusive findings, the study has made way for several other questions that needs to be answered by conducting a similar systematic research which could further contribute to the understanding of the disorder as well as add to the collection of the existing worthy research in the field of speech-language pathology. Some of the questions that can be probed and answered in future based on the study include the following:

- There is a need to conduct the study on large sample size so as to validate the findings of the current study.
- The study can also be conducted in other languages of the country.
- Also, a need is felt to conduct a similar study in children with stuttering so as to study the developmental changes, if any, that exists.
- There is a need to evaluate how the phonological encoding abilities of PWS vary with respect to different severities i.e.: mild, moderate and severe.
- There is a need to evaluate how the phonological encoding abilities vary with respect to the complexity of the stimuli i.e.: trisyllabic versus polysyllabic words.
- Further, there is a need to evaluate the phonological encoding abilities in bilingual adults with stuttering as opposed to monolinguals, which would further contribute to draw conclusions regarding how the differences in

phonological encoding if any between the two languages would contribute to account for differences in severity of stuttering across the two languages.

- Education level is found to have a positive effect on the phonological processing skills of an individual. Thus, studies comparing the phonological encoding abilities among the educated individuals with and without stuttering will be worthy.
- Studies comparing the performance of PWS across the two paradigms i.e. phoneme monitoring paradigm and phonological priming paradigm can also be conducted as both of these paradigms do not require overt responses and tap only on phonological encoding and thus can further contribute to the validation of the results of the current study.
- Investigation of the fast-mapping abilities in children and adults who stutter would also be helpful in determining if the differences uncovered in the current study were the result of difficulties in establishing and/or storing new phonological codes. Learning more about how both children and adults who stutter learn new words and generate new phonological codes could help to clarify some of the questions raised by the results of the current study.

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Appendix

Words	Pictures
/porake/	
/sapota/	
/balapa/	
/tagarU/	
/batani/	

Words	Pictures
/bavuta/	
/kittale/	
/huko:sU /	
/t raka/	

Words	Pictures
/bagilU/	
/tabala /	
/godambi/	
/sakkare/	

Words	Pictures
/mosale /	
/menasU/	
/takadi/	
/ taka /	

Words	Pictures
/t pati /	
/rangoli /	
/nerale/	
/kobbari /	

Words	Pictures
/madike /	
/kamala/	
/badami /	
/hasirU /	

Words	Pictures
/neharU /	
/vivaha /