COMPARISON OF DIADOCHOKINETIC RATE AND RATE OF SPEECH IN CHILDREN WITH AND WITHOUT STUTTERING

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A Dissertation Submitted in Part Fulfilment of Degree of Master of Science

(Speech-Language Pathology)

University Of Mysuru

Mysuru

CERTIFICATE

This is to certify that this dissertation entitled **" Comparison of Diadochokinetic rate and Rate of Speech in Children with and without Stuttering "** is a bonafide work submitted in part fulfilment for degree of Master of Science (Speech-Language Pathology) of the student (Registration Number: 14SLP029). 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 other Diploma or Degree.

Mysuru
May, 2016

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DECLARATION

This is to certify that this dissertation entitled **"Comparison of Diadochokinetic rate and Rate of Speech in Children with and without Stuttering"** is the result of my own study under the guidance of Dr. Y. V. Geetha, Professor of Speech Sciences, Department of Speech-Language Sciences, All India Institute of Speech and Hearing, Mysuru, and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru
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Dedicated to,

Shree Raghavendra Swamy

My beloved Daddy & Amma

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Chapter I

INTRODUCTION

Speech is a complex motor activity distinctive to human race. Speech motor control refers to the systems and strategies that are responsible for the smooth and coordinated processes of breathing, phonation and articulation (Andrade, Queiróz & Sassi, 2010). The ability to control voluntary sequential motor speech movements (required for the positioning of articulators during the production of phonemes) depends on the accuracy of the motor commands and on the smoothness of the transition between articulatory positions (Andreatta, Barlow, Biswas & Finan, 1996). Speech may be subjected to variability and disruptions at different levels of speech processing owing to its complex nature. Fluency is one of the finer aspects of speech which would get disrupted due to in-coordination between any of the speech production systems. Fluency is defined as production of long continuous effortless utterance, at a rapid rate (Starkweather, 1981). There are many conditions where speech fluency could be impaired and stuttering is one such important condition.

Van Riper (1982) defined "Stuttering as a disruption of the simultaneous and successive programming of muscular movements required to produce a speech sound or its link to the next sound in a word. Anticipation of this programming difficulty can then cause struggle and avoidance reactions which are secondary, variable and learned".

Stuttering is a speech disorder where speech disruptions are typical and is characterized by uncontrolled repetitions of sounds and syllables, sound prolongations and articulatory blocks. Perhaps the best-known description of stuttering is given by Wingate (1964). According to him, 1. "Stuttering refers to (a) disruption in the

fluency of verbal expression, which is (b) characterized by involuntary, audible or silent, repetitions or prolongations in the utterance of short speech elements, namely: sounds, syllables, and words of one syllable. The disruptions (c) usually occur frequently or are marked in character and (d) are not readily controllable. 2. Sometimes the disruptions are (e) accompanied by accessory activities involving the speech apparatus, related or unrelated body structures, or stereotyped speech utterances. These activities give the appearance of being speech-related struggle. 3. Also, there are not infrequently (f) indications or report 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. (g) The immediate source of stuttering is some in-coordination expressed in the peripheral speech mechanism; the ultimate cause is presently unknown and may be complex or compound."

Theories of stuttering provide different viewpoints of the disorder and can ultimately impact on how the disorder is evaluated and treated. Theories on etiology of stuttering describes the circumstances under which stuttering first develops (Bloodstein, 1995).

Most theories of the causes of stuttering postulate that multiple factors are involved in producing these motor breakdowns, including genetic, linguistic, and psychosocial factors (e.g., Starkweather, Gottwald & Halfond, 1990; Wall & Myers, 1995). There is a strong body of evidence suggesting that stuttering is a hereditary disorder which is a manifestation of dysfunction in central motor speech control. The impaired ability of the basal ganglia to produce timing cues for the initiation of the next motor segment in speech is the core dysfunction evidenced (Alm, 2004).

Accordingly, underlying instabilities in the speech motor systems of individuals who stutter are believed to be reflected as overt disfluencies. Empirical support for this view is provided by articulatory kinematic evidence of reduced speech motor stability in adults who stutter (Kleinow & Smith, 2000) and subtle fine motor deficits reported in PWS in other motor systems (Forster & Webster, 2001). Loucks and De Nil (2006) studied verbal-motor deficit in adults with stuttering which hinted that there were less movements and flexibility in adults with chronic stuttering compared to the controls in the absence of visual feedback.

Findings that people who stutter (PWS) often differ from controls in terms of the variability speed, and relative timing of their articulatory movements when producing perceptually fluent speech are well established (Kleinow & Smith, 2000; Max & Gracco, 2005; McClean, Tasko & Runyan, 2004).

Stuttering is a disorder of childhood wherein the onset occurs in more than 90% of individuals before the age of 6 years. According to Bloodstein, Bernstein and Ratner (2007), the onset of developmental stuttering occurs at any age from early years to approximately age nine. The prevalence of developmental stuttering is approximated to be 1% with the life span incidence of up to 5% (Guitar, 1998). The proportion of boys to girls who stutter is higher and increases with age. That is, in the preschool years, the ratio of boys to girls is 2:1 but this ratio goes up to 4 or 5:1 in older, school-aged children and adults, which reflects discrepancy of spontaneous recovery among boys and girls (Drayna, Kilshaw, & Kelly, 1999). Genetics plays an important role in the cause of developmental stuttering, as evidenced by research studies of identical and fraternal twins, and studies of family histories of stuttering. In

addition, persistence and recovery from developmental stuttering appear to have a genetic basis (Yairi, Ambrose & Cox, 1997).

While genetic view of stuttering explains cause of stuttering to have strong genetic basis, other models like that of Demand capacity model (DCM; Starkweather, 1987) focuses on different aspects of cause-effect relationship in children with stuttering (CWS). This model proposes that the cause of stuttering is due to the result of person`s capacity to produce speech which is not adequate to meet the demands placed on him. It is proposed that disfluent speech arises when the balance between a child's capacity to produce fluent speech and the demands placed on the child is not maintained. Capacities are considered as inherited tendencies, strengths, weakness and perceptions in motor, linguistic, socio-emotional and cognitive skills. The sources of demand include environmental, communication partner and/or stutterer`s itself (Adams, 1990). The DCM model recommends that slowing rate of speech when communicating with a child who stutters would reduce the demands, and in turn provides more chance for the child to speak fluently. Siegel (2001) anticipated to consider a change in the emphasis of the model from demands and *capacities* to demands and *performance*. This was suggested because Siegel felt that capacities cannot be completely identified and independently measured, particularly in a clinical background. As a support of the view stated in DCM, Conture (2000) proposed a terminology "performance gap hypothesis". This explains that there is a mismatch between child`s speaking rate (reaction of the child to environmental demand) and DDK (capacity of the child) which highlight that speaking at faster rate in turn serves as a factor increasing likelihood of stuttering. However, this study has not revealed a direct relationship between the speaking rates of individuals in a child's environment

and the child's own speaking rates (Bernstein Ratner, 1992; Yaruss & Conture, 1995; Zebrowski, Weiss, Savelkoul & Hammer, 1996).

Hall, Amir and Yairi (1999) stated two main theories related to rate of speech and stuttering. The psycholinguistic model suggests that children and adults with stuttering need more time to process language related and phonologically related information. This delay lowers the fluency level in persons with stuttering (PWS) than in persons with no stuttering (PWNS). Another theory considers stuttering as a neuro-motoric and rhythm disorder, which links to articulatory rate and in turn controls compensatory articulatory movements. Evidences from research studies have shown possible relation between dysfluency and fast rate of speech. However, these are inconclusive (Vanryckeghem, Glessing, Brutten & McAlindon, 1999). Hall, Amir & Yairi, (1999) considered articulatory rate as a more efficient measure of time taken by speaker to execute overt speech and they also observed different articulation rate in conversation in terms of number of phones in a second which discriminated CWS from CWNS. Kloth, Kraaimaat, Janssen and Brutten (1999) investigated the articulatory and linguistic skills in persistent and recovered groups of young CWS and even the communicative and speaking behaviors of their mothers before and after the onset of stuttering in the high risk (with family history of stuttering) group. It was found that the articulatory skills of the children under study, measured before and soon after the onset of stuttering, distinguished between those youngsters for whom this disfluent behaviour would persist or remit. Children with persistent stuttering had a greater variability of rate of articulation than the ones who recovered. This greater variability in persistent group shows less developed speech motor system. In other investigations, younger CWS produced faster articulatory movements in either fluent or disfluent speech (Throneburg & Yairi, 1994; Zebrowski, 1994; Kowalcyzk &

Yairi, 1995). These findings support the hypothesis of Conture and colleagues (1993) who believed that CWS speak faster than the abilities they have. Meyers and Freeman (1985) believed that more the children stutter, slower they talk during fluent speech.

In a variety of disorders speech and language, evaluation includes the usage of maximum performance (Kent, Kent & Rosenbek, 1987; Wit, Maassen, Gabreëls & Thoonen, 1993). The DDK rate can be considered as one measure of the oro-motor capacity of an individual. It is the process by which the ability to carry out rapid repetitions of effortless patterns of opposite muscular contractions (Baken & Orlikoff, 2000). The diadochokinesis (DDK) tasks have been employed in both clinical assessment and research areas as a tool to assess an individual's speech motor skills. According to literature, diadochokinesis provides hint to articulatory placement and acoustical index of motion speed. This rate also provides information about an individual`s ability to make quick speech movements using different speech articulators. A child`s capacity to rapidly move her/his articulators can be assessed using DDK which could be used in comparison with child`s speaking rate in conversation.

Since DDK is established as a tool to measure the speed, range and coordination between the speech articulators, it can be used as an effective task to study the speech motor abilities in children with stuttering. Some studies on DDK rates of CWS have suggested that on the performance during speech motor task a large percentage of CWS showed oral motor problems (Olander, Smith & Zelaznik, 2010). Yaruss, Logan and Conture, (1995) showed statistically significant differences in SMR tasks only between fluent and CWS, which suggests that children with no stuttering (CWNS) were able change their speech articulatory positions more quickly

than CWS. Andrade, Queiroz and Sassi (2010) noted a significant difference for SMR, that the group of CWNS presented a better ability to quickly move their speech articulators. They postulated that when the AMR and SMR tasks are compared, the SMR task presented a higher motor demand which involves deficits in planning or in motor programming.

In an earlier study, Lass and Sandusky (1971) failed to demonstrate a strong association between Oral- DDK and speech rates, whereas later studies (Ackermann, Hertrich & Hehr, 1995; Ziegler, 2002) found that DDK rates were highly correlated with speaking rate, as well as with other measures of speech impairment. Alternatively, one may relate oral-DDK performance, specifically to articulation (rather than speaking) rate, a measure for fluent speech excluding disfluencies, long pauses or speech breaks (Hall, Amir & Yairi, 1999). Yet the relation between speech and oral-diadochokinetic rates is somewhat debated in the literature.

Need for the study:

Very few studies establish a link between a child's capacity and performance for fluent speech, measured in terms of DDK and articulatory rate. Moreover, results of these studies are debatable, making it difficult to conclude. Studies pertaining to DDK rates in CWS and CWNS are highly limited. Within the Indian context, there are limited studies, to draw a relationship, if any, among the two measures. From the research findings stated earlier, one can assume the presence of a relationship between stuttering and the variables like articulatory rate and diadochokinesis. These variables give an insight regarding the cause of stuttering, severity of the disorder, recovery and other aspects of stuttering. Hence, research on these lines might be of theoretical as well as clinical importance.

Aim

The primary aim of the current study was to investigate whether the CWS differ in terms of coordinating speech articulators during speech task (rate of narrated speech) and non-speech task (DDK rate) when compared to CWNS.

Objectives: The specific objectives of the study were:

1. compare the capacity and performance of speech articulators using DDK and rate of speech between CWS and CWNS
2. compare if CWS and CWNS differ with respect to AMR and SMR

Chapter II

REVIEW OF LITERATURE

Speech is a sensorimotor process that involves active strength regulation between the motor system and the vocal tract. Andreatta, Barlow, Biswas and Finan (2010) stated that "the ability of sequential motor command (necessary for the adequate positioning of the articulators during volitional phoneme production) depends also on the motor commands of precision and smoothness in articulatory transition during volitional speech production". Oliveira, Ribeiro, Merlo and Chiappetta (2013), defined "fluency as one of the aspects of speech production pertaining to continuity, smoothness, speech rate and/or effort through which phonological, lexical, morphological and/or syntactic language units are expressed and it has also been described as a multifaceted phenomenon, composed of various elements, such as disfluencies, effort/strain, speech rate and silent pauses". As described by some literature resource, stuttering is caused due to inappropriate control of speech timing. Individuals with stuttering exhibit difficulty in moving from one sound to other sound in a word and also exhibit difficulty in initiating sound production.

2.1 Rate of Speech

Rate of speech is the speed at which a person speaks. Pellowski, (2010) defined rate of speech as "the speed at which speakers shape and configure their oral cavities to perform articulatory movements necessary for speech production". Rate of speech is usually known to reveal a processing demand that may result in increased instances of disfluencies. Generally, in terms of minute, rate of speech can be calculated in two ways: words per minute (wpm) and/or syllables per minute (spm).

Walker and Black, (1950) reported that average rate of adult speakers of English is 5-6 syllables per second. Paucity in implications of these findings remain, as rate of speech is a susceptible characteristic of speech that can be influenced by several potential factors such as type of the syllable, length of the utterances, type of the speaking situation, perception of the information transmission, language proficiency, familiarity of task, interest of the speaker, word length, cultural aspects and cognitive aspects which needs to be considered.

2.2 Stuttering and rate of speech in CWS

It is a widely evidenced notion that there is a relationship between stuttering and speech rate, even though the nature of this relationship is not yet well understood. Much attention has been given to the rate of speech of CWS during therapeutic practice, and a commonly used therapy approach is advising parents of CWS to slow their own speech rate while conversing with their CWS (Meyers & Freeman, 1985). Theories put forth by researchers regarding the speech rate of CWS state that they may speak faster than they are able to co-ordinate their articulators (Conture, Louko & Edwards, 1993; Kloth et al., 1995). In contrast, Meyers and Freeman (1985) have found that CWS speak slower than their fluent counterparts and some other studies have also reported inconsistencies in the differences between speech rate of CWS or CWNS (Kelly & Conture, 1992; Yaruss, Logan, & Conture, 1995). Furthermore, Dawson, (1929) has reported that the rate of speech of girls were faster when compared to that of boys until the age of 12.

Jannsesn, Kraaimaat and Brutten, (1995) reported that those children who developed stuttering later in their life had faster rate of speech than their normal fluent peers before the onset. Contrastively, Hall, Amir and Yairi, (1999) reported that those

children who recovered from stuttering exhibited a slower rate of speech than those whose stuttering had persisted. Meyers and Freeman (1985) suggested that mothers of CWS spoke faster to their own children, than mothers of CWNS. They found that CWS spoke at a slower rate of speech than CWNS. The similar trend was also observed with respect to degree of stuttering, and amount of stuttering, i.e. those children diagnosed with severe stuttering were speaking at a slower rate than children who had been diagnosed with moderate stuttering and the more the children stuttered, the slower they talked during fluent speech instances and faster their mothers talked while interacting with their own children. Guitar, Schaefer, Donahue and Bond (1992) also reported a strong correlation between mother`s rate of speech and her child`s amount of stuttering. They speculated that speech rate contributes to the onset, development and maintenance of stuttering. Moreover, the number and duration of both filled and silent pauses have also been found to strongly correlate with expert's ratings of perceived fluency of language during spontaneous speech (Cucchiarini, et al., 2002).

Researches also reveal speech rate differences across ages and tasks. The rate of speech slowly increases as children progress from the preschool years through the upper elementary-school years (Logan et al., 2011). Based on their findings, Shipley and McAfee, (2008) stated that the conversational speech rate for kindergarteners is around 125 wpm. Sturm and Seery (2007) conducted a study in typically developing children and results revealed that the average conversational speech rate for 7-year olds was 117.7 wpm (range of 91.1-152.3) and the average speech rate for narratives was 124.6 wpm (range of 86.7-153.5). Tilstra and McMaster (2007) elicited narratives from kindergarten children using a single picture prompt and observed that their

average rate of speech was 58.6 wpm specific to task. Rate of speech continues to increase until about age 11, and then attain plateau.

Studies have also examined the differences between native speech (L1) and speech in a person's second language (L2) and have found that the overall rate of speech in L2 is slower when compared to native speech (Garcia, 1991; Derwing & Munro, 1997; Prezas, 2008). Prezas (2008) explored rate of speech in bilingual children and found that the average rate of speech in Spanish (L1) was 76 sps, while in English (L2) the average rate was significantly lower (61sps). In line with the above findings, Garcia, (1991) proposed that bilingual speakers take longer to process both of their languages and in turn have slower rate of speech. Sargent, Robb and Zebrowski (2006) investigated the rate of speech of 5 CWS and 5 CWNS and reported that CWS spoke slower than fluent counterparts. In summary, there is no unified view that CWS speak at a different rate to CWNS.

Yaruss, Newman and Flora, (1999) investigated rate of speech of 18 children (9 CWS and 9 CWNS) between 4-5 years of age and found that 9 CWNS showed a strong correlation between articulatory speaking rate and their diadochokinetic rate whereas other 9 CWS showed a negative correlation between rate of speech and DDK which was low. Based on these findings, authors speculated that those children who exhibited positive correlation speak at rates equivalent to their inherent abilities and in contrast, CWS may attempt to speak at higher rates that exceed their abilities and compromise the swift and precise movements of their articulators. Authors also found that children who demonstrated faster DDK produced higher number of errors than children with slower DDK rates and stated that production of more errors is probably due to exceeding their inherent abilities to precisely and rapidly move their

articulators. In agreement with the above findings, a study done by Kloth, Kraaimaat, Janssen and Brutten (1999) also indicated that those CWS speak more faster than the abilities they have and that the high risk children who developed stuttering subsequently on follow up differed with their peers only with respect to their speaking rates.

Some authors (Kowalcyzk & Yairi, 1995; Throneburg & Yairi, 1994; Zebrowski, 1994) revealed that young CWS produced faster articulatory movements in both fluent and dysfluent speech. The relationship between stuttering and speech rate has been extensively studied evaluating the moments of stuttering. Explanations regarding the relationship between speaking rate and stuttering include: (1) that CWS attempt to speak faster than they are physically capable of (Conture et al., 1993) and (2) that parents of CWS put them under unnecessary pressure by conversing to them at a rapid rate of speech (Costello & Ingham, 1984).

Rate of speech has also been examined by many researchers in AWS, and concluded that fluency increases as rate of speech decreases (Onslow & Ingham, 1987; Zebrowski & Kelly, 2002). Logan and LaSalle (1999) found that fast speaking adults tends to demonstrate more occurence of disfluent clusters in their speech. Dailey, Hall and colleagues (1999) found that pre-school CWS exhibited significantly slower rate of speech (7.7–10.2 pps) when compared to CWNS peer group whose articulation rates were 11.4–12.2 pps. On the other hand, Yaruss and Conture, (1995) found no articulation rate differences between pre-school CWS and CWNS while reporting the data in syllables per second (sps). Similarly, Tumanova, Zebrowski, Throneburg and Kayikci, (2011) investigated rate of speech in pre-schoolers and

speculated that as the stuttering occurs more frequently and prolongation duration of a sound is longer, child`s articulatory rate will be slower.

Johnson in 1980 reported that 7 of the preschool CWS of age 3-6 years produced a mean syllable rate which reduced from 182 to 163 syllables per minute at pre and post therapy respectively. Mason (1981) found a mean syllable rate of 171 syllables per minute for 18 preschool CWS between 2-8 years of age during their fluency follow-up. Meyers and Freeman in 1985 found that 12 CWS preschoolers showed significant slower articulation rate with mean value of 3.51 sps and also found that CWNS produced mean of 4.18 sps. Richardson (1985) reported the mean rate of speech for twelve CWS was 201.0 spm and articulation rate was 4.0 sps and in CWNS the mean rate of speech was found to be 195.9 syllables per minute (spm) and mean articulation rate was found to be 3.7 sps where pause time was excluded in rate of speech measure.

In 1989, Pindzola, Jenkins, and Lokken presented rate of speech normative data for 30 CWNS of age 3 years, 4 years and 5 years in conversational speech and found the total mean rate of speech as 148.4 spm and mean articulation value of 179.3 spm respectively. In the speech of 14 preschoolers who stutter, Chon and colleagues (2012) found that in preschoolers longer utterances reflected slower rate than shorter utterances, considering only fluent part of their utterances. In this regard, the authors speculated that in these children a slower articulation rate surrounds the stuttered words as a possible compensatory behavior for the increased speech motor and linguistic demands of these longer and more complex utterances. In other studies that have also used similar method have found a trend for the disfluent utterances to be somewhat slower, but not significantly slower when compared to perceptibly fluent

utterances, both in pre-school and school age CWS (Chon et al., 2012; Logan & Conture, 1997; Sawyer, Chon, & Ambrose, 2008; Yaruss & Conture, 1996; Logan et al., 2011).

Jayaram (1976) analyzed stuttering pattern linguistically in 2 Kannada-English bilingual adults of mean age 26 years. The participants were interviewed informally and given topics to talk about them in both the languages and asked questions in both languages to elicit spontaneous speech and were also given reading passage to read in both languages. Results indicated that the rate of speech is same in both the languages for both the participants except in reading task which showed reduced rate of speech. Subject 1 had rate of speech of 169.60 wpm in English and 101.3 wpm in Kannada for reading task whereas, subject 2 had rate of speech of 110.60 wpm English and 67.50 wpm in Kannada. This result signifies that stuttering is purely motoric phenomenon and it does not vary across languages.

Rathna and Bharadwaja (1977) did a study across Indian languages to find out the rate of speech in reading tasks in words per minute in Hindi, Punjabi, Kannada, Tamil and Marathi and found 198, 163, 193, 127 and 131 languages respectively. Likewise, Deepti and Anuradha (2011) studied speaking rate in 20 Punjabi speaking persons ranging from age 18 to 40 years and found that the rate of speech was significantly higher in reading task than picture description task.

Even though rate of speech is an important parameter there are very few studies done on this in Indian context. Due to difference in linguistic structure in Dravidian and Indo-European languages, probably the rate of speech might also differ. Hence, to see this Savithri and Jayaram (2004) did a study and reported that there was difference in rate of speech in speaking and reading task across age groups

and 4 Dravidian languages such as Tamil, Kannada, Telugu and Malayalam in terms of syllables per second, syllables per minute and words per minute. Results showed that Malayalam people exhibited highest syllable rate per second as well as syllable per minute compared to other 3 languages and rate of speech increased with age through 40 years of age and declined after 40 years in all languages except in Tamil language.

Ravi Kumar and Savithri (2008) aimed to compare the rate of reading in Manipuri and Kannada language across gender. They took 10 native speakers of Manipur and Kannada in each group in the age range of 18 years to 25 years. All the subjects were literates and recruited from urban population. A standard reading passage in Kannada and a story passage in Manipuri were used as stimuli for reading tasks. Subjects were instructed to read the passage. All reading samples were audio/video recorded. The pauses in the samples were truncated and the rate of reading was measured as syllables per seconds, syllables per minute and words per minute. Their findings indicated a significantly faster rate of reading in Kannada relative to Manipuri and no gender differences were noticed.

Kapoor, Kaur, Singhal and Dass (2011) examined normal rate of speech in 10-14 years old age group (20 males and 20 females) Punjabi speaking children who had normal speech fluency. The study utilized various speech tasks such as reading passage task, picture description and spontaneous speech. The results revealed that the rate of speech is 148-216 wpm during reading task; 139-171wpm during picture description task and 127-156 wpm during spontaneous speech. The rate of speech was observed across gender and found that males did not differ significantly from females.

The rate of speech was found to be higher in reading task than picture description task and spontaneous speech in both genders.

2.3 Diadochokinetic rate (DDK)

The accuracy of motor command and the smoothness of transition of articulators reflect the ability of controlling sequential speech motor voluntary movements. DDK is also involves alternate motion rates (AMR) and sequential motor rates (SMR), both used to measure the speed necessary to stop firm motoric impulses These DDK tasks can be used to check neurological ability of a person. DDK acts as acoustical index for motion speed and articulatory placement. This reflects both neuromotor maturation and the integration of structures involved in speech, such as the lips and tongue.

While explaining the speech motor control process in CWS, few facts suggest that this population show larger percentage of oral-motoric problem and also exhibit difficulty in planning and /or programming speech movements, as evidenced by their speech motor performance during their speech production. Based on few observations, during standard DDK production task, typically developing children also exhibited frequent errors (Canning & Rose, 1974; Williams & Stackhouse, 2000).

To assess the speech motor abilities in children with speech and language disorders oral diadochokinetic (DDK) rates are usually used (Bernthal & Bankson, 1997; Conture, 2001; Conture & Caruso, 1987; Curlee, 1993; Hale et al., 1992; Maassen, Thoonen, & Wit, 1991; Williams & Stackhouse, 2000). DDK rate is considered as a subsystem of rate of speech wherein the person has to move his/her articulators as fast as s/he can to produce the syllables. It measures the rate at which an individual can repeat a syllable rapidly, clearly, loudly, and rhythmically in two

ways (AMR and SMR). It also gives information regarding the person's ability to control his/her articulators and the speaking ability/capacity of that individual. Generally, DDK rate can be used to determine how rapidly a child can repeat strings of nonsense syllables, such as "puh" or "puh-tuh-kuh" and usually a speech language pathologist assesses this (e.g., Fletcher, 1972). Most of the studies speculated that DDK rates increase as the child`s motor system matures and the task outputs the speed with which a child moves his/her speech articulators, which approximates with the spontaneous speech (Kent et al., 1987; Henry, 1990). It is noted that by 9-10 years of age adult-like DDK rates will be achieved (Canning & Rose, 1974) or by age 15 (Fletcher, 1972), which depends on the criteria used to show adult like performance. Findings from prior studies show that preschool children were able to produce approximately one trisyllabic token ("puh-tuh-kuh", or "pattycake") per second by 6 years of age and the rate increases to approximately 1.5 trisyllables per second (Robbins & Klee, 1987).

There are few parameters traditionally measured with respect to DDK rate measures. The Average Diadochokinesia Period (DDKavp), in milliseconds is the average time between every consonant vowel vocalizations defines the average period. This period has inverse correlation with rate. For average syllable duration, the normative reference mean value is 171.18 ms. The second parameter is average diadochokinesia rate, this is described by the number of consonant vowel vocalizations per second. This rate is inversely related to average period. 5.89 sps is the normative mean reference value for the average period. The Coefficient of Variation of Diadochokinesia Period (DDKcvp) in percentage was one of the parameters related to the utterance perturbation. This parameter is used for measuring the degree of rate variation in average period. This number shows lesser value if there is a

repetition of consonant vowel vocalizations with seldom variations in rate. An individual ability to maintain constant rate during the repetition of syllables is assessed by this parameter. The adequate value of 6.00% of variation of the rate is considered in the software. Other parameter of perturbation which is also expressed in percentages is Perturbations of Diadochokinesia Period (DDKjit). It measures the cycle-cycle variation in the period and it assesses the ability to maintain constant rate of the syllable repetition. 1.25 % of cycle to cycle variation forms the reference value.

Coefficient of Variation of Diadochokinesia Peak Intensity (DDKcvi %) was the last parameter that was selected. This measures the degree of intensity variation in the peak of each consonant-vowel vocalization. It assesses an individual's ability to maintain constant amplitude of the syllables repetition. If they do not exceed 1.90% of mean variation, then the variation of the parameter was considered to be normal (Padovani, 2008). All these values are with references to adult normality.

2.4 Stuttering and Diadochokinetic rate in CWS

Although a few direct comparisons of DDK rates produced by CWS and CWNS have not showed any significant group differences, few recent studies demonstrated significant group differences only in SMR task between CWNS and CWS, suggesting that CWNS were able to change the positions of articulators more quickly than CWS. It is reported that for SMR task performance high motor demand is needed.

Russell (1941) reported a study based on the rate of diadochokinetic movements of the jaw at the ages from seven to maturity. The subjects selected were 21 normal males, 18 normal females, 18 male stutterers and 18 female stutterers. He concluded that there is increase in rate of DDK of jaw from the age of 7 to 18 years, but

statistically the rate of DDK movement does not closely correlate with the age. The female norm established in this study is greater than the male norm for DDK. There seemed to be no correlation with age after 17.

Riley and Riley (1979) suggested that a large percentage of CWS exhibit oral motor problems, as evidenced by their performance during the DDK task. Still, direct comparisons of DDK rates produced by children who stutter and their normally fluent peers have revealed no significant between-group differences (Wolk et al., 1993; Yaruss, Logan, & Conture, 1995). Thus, although DDK rates are commonly assessed in children with various speech or language disorders, the clinical implications of fast or slow DDK rates are not entirely clear (Kent et al., 1987; McDonald, 1964; Tiffany, 1980).

Haswlager, Slis and Rietveld (1991) conducted a study to investigate the development of rate of speech in children in the age range of 5-11 years. Both DDK and spontaneous speech sample were collected. Result indicated that rate of speech increases with age and is higher in longer utterances than in shorter utterances. Spontaneous speech rate and the DDK rate were found to be weakly related and also showed no differences between genders for both the groups.

Yaruss, Logan and Conture, (1995) speculated through their findings that stuttering could be associated with a discrepancy between a child`s performance in speaking and articulatory speaking rates and also speaking ability which is typically indicated by DDK rates. The rate at which syllables can be produced continuously is determined by the degree of coarticulatory overlaps and speed of articulation movement (Gay, 1978; Starkweather, 1981). Yaruss et al. (1995) compared 9 CWS and 9 CWNS using measures of rate of speech and DDK rate to examine relation

between children`s performance and speaking ability. They found a strong positive correlation in CWNS between these tasks, highlighting that CWNS speak at rates that are in line with their abilities, while CWS exhibit a mild correlation suggesting that CWS may attempt to speak exceeding their capacity to move their articulators more rapidly and more precisely. According to DCM, it can be inferred that CWS were placing more demand on their speech motor system to speak at rates exceeding their capacity for speaking rapidly.

The use of DDK in the assessment of children's speech development appears to be relatively widespread, and some studies have shown clear differences in performance on oral DDK tasks between children with impaired speech and children with typically developing speech. (Dworkin, 1978, 1980; McNutt, 1977; Wolk, Edwards, & Conture, 1993).

The study by Yaruss (1997) also supports notion that CWNS exhibits a transaction between production rate and accuracy in DDK task, especially children who produced faster rate for SMR /pataka/ nonsense trisyllable and also showed more errors than children who produced slower DDK rates. This finding was interpreted as showing that the children who produced more errors were actually exceeding their ability to rapidly and precisely move their articulators in a speech related task.

Zackiewicz et al in 1999 used DDK to analyse oral movement rate in children with persistent developmental stuttering and in normally fluent children. The research group included 19 CWS and the control group included 31 CWNS. Results of the study revealed that there were similarities in performance in DDK task for both CWS and CWNS. However, statistically significant differences were observed for sequential /pataka/ movement, where CWNS performed better.

Diadochokinetic speech rate, which is used to assess speech motor skills and articulation abilities, also increases as a child's motor system matures. When children in kindergarten were asked to repeat the phrase "pətəkə" for one minute, the normal diadochokinetic rate was 1.14 to 1.45 repetitions per second (St. Louis & Ruscello, 2000). Prathanee, Thanaviratananich and Pongjanyakul (2003) studied the oral DDK rates for normal Thai children between the age range of 6 and 13. The participants were197 in number and were instructed to repeat 20 monosyllabic (/pa/, /ta/, /ka/ and /la/), 15 bisyllabic (/pata/, /paka/) and 10 trisyllabic (/pataka/) utterances. Analysis was done using the software Visi Pitch. The findings of the study revealed that the average rate for /p/ was 4.55, for /ta/, /la/ and /ka/ was 4.58, 4.82 and 5.87 seconds and (/pata/, /paka/) and (/pataka/) were 6.97, 7.52 and 6.85 seconds respectively. There was age and gender influences on oral DDK time. Differences among boys and girls were significant for /pa/, /ta/ and /ka/. Boys tended to be faster than girls. However, gender effect was not consistent across research.

Juste, Rondon, Sassi et al (2012) analysed Diadochokinesis acoustically in 20 fluent and 26 CWS of preschool and school aged children. The results revealed significant differences between age groups independent of speech fluency in which preschoolers performed poorer, which suggest differences are related to speech motor age development and not to only stuttering. The outcome of various researches have indicated that as the motor systems of children mature, the DDK rates were also found to be increasing (Kent et al., 1987; Henry, 1990), and by 9-10 years adult like rates are achieved (Canning & Rose, 1974) or by age 15 (Fletcher, 1972). Studies have also shown that DDK rates are highly variable, both within and between participants, in which higher variability was apparent for the younger age groups (Canning & Rose, 1974; Robbins & Klee, 1987; Williams & Stackhouse, 2000). Various authors have

documented that articulator movement variability is greater in children than adults (Sharkey & Folkins, 1985; Green et al., 2002; Grigos, Saxman & Gordon, 2005). Physiologic findings indicate that oro motor coordination (i.e., lip and jaw movement) remains more variable for 8 years old than for younger adults at 14 years of age (Smith & Zelaznik, 2004). This finding suggests that maturation of speech motor control continues to develop throughout adolescence. Although coordination between lips was shown to be more variable in children at 14 years of age than in adults, a plateau in performance was observed between 7 and 12 years of age (Smith & Zelaznik, 2004).

Michal Ichta, Boaz M. Ben-David (2013) did a study aimed to establish a normative for oral-DDK rate in (young to middle-age) adult English speakers as well as in Hebrew speakers, by collecting data from the literature and to investigate the possible effect of language (and culture) on oral-DDK performance. They first offered an English norm with a mean of 6.2 sps, and a lower boundary of 5.4 sps that can be used to indicate possible abnormality. Next, they found significant differences between four tested languages (English, Portuguese, Farsi and Greek) in oral-DDK rates. Results suggest the need to set language and culture sensitive norms for the application of the oral-DDK task world-wide. Finally, they found the oral-DDK performance for adult Hebrew speakers to be 6.4 sps, not significantly different than the English norms. This implies possible phonological similarities between English and Hebrew.

Zackiewicz in 1999 conducted a study on 70 AWS (51 male and 19 female) to correlate the stuttering severity index with one of the indices for assessing fluency/speech rate. All were native speakers of the Brazilian Portuguese language. A

speech sample from each participant containing at least 200 fluent syllables was videotaped and analyzed according to stuttering severity index test and speech rate parameters. The results obtained in this study indicate that the stuttering severity and the speech rate present significant variation, i.e., the more severe the stuttering is, the lower the speech rate in words and syllables per minute. In a very mild stuttering the mean number of words per minute was 80.61 and in a very severe stuttering this number was 44.98. The difference between the stuttering severity indices also indicated progressive decrease, i.e., the more severe the stuttering, the lower the articulation ability. In very mild stuttering the mean number of spm was 146.31 and in a very severe stuttering this number was 80.77.

Castro and Wertzner (2011) studied oral DDK using the MSP software in typically developing Brazilian Portuguese speaking children in the age range of 8-10 years old. The results indicated that the mean number of syllables per second ranged from 4.8 to 5.2 for /pa/, between 4.9 and 5.4 for /ta/ and between 4.3 and 5.1 for /ka/. Wong et al (2011) conducted a study to report the motor speech characteristics in healthy paediatric population. This was conducted in 112 subjects (58 males and 5 females) aged 4 to 18 years. Subjects were divided into 3 sub groups (4-8 years, 9-13 years and 14-18 years). Speech samples were recorded and analysed using MSP software. Results indicated that there was an increase in average DDK rate and standard syllabic duration with age. There were no identified differences in motor speech characteristics between males and females across the measured age range. The average DDK rate among children aged 4-18 years was 5.07 syllables/ second. DDK rate increased with age in both males and females.

John et al (2012) conducted a study to establish norm for adult Kannada speakers in motor speech profile. In their study, native Kannada speakers (n=300) were divided into three age groups (20-40, 41-50 and 51-60 years) with 50 males and 50 females in each group. The obtained data are reported across age and gender for the parameters of DDK, second formant transition and voice and tremor characteristics of MSP software. The findings indicated that there was an overall age and gender effect for all the parameters. Similarly, the normative data for adults in the age range of 20-60 years was developed by Manjula and Patil (2014) using MSP software. 400 subjects were divided into 4 age groups (20-30, 30-40, 40-50 and 50-60 years). Results revealed that the DDK value had a significant age and gender effect. In syllabic rate there was no significant age or gender effect.

Wertzner et al (2011) studied the oral motor skills in children with and without speech sound disorder. Subjects consisted of children in the age range of 5-7 years. DDK skills were assessed by the repetition of the sequences /pa/, /ta/, /ka/ and /pataka/ measured both manually and by the MSP software. The findings indicated that there was a significant age effect that was seen for the control group and gender effect was observed for both experimental and control group. Result presented strong agreement between the values of oral diadochokinesis measured manually and by MSP software.

A study was conducted in adults across Nepali and Malayalam languages to compare DDK and rate of speech by Dhakal, Chacko, Vishnu and Sreelakshmi (2015). There were 40 participants in the study and data was collected from picture description and oral reading, mainly for measuring rate of speech in terms of words per minute. DDK rate was also analysed and results revealed there was no

correlation between DDK and rate of speech across languages. Even though, Nepali speakers were found to have faster rate of speech their DDK rates were similar to those of Malayalam speakers. This specifies the need to have independent normative for different languages.

Deepthy (2015) conducted a study to determine the normative data for speech motor characteristics in 4-10 year old typically developing Kannada speaking children and to compare the results across age and gender using MSP software. A total of 90 participants were taken for the study. The participants were divided into 3 subgroups (4-6 years, 6-8 years and 8-10 years). Parameters like DDK rate, second formant transitions (F2), voice and tremor parameters, intonation stimulability, and syllabic rates were assessed using MSP software. In the study the mean values of DDK parameters like average DDK rate (DDKavr), maximum intensity of DDK sample (DDKmxa), average intensity of DDK sample (DDKava), average syllabic intensity (DDKsla) were found to be increasing with age. The results have indicated that there is a significant decrease in the mean value of average DDK period (DDKavp) with increase in age. This could be because of the neural maturation that is taking place with age leading to better coordinated control over musculatures. Overall there was no significant gender effect seen across age groups. Differences in the mean values of the DDK parameters were less in 4-6 versus 6-8 year age group comparison when compared to 6-8 versus 8-10 years. Also, the finding of syllabic rate parameter indicated that the mean value for syllabic rate and percentage speaking time (SLspk) increased with age. It was also observed that the age group difference was noticed more in the comparison between 4-6 versus 8-10 years age groups. Overall, there was no gender effect noticed across age groups. The reason for the above results could be due to neuromuscular maturation and therefore measurements may be one way of

characterizing a child's progression in development in achieving adult like speech motor control.

Chapter III

METHOD

The current study aimed to investigate whether the CWS differ in terms of coordinating speech articulators during speech task (rate of narrated speech) and non speech task (DDK rate) when compared with children with no stuttering (CWNS). The study was carried out as described below.

3.1 Participants:

The study included total of 60 native Kannada speaking participants in the age range of 6-10 years. All the participants were subdivided into 6-7 years, 7-8 years, 8-9 years and 9-10 years. The clinical group consisted of children with stuttering (CWS) and the control group consisted of age and gender matched children with no stuttering (CWNS).

3.1.1 Clinical group:

20 children with stuttering, including 16 males and 4 female participants between the age ranges of 6 years to 10 years were considered for the experiment. The participants in CWS group were recruited from the Department of Clinical Services, AIISH, Mysuru, who availed the OPD or speech therapy services.

Inclusion criteria for the clinical group were:

- Native Kannada speakers
- Normal hearing sensitivity
- No cognitive deficits
- No psychological and neurological deficits

- No sensory impairments
- No motor or physical impairments
- No other associated speech and hearing problems
- No orofacial anomalies
- Should be diagnosed as having stuttering by a qualified speech language pathologist

3.1.2 Control group:

The control group included age matched 40 normal healthy children consisting of 20 males and 20 females, with no history of speech, language and hearing problems or any medical problems. They had similar inclusion criteria except for the presence of stuttering. The participants in the CWNS groups were selected from the nearby schools, matched for age and gender.

3.2 Instrumentation and Materials

1. A Checklist was prepared to collect demographic data and other information from all the participants.
2. Stuttering Severity Instrument -3 (SSI-3; Riley, 1994) was used to diagnose and rate the severity of stuttering.
3. Pictures from the fluency test (Nagapoornima, 1990) and pictures like "The two friends" were used to elicit the speech samples.
4. Kannada Diagnostic Photo Articulation Test (KDPAT; Deepa & Savithri, 2010) was used to screen for articulation

5. Linguistic Profile Test (LPT; Karanth, 1980) was used to screen for language ability in all the participants.
6. Praat software was used to manually analyze the rate of speech in CWS and CWNS and also to remove background noise if present.
7. Video recorder (Sony handycam) and LS 100 audio recorder was used to record rate of speech and stopwatch was used to note down the time for collecting data for the study.
8. The Motor Speech Profile (MSP) module 5145 was used to measure the parameters for the study. It is an integrated software and hardware system from Computerized Speech Laboratory (CSL) Model 4500 (KayPENTAX, Lincoln Park, New Jersey). It provides a reproducible, non–invasive and objective method for assessing DDK in subjects.
9. SPSS software version_17.0 was used for statistical analysis.

3.3 Procedure

Initially informed written consent was obtained from the parents of all the participants and tasks were carried out individually. The data collection for the study was carried out in a quiet room with adequate light and ventilation in the room. The participants were seated comfortably on a chair and data was collected individually from each of the participants.

Initially WHO checklist was used to screen for any associated problems to ensure the participants fulfilled the inclusionary criteria for the study. The parents of all the participants were instructed to fill/ answer the checklist which was developed to collect information regarding the demographic data from all participants including details of stuttering history from CWS. The CWS and CWNS were screened for

language and articulatory abilities using Linguistic Profile Test (LPT) and Kannada Diagnostic Photo Articulation Test (KDPAT) respectively.

Subsequently, general conversation was carried out with the children and later pictures from the Fluency Test (Nagapoornima, 1990) were presented and the children were asked to describe the presented picture. They were also asked to narrate /talk about topics of their choice (like festival, favourite place, zoo and exhibition). Narrated speech samples of not less than 300 words were collected from each participant individually. The rate of speech was estimated by considering the perceptually fluent syllables in each utterance by removing all instances of stuttering like disfluencies like sound/syllable/word repetitions, prolongation, blocks, other disfluencies like interjection, revisions and pauses (greater than 250 ms) based on waveform depiction and audio sample using PRAAT software. The rate of speech in syllables per minute was calculated in narrated speech.

Protocol for obtaining the data on DDK

The MSP software provides option for capturing and analysing DDK parameter. The Diadochokinetic rates (DDK) i.e., both AMR (Alternate Motion Rates) and SMR (Sequential Motion Rates) were obtained from each participant.

AMR was recorded by asking the participant to take a deep breath and repeat the single syllable /pa/ iterations as clearly and as quickly as possible for as long as he/she can; similarly /ta/ and /ka/ were also recorded separately using a mic placed 10-15 centimetre away from participant's mouth. SMR was recorded by asking the child to take deep breath and say the multi syllable sequence /pataka/ as quickly as possible for as long as he/she can. Practice trials were given before the commencement of the actual recording. The AMR and SMR task were recorded three

times. The average of AMR and SMR of 3 recordings were considered for the calculation of rate of DDK in syllable per second.

The DDK parameter was analysed using MSP module. Each sample in AMR and SMR recordings were loaded to the software. The sample were selected and analysed for 6-8 sec. MSP summarises and displays the numerical outcomes automatically. Parameters like Average DDK period (DDKavp), Average DDK Rate (DDKavr), Coefficient of Variation of DDK Period (DDKcvp), Perturbation of DDK Period (DDKjit) and Coefficient of Variation of DDK Peak Intensity (DDKcvi) values were considered in the study.

Statistical analysis

The values of the tasks, i.e., the average AMR and SMR DDK rates and rate of speech of each task were statistically analysed using SPSS (Statistical Package for Social Sciences) software_version 17. Descriptive statistics was done to observe the mean and standard deviation across age and groups. All the data were subjected to the normality test across age and group. The Shapiro-Wilk test was employed to determine the normality of the data distribution. The result showed that most of the data were not following the normal distribution principle. Hence, non parametric test was used to check the age group and group comparison. The non parametric tests used were like, Kruskal Wallis test which was done to see the overall effect of age group. Those parameters which showed a significant difference were further taken up for pair wise comparison. Mann-Whitney U test was carried out to know the group effect. Further, Cronbach's alpha test was obtained for determining the test-retest reliability.

Chapter IV

RESULTS AND DISCUSSION

The study aimed at comparing the capacity and performance of speech articulators by measuring DDK (AMR and SMR) and rate of speech between CWNS (control group) and CWS (experimental group) across 4 age groups (6-7 years, 7-8 years, 8-9 years and 9-10 years).

The parameters which were measured are listed in table 4.1.

Table 4.1 *List of Parameters Measured Under Each Group of Measures*

Sl. No.	Diadochokinetic Rate Related Measures	Symbol	Unit
1.	Average DDK Period	DDKavp	ms
2.	Average DDK Rate	DDKavr	/s
3.	Coefficient of Variation of DDK Period	DDKcvp	%
4.	Perturbation of DDK Period	DDKjit	%
5.	Coefficient of Variation of DDK Peak Intensity	DDKcvi	%

The results of the present study are discussed under major headings which are further compared across age groups.

4.1 Participant details

4.2 Diadochokinetic Rates (DDK) in terms of AMR and SMR

4.3 Rate of speech in Conversational speech and story narration

4.4 Test-retest Reliability

4.1 Participant details

Sixty Kannada speaking participants aged between 6 years to 10 years were recruited and they were divided into CWNS (control group) and CWS (clinical group) and were further subdivided into four groups with respect to age (6-7 years, 7-8 years, 8-9 years and 9-10 years). Each CWNS age group consisted of 10 participants with equal distribution of males and females, and in CWS group each age group consisted of 5 participants with 4 males and 1 female participant.

Table 4.2 *Participant details in CWNS and CWS groups*

Age groups (years)	**CWNS**		**CWS**		**Total**
	Male	Female	Male	Female	
6-7 years	5	5	4	1	15
7-8 years	5	5	4	1	15
8-9 years	5	5	4	1	15
9-10 years	5	5	4	1	15
Total	20	20	16	4	60

A checklist was administered on CWS for extracting information regarding their family, developmental, birth history and about their academic performances. According to the data obtained in CWS group, out of twenty CWS, sixteen children were male and four were female. Two children had family history of stuttering and none of them had history of delayed speech and language development, abnormal structural and functional oral mechanism and academic difficulties and all the children had English has their medium of instruction except one child. All CWS were diagnosed as stuttering; 9 with milder degree, 7 with moderate degree and 4 with severe stuttering.

Table 4.3 *Details of CWS based on Checklist data*

Particulars	Age range (years) in CWS				
	6-7 yrs	7-8 yrs	8-9 yrs	9-10 yrs	Total
Number of subjects (N)	5	5	5	5	20
Positive family history of stuttering	0	0	0	2	2
Delayed speech and language development	0	0	0	0	0
Kannada as a medium of instruction	0	0	0	1	1
Below average academic performance	0	0	0	0	0
Exposure to more than 2 languages	0	5	5	4	14
Abnormal articulation	1	1	0	0	2

4.2 Diadochokinetic Rates (DDK) in terms of AMR and SMR

There were 4 tasks in measuring Diadochokinetic rate - repetition of /pa/, /ta/ and /ka/ (AMR) individually and repetition of /pataka/ together in sequence (SMR). The results are discussed according to each task below.

4.2.1 Comparison of CWNS and CWS on AMR task across age groups

4.2.1.1 Repetition of /pa/ syllable

Effect of age group for the task /pa/

The table 4.4 presents the mean, standard deviation (SD), median, /Z/ value and p values of CWNS and CWS across different age groups for repetition of /pa/ syllable. On observation, it can be noted that the mean values for the parameters like pDDKavr increased with age in CWNS group as well as in CWS group.

Table 4.4: *Mean, SD, Median, /Z/ and p value of CWNS and CWS across age group for AMR task for /pa/*

Parameter(s)	Age Range (Years)	CWNS			CWS			Z-Value	P-Value
		Mean	SD	Median	Mean	SD	Median		
pDDKavp(ms)	6-7	205.99	24.79	200.78	221.88	27.74	240.24	0.735	0.462
	7-8	228.23	46	216.32	251.51	57.51	218.4	0.735	0.462
	8-9	202.03	17.89	203.16	194.06	34.39	182.6	0.49	0.624
	9-10	192.25	24.34	193.71	196.46	20.62	189.53	0.367	0.713
pDDKavr (/s)	6-7	4.91	0.59	4.98	4.36	0.47	4.16	1.71	0.086
	7-8	4.52	0.79	4.62	4.13	0.87	4.57	0.735	0.462
	8-9	4.98	0.49	4.92	5.28	0.9	5.47	0.49	0.624
	9-10	5.27	0.66	5.16	5.13	0.47	5.27	0.367	0.713
pDDKcvp(%)	6-7	33.87	25.9	30.37	31.32	26.1	21.13	0	1
	7-8	43.22	39.96	33.09	45.55	47.53	26.57	0.612	0.54
	8-9	35.78	15.96	33.73	31.44	22.92	20.74	0.735	0.462
	9-10	30.4	25.68	19.77	19.51	11.74	19.07	0.49	0.624
pDDKjit (%)	6-7	6.39	5.31	4.91	6.51	5.55	3.3	0.367	0.713
	7-8	7.82	6.74	6.48	9.3	9.33	5.37	0.612	0.54
	8-9	6.28	2.84	6.3	5.29	4.2	4.41	0.857	0.391
	9-10	5.06	3.96	3.55	3.44	1.97	2.91	0.857	0.391
pDDKcvi (%)	6-7	3.44	1.78	2.87	3.45	0.63	3.36	0.367	0.713
	7-8	3.65	2.12	3.94	4.37	2.93	4.86	0.612	0.54
	8-9	4.17	2.23	3.76	3.88	0.83	4.01	0.49	0.624
	9-10	3.56	1.69	4.10	2.77	1.01	2.51	0.98	0.327

*Note: *p<0.05 **p<0.01*

Mean values of pDDKavp were observed to be reducing with an increase in the age from 6-7 years to 9-10 years in both CWNS and CWS groups. Mann-Whitney U test was performed to compare the results across age groups and it revealed that all DDK parameters - Average DDK period (DDKavp), Average DDK Rate (DDKavr), Coefficient of Variation of DDK Period (DDKcvp), Perturbation of DDK Period (DDKjit) and Coefficient of Variation of DDK Peak Intensity (DDKcvi) for syllable /pa/ has not shown any significant difference across age groups.

Comparison between CWNS and CWS for task /pa/

The table 4.4 reveals the mean values for the parameter pDDKavr. The pDDK syllable/sec rate was higher for CWNS group than CWS group across three age groups except 8-9years. On comparing the overall mean scores of all the parameters for /p/, between CWS and CWNS groups, inconsistent differences were noted. The statistical test results indicated that all of the DDK parameters like Average DDK period (DDKavp), Average DDK Rate (DDKavr), Coefficient of Variation of DDK Period (DDKcvp), Perturbation of DDK Period (DDKjit) and Coefficient of Variation of DDK Peak Intensity (DDKcvi) for /pa/ did not show any significant difference between CWNS and CWS groups.

4.2.1.2 Repetition of /ta/ syllable

Effect of age group for the task /ta/

The table 4.5 indicates the mean, standard deviation (SD), median, /Z/ values and p values of CWNS and CWS across age groups for repetition of syllable /ta/. It can be noticed that the mean values for all the parameters except tDDKavr show lowering trend with increase in age from 6-7 years to 9-10 years in both CWNS and CWS groups. Mann Whitney U test results revealed that all the DDK parameters like average DDK period (DDKavp), average DDK rate (DDKavr), coefficient of variation of DDK period (DDKcvp), perturbation of DDK period (DDKjit) and coefficient of variation of DDK peak intensity (DDKcvi) for /ta/ did not show any significant differences across age groups.

Table 4.5: *Mean, SD, Median, /Z/ value and p value of CWNS and CWS across age group for AMR task for /ta/*

Parameter(s)	Age Range (Years)	CWNS			CWS			z-Value	p-Value
		Mean	SD	Median	Mean	SD	Median		
tDDKavp (ms)	6-7	207.01	46.16	201.18	260.75	61.06	249.9	1.53	0.12
	7-8	203.8	38.42	198.61	220.21	30.51	228.47	0.042	0.297
	8-9	206.19	34.17	211.99	235.49	51.18	229.16	0.98	0.327
	9-10	196.99	21.05	202.64	211.58	15.14	215.91	1.22	0.221
tDDKavr (/s)	6-7	5.05	1.15	4.97	3.78	0.58	3.99	1.77	0.07
	7-8	5.05	0.88	5.03	4.61	0.7	4.37	0.042	0.297
	8-9	4.97	0.87	4.71	4.38	0.83	4.36	0.98	0.327
	9-10	5.13	0.66	4.93	4.74	0.34	4.63	0.225	0.221
tDDKcvp (%)	6-7	39.79	35.39	27.77	48.36	49.21	21.71	0.3	0.75
	7-8	32.46	29.5	20.7	19.59	13.08	14.5	0.552	0.581
	8-9	33.47	17.12	33.16	29.85	19.02	23.99	0.245	0.806
	9-10	25.53	14.84	31.9	23.14	15.79	18.65	0.245	0.806
tDDKjit (%)	6-7	7.38	6.34	5.4	9.81	8.73	9.51	0.3	0.75
	7-8	5.81	5.03	3.51	3.79	2.39	2.95	0.674	0.5
	8-9	5.93	2.95	5.7	8.35	7.58	7.58	0.245	0.806
	9-10	4.23	2.34	4.29	3.85	2.17	3.06	0.122	0.903
tDDKcvi (%)	6-7	3.34	1.27	3.06	3.82	1.48	3.61	0.55	0.58
	7-8	2.87	1.45	2.44	4.12	2.11	3.71	1.042	0.297
	8-9	3.68	1.47	3.77	4.17	2.72	3.28	0.122	0.903
	9-10	2.7	1.17	2.45	2.15	1.29	1.93	0.735	0.462

*Note: *p<0.05 **p<0.01*

Comparison between CWNS and CWS for the task /ta/

On observation, the table 4.5 indicates that the mean values of the parameter tDDKavr are comparatively higher for CWNS group than CWS group, whereas the tDDKavp shows lesser mean values for CWNS than CWS group across all age groups. Table 4.5 shows DDK parameters, average DDK period (tDDKavp), average DDK rate (tDDKavr), for syllable /ta/ has shown statistically significant differences between CWNS and CWS groups.

4.2.1.3 Repetition of /ka/ syllable

Effect of age group for the task /ka/

The Table 4.6 illustrates the mean, standard deviation (SD), median, /Z/ value and p value of CWNS and CWS across age groups for repetition of syllable /ka/. On observation, it can be inferred that the mean values for the parameters like kDDKavr, i.e., kDDK syllable/sec rates increased with age in CWNS as well as in CWS groups and mean score was found to be better for 9-10 years age group. The kDDKavp, kDDKcvp, kDDKjit and kDDKcvi mean values were observed to show decreasing trend with an increase in the age from 6-7 years to 9-10 years in both CWNS and CWS groups. While comparing across age groups using Mann Whitney U test, the results showed statistical significance in only three DDK parameters in different age groups. The average DDK period (kDDKavp) at 6-7 years age range, average DDK rate (kDDKavr) at 6-7 years age range and coefficient of variation of DDK peak intensity (kDDKcvi) at 7-8 years age range showed significant difference across CWNS and CWS groups.

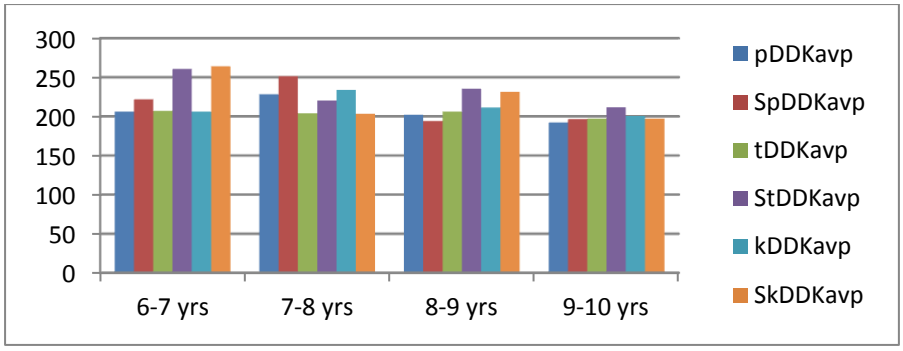
Table 4.6: *Mean, SD, Median, /Z/ value and p value of CWNS and CWS across age group for AMR task /ka/*

Parameter (s)	Age Range (Years)	CWNS			CWS			z-Value	p-Value
		Mean	SD	Median	Mean	SD	Median		
kDDKavp (ms)	6-7	206.15	33.61	207.44	263.9	43.27	271.71	2.32	.020*
	7-8	233.83	51.5	229.73	203.42	27.03	202.17	0.165	0.244
	8-9	211.16	23.61	220.16	231.3	44.56	240.77	1.83	0.066
	9-10	200.55	30.46	202.58	197.24	40.5	197.74	0.122	0.903
kDDKavr (/s)	6-7	4.97	0.83	4.84	3.88	0.72	3.68	2.32	.020*
	7-8	4.44	0.85	4.35	4.98	0.65	4.94	0.165	0.244
	8-9	4.79	0.57	4.54	4.49	1.1	4.15	1.83	0.066
	9-10	5.08	0.76	4.94	4.85	0.53	5.05	0.49	0.624
kDDKcvp (%)	6-7	37.98	22.26	33.13	22.57	11.47	18.68	1.59	0.111
	7-8	28.32	30.49	19.52	39.2	27.37	35.09	0.287	0.198
	8-9	27.1	29.41	15.2	28.79	13.82	32.66	0.85	0.391
	9-10	25.66	13.01	23.15	30.83	14.99	31.34	0.857	0.391
kDDKjit(%)	6-7	7.7	3.93	6.79	6.33	4.9543	6.1	0.73	0.462
	7-8	7.16	10.23	3.96	7.12	3.72	7.96	0.797	0.426
	8-9	5.02	4.53	3.63	6.44	3.5	6.13	1.34	0.178
	9-10	4.58	2.29	3.7	4.97	2.08	4.79	0.367	0.713
kDDKcvi(%)	6-7	3.55	1.27	3.04	4.72	0.92	5.02	1.71	0.086
	7-8	3	1.32	2.91	4.85	1.29	5.03	0.268	.023*
	8-9	4.04	3.2	2.4	3.34	0.61	3.59	0.85	0.391
	9-10	3.31	1.17	2.79	3.33	0.54	3.47	0.613	0.54

*Note: *p<0.05 **p<0.01*

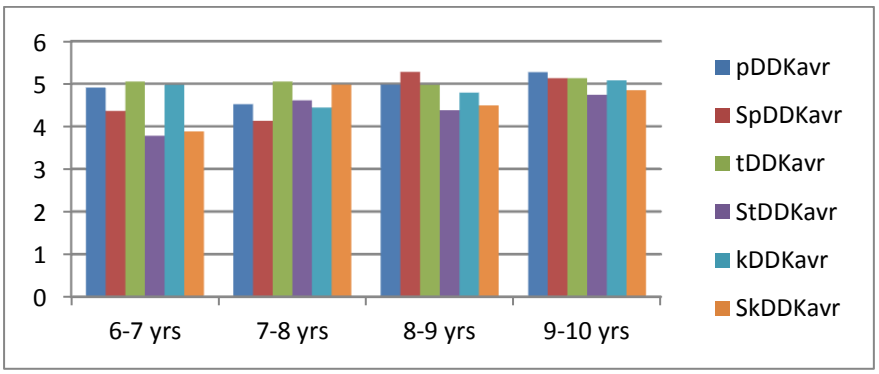
Comparison between CWNS and CWS for the task /ka/

Based on observation, the table values illustrate that CWS group has shown higher mean score in kDDKavp, kDDKcvp and kDDKcvi parameters and CWNS group has shown better mean score for kDDKavr, kDDKjit parameters. On comparison using Mann-Whitney U test, only coefficient of variation of DDK peak intensity (kDDKcvi) showed significant differences between CWNS and CWS groups.



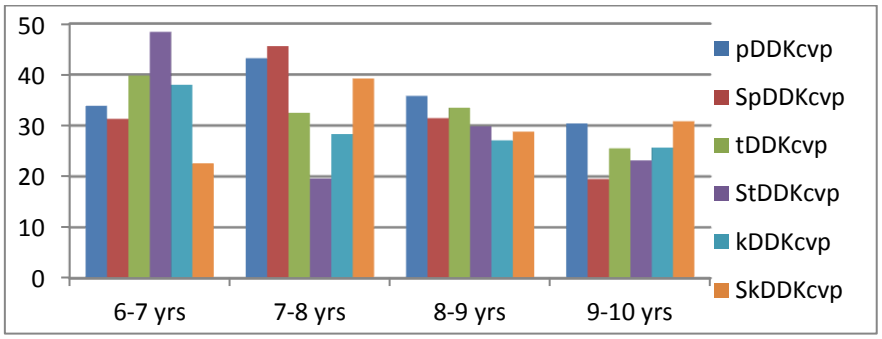
Note: `S` prior to each parameter represented CWS group

Figure 4.1: Mean scores of the AMR average DDK period (DDKavp) parameter across age group in CWNS and CWS



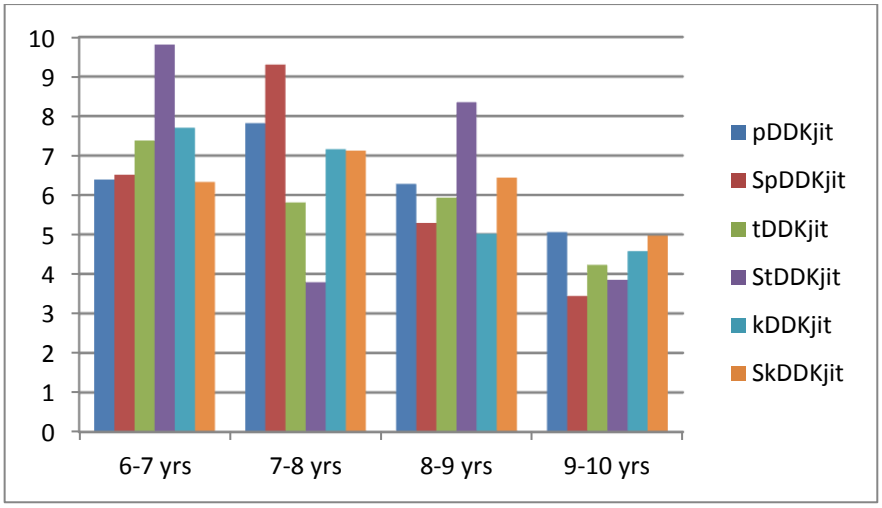
Note: `S` prior to each parameter represented CWS group

Figure 4.2: Mean scores of the AMR Average DDK Rate (DDKavr) parameter across age group in CWNS and CWS.



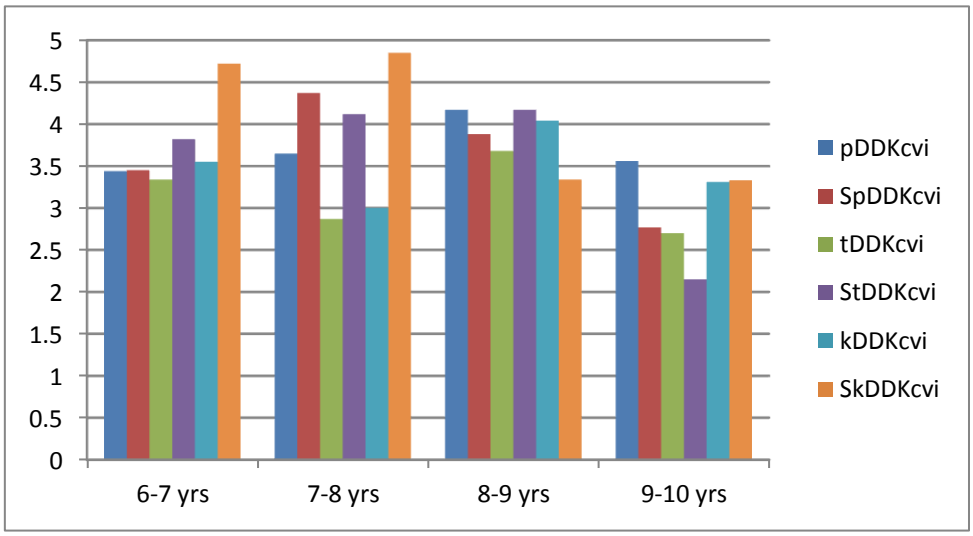
Note:`S` prior to each parameter represented CWS group

Figure 4.3: Mean scores of the AMR Coefficient of Variation of DDK Period (DDKcvp) parameter across age group in CWNS and CWS



Note: `S` prior to each parameter represented CWS group

Figure 4.4: Mean scores of the AMR Perturbation of DDK Period (DDKjit) parameter across age group in CWNS and CWS.



Note: `S` prior to each parameter represented CWS group

Figure 4.5: Mean scores of the AMR Coefficient of Variation of DDK Peak Intensity (DDKcvi) parameter across age group in CWNS and CWS.

Mann Whitney test was administered to investigate the difference between CWNS and CWS for different variables, irrespective of age. The significant difference is noticed in AMR parameters like tDDKavp, tDDKavr and kDDKcvi. All other parameters did not showed any significant difference across groups.

Table 4.7: Z value and P values for overall AMR parameters between CWNS and CWS

Parameters	/Z/	P
pDDKavp	0.66	.50
pDDKavr	1.07	.28
pDDKcvp	0.93	.351
pDDKjit	0.72	.466
pDDKcvi	0.14	.882
tDDKavp	2.47	.013*
tDDKavr	2.74	.006*
tDDKcvp	0.78	.433
tDDKjit	0.21	.832
tDDKcvi	0.42	.672
kDDKavp	1.16	.246
kDDKavr	1.40	.160
kDDKcvp	0.84	.397
kDDKjit	0.98	.327
kDDKcvi	2.5	.012*

*Note: *p<0.05 **p<0.01*

4.2.2 Comparison of CWNS and CWS on SMR parameters across each age group

4.2.2.1 Repetition of /pataka/ syllable

Effect of age for SMR task

The Table 4.8 represents the mean scores, standard deviation (SD), median, /Z/ and p values of CWNS and CWS across age group. On observation, the mean scores of all SMR parameters did not show any observable changes across age groups except the mean values for the parameter ptkDDKavr lessens as the age increases. Mann Whitney U test performed to compare the SMR parameters across age groups did not show any statistical significance.

Table 4.8: Mean, SD, Median, /Z/ value and p value of CWNS and CWS across age group for SMR task /pataka/

Parameter (s)	Age Range (Years)	CWNS			CWS			z-Value	p-Value
		Mean	SD	Median	Mean	SD	Median		
ptkDDKavp (ms)	6-7	186.98	25.8	179.05	189.44	30.58	188.72	0.306	0.759
	7-8	184.89	33.71	181.53	201.52	54.48	186.57	0.552	0.581
	8-9	179.49	13.6	176.15	207.72	65.71	201.27	0.49	0.624
	9-10	162.12	14.77	164.14	178.17	32.86	170.38	0.98	0.327
ptkDDKavr (/s)	6-7	5.42	0.65	5.58	4.99	0.59	4.66	0.41	0.159
	7-8	5.56	0.98	5.51	5.21	1.17	5.36	0.552	0.581
	8-9	5.59	0.41	5.67	5.16	1.42	4.96	0.49	0.624
	9-10	6.21	0.57	6.09	5.75	0.99	5.86	0.98	0.327
ptkDDKcvp (%)	6-7	50.56	18.19	44.54	51.41	23.26	64.5	0.061	0.951
	7-8	45.76	17.36	47.5	74.03	40.17	70.85	0.41	0.159
	8-9	60.88	29.08	53.99	52.74	21.02	42.99	0.49	0.624
	9-10	45.96	21.22	46.55	52.04	31.89	39.79	0.122	0.903
ptkDDKjit (%)	6-7	10.48	7.07	7.46	10.48	5.3	11.91	0.061	0.951
	7-8	8.67	5.01	6.9	12.87	8.01	11.71	0.042	0.297
	8-9	9.38	3.69	8.06	14.12	14.97	6.98	0.245	0.806
	9-10	7.33	3.35	6.99	9.41	7.47	6.8	0.122	0.903
ptkDDKcvi (%)	6-7	3.89	1.4	3.97	4.44	1.26	5.18	0.797	0.426
	7-8	3.73	1.54	3.26	5.15	2.44	3.75	0.165	0.244
	8-9	4.75	1.89	4.28	4.7	2.04	4.82	0.122	0.903
	9-10	4.42	2.06	4.26	3.92	0.71	3.94	0.245	0.806

*Note: *p<0.05 **p<0.01*

Comparison between CWNS and CWS for SMR task

The table represents the mean scores, standard deviation (SD), median, /Z/ and p values of CWNS and CWS for the parameters of the SMR task /pataka/. The mean values for all parameters were found to be showing no observable difference between CWS and CWNS. DDK parameters - average DDK period (DDKavp), average DDK rate (DDKavr), coefficient of variation of DDK period (DDKcvp), perturbation of DDK period (DDKjit) and coefficient of variation of DDK peak intensity (DDKcvi) for SMR did not show any statistical significant differences when comparison between CWNS and CWS groups was carried out using Mann Whitney U test.

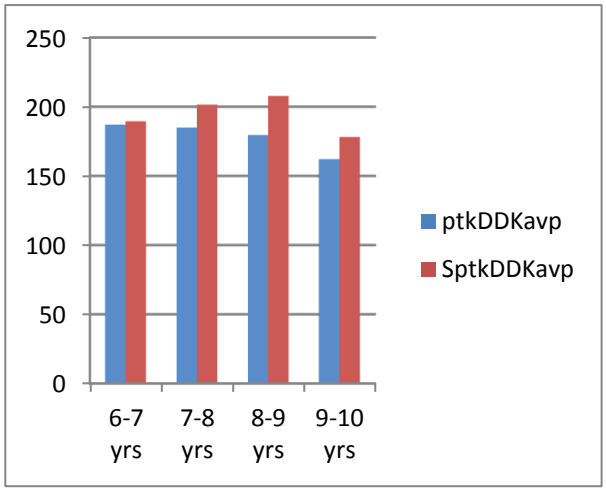


Figure 4.6.1: SMR Average DDK period(DDKavp)

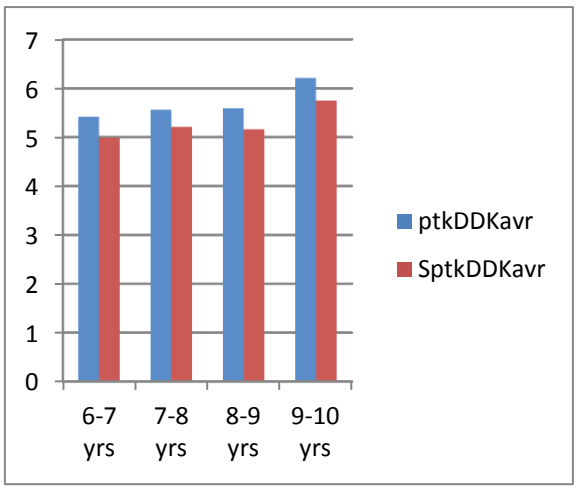


Figure 4.6.2: SMR Average DDKrate(DDKavr)

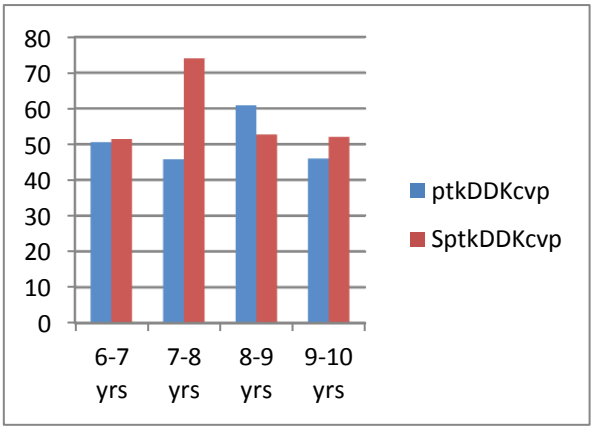


Figure 4.6.3: SMR Coefficient of Variation of DDK Period (DDKcvp)

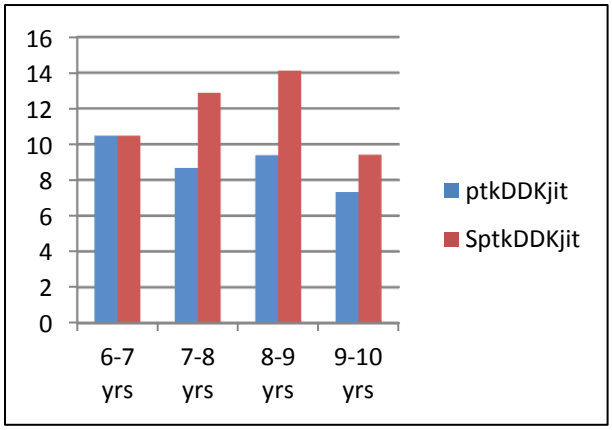


Figure 4.6.4: SMR Perturbation of DDK Period (DDKjit)

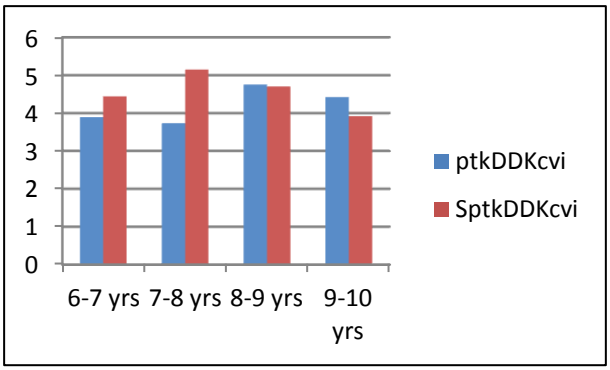


Figure 4.6.5: Coefficient of Variation of DDK Peak Intensity (DDKcvi)
Note: `S` prior to each parameter represented CWS group
Figures 4.6: Mean scores of the SMR parameters across age group in CWNS and CWS

Table 4.9: *Z value and P values for overall SMR parameters between groups*

Parameters	/Z/	P
ptkDDKavp	1.153	.249
ptkDDKavr	1.654	.098
ptkDDKcvp	.525	.599
ptkDDKjit	.588	.556
ptkDDKcvi	.808	.419

*Note: *p<0.05 **p<0.01*

DDK rates compared across age

In summary, the significant differences across age groups for AMR parameters were found only in repetition of /ka/ task (AMR) in parameters such as kDDKavp, kDDKavr in 6-7 years age group and kDDKcvi in 7-8 years age group. All other parameters did not show any statistical significant differences across groups. The comparison of overall average DDK rate (DDKavr) across age has revealed a significant difference across the age groups. The data demonstrated that the average rate significantly increased with the progression of age indicating a clear developmental trend.

DDK rates increased with age from an average of 4.9 to 5.27 for /pa/, 5.0 to 5.2 for /ta/, 4.90 to 5.08 for /ka/, and 5.42 to 6.21 for /pataka/ in CWNS group and an average of 4.3 to 5.13 for /pa/, 3.7 to 4.74 for /ta/, 3.8 to 4.85 for /ka/, and 4.9 to 5.7 for /pataka/ in CWS group. These differences in CWS group were more marked than in CWNS groups. Only parameters like kDDKavp, kDDKcvi and kDDKavr have shown statistical significant age group differences. The mean values of kDDKavp, kDDKcvi parameters were found to be decreasing with age and kDDKavr was found to be increasing with age, which signifies increase in motor ability as the average DDK rate which reflects developmental trend with age. The mean values for perturbation of DDK period (DDKjit) was found to be decreasing with age. Some studies related to DDK rates have been carried out in Indian context on children. Deepthy (2015) studied motor speech characteristics in 4-10 years old typically developing Kannada speaking children and found results similar to the present study wherein repetition of syllable /ka/ showed significantly different across age groups in parameters as kDDKavp, kDDKavr, kDDKjit and kDDKcvi. On the other hand, the repetition task of syllables /pa/ and /ta/ showed significant differences contrasting to the present findings where significant differences were not found. Devadiga and Bhat (2012) also found similar results in their study demonstrating increase in DDK rates with age in both males and females. Likewise, Modolo, et al., (2010) studied oral and vocal DDK in 150 children and found that 10 years old children produced more iterations than 8 years for both SMR and AMR tasks. The above results are to an extent parallel to the present findings as results of present study showed increasing trend in mean scores but did show statistical significance for all parameters except for syllable /k/. Similar trend was also observed by Yaruss and Logan, (2002) who

speculated younger children to have more difficulty with the nonsense sequence "puh-tuh-kuh" than older children. A study attempted by Wonga, et al., (2011) in repletion of /pa/ syllable revealed differing results indicating age-dependent changes such as an increase in average diadochokinetic rate which is contradicting the present findings which did not show significant changes across ages specific to repetition of /pa/. Modolo, (2011) found that 8-10 years old children exhibited a rise in the average DDK rate, a rise in the coefficient of variation of period for syllable 'ka' and a rise in the coefficient of variation of the peak intensity for the syllable 'ta' as age increased.The present results of DDK rate is consistent with several studies (Canning & Rose 1974; Williams & Stackhouse, 1998; Prathanee, et al., 2003), which have found that the accuracy of productions improved with age showing significant differences across age groups. Padovani et al in 2008 reported that there is reduction of DDK rate as the utterances went more posterior in the oral cavity.

In the present study, it has been observed that significant differences are obtained only corresponding to repetition of syllable /ka/ which could be attributed to the effort required for the production of that syllable as it involves more muscles than anterior phonemes and susceptible to enormous variations.

DDK rates compared between CWS and CWNS

The results of Mann Whitney U test to compare between CWNS and CWS for different variables, irrespective of age showed significant differences in AMR parameters such as tDDKavp, tDDKavr and kDDKcvi. Unsurprisingly, other parameters did not show any significant difference between CWS and CWNS groups. In addition, SMR

parameters did not indicate any statistical significance between CWS and CWNS groups. However, these results do not support Riley and Riley's (1979) statement that a large percentage of CWS exhibit reduced performance during the DDK task due to their oral motor problems. Moreover, these findings are in agreement with several other researches that have obtained no significant group differences between CWS and CWNS for DDK rates (Wolk et al., 1993; Yaruss, Logan, & Conture, 1995, Yaruss and Logan, 2002; Juste, et al., 2011).

4.3. Rate of speech:

4.3.1. Comparison of CWNS and CWS on conversational speech and story narration across each age group

Table 4.10: *Mean, SD, Median, /Z/ value and p value of CWNS and CWS all age range for the parameters of Rate of speech task*

Parameter	Age Range (Years)	CWNS			CWS			Z-Value	p-Value
		Mean	SD	Median	Mean	SD	Median		
Conversation	6-7	234.6	29.54	228	165.2	23.03	173	3.06	.002**
	7-8	229.3	12.12	231.5	188.4	23.3	189	2.93	.003**
	8-9	238.1	23.95	238.5	208.8	35.93	217	1.59	0.111
	9-10	242.8	20.84	245	207.8	24.84	206	2.14	.032*
Story Narration	6-7	233.4	29.06	232.5	170.2	32.59	163	2.57	.010*
	7-8	235.5	23.33	233	221.6	24.96	229	0.552	0.581
	8-9	229.8	21.83	236	238	22.13	246	0.73	0.462
	9-10	232.3	25.45	238	216.2	30.64	218	0.86	0.39

*Note: *p<0.05 **p<0.01*

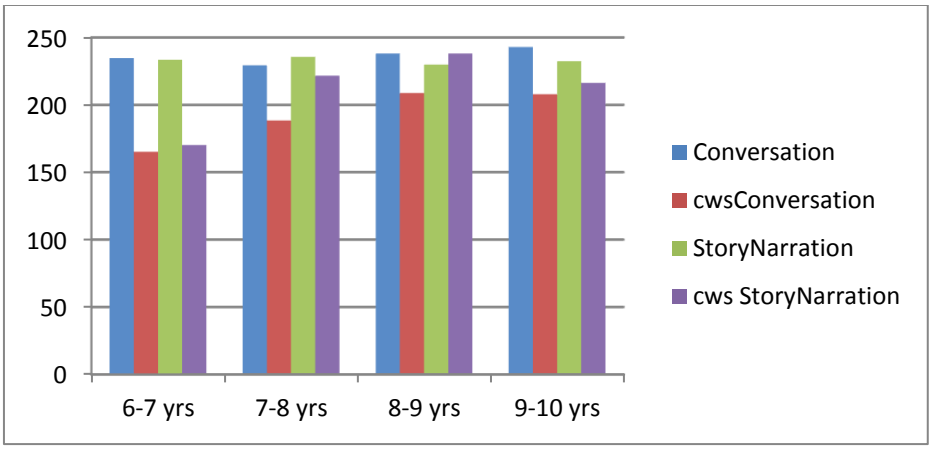


Figure 4.7: Mean scores of the Conversation and Story Narration parameters across age group in CWNS and CWS

Effect of age for rate of speech

The table 4.9 represents the mean scores, standard deviation (SD), median, /Z/ and p values of CWNS and CWS for the parameters of the rate of speech task across different age groups. In CWS, it was observed that the mean values increased with age for both conversational speech as well as for story narration task, more mean value indicating faster rate of speech. In conversation task, comparison across age group was done using Mann Whitney U test and found significant differences between the CWNS and CWS groups across 6-7 years, 7-8 years and 9-10 years age groups indicates rate of speech varies between CWS and CWNS groups across age. CWS exhibited slower rate of speech than CWNS at younger age range and rate of speech improved with age. However, story narration task showed significant difference in rate only in 6-7 years age range group.

Researchers have reported both contrasting and inconsistent findings relative to present study across age groups (Amster & Starkweather, 1985; Pindzola, Jenkins, & Lokken, 1989). Whereas, Kowal et al., (1975) found significant increase in the rate of speech between 2 and 3 years which is in confirmation with the findings of the present study. This increasing trend observed can be attributed to the developmental rate changes which do not proceed on a yearly basis but rather increase sporadically at certain age intervals.

The findings of the present study are supported by various studies where they have suggested reduction in the segmental duration with age in children (Kubaksha & Keating, 1981; Nittrouer, 1993; Robb & Saxman, 1990; Iverson, 2010). In line with the present study, Smith (1978) also suggested that the duration of segments were longer in children when compared to adults in which reduction in duration was found in 4 year olds when compared to 2 year old children.

Comparison between CWS and CWNS for rate of speech

On observation, in 6-7 years, both conversation and story narration mean values of rate of speech showed observable differences between the CWNS and CWS groups. Mann Whitney test was administered to investigate the difference between CWNS and CWS for different parameters, irrespective of age. The significant difference was noticed in conversational speech task but story narration task did not show any significant difference between groups. The present study mean value indicates rate of speech is faster in CWNS groups. Logan, Byrd, Mozzochi and Gillam in 2011, determined rate of speech results on narrative task and conversation in CWNS and CWS school-aged

children. CWNS showed faster speech rate than CWS. Older children showed faster speech rate than younger group which showed similar result to the present study.

In contrast with the above results, Ryan, (1998), Kelly and Conture (1992), reported no significant differences in CWS and CWNS children in conversation speech.

Table 4.11*: Overall results of rate of speech parameters between CWNS and CWS*

Parameters	/Z/	P
Conversation	4.534	.000**
Story Narration	1.883	.060

*Note: *p<0.05 **p<0.01*

These results indicate that there was influence of few parameters on the capacity and performance of speech articulators between CWNS and CWS. In case of moderate to severe degree of stuttering, the rate of speech was found to be very slow and reflected less number of syllables per minute as compared to milder degree of stuttering, but perceptually it was faster rate of speech. This notion has been speculated by Zackiewicz (1999), who found lesser articulatory abilities in more severe stutterers, which lowered the rate of speech in terms of words per minute and also in syllables per minute. However, as there was less number of children under different severity levels, it was not compared separately.

4.4 Test-retest Reliability

Testing was repeated on 10% of participants from both the groups. The test-retest reliability was done using the Cronbach's alpha co-efficient of reliability test. The **r**eliability was found to be 0.978 in CWNS and 0.701 in CWS for conversational speech

task, and 0.963 in CWNS and 0.996 in CWS for story narration task. This suggested good test-retest reliability in rate of speech in both the groups, but test-retest reliability was not found in DDK task due to factors in MSP software recording like background noise, where even a slight variation in recorded sample outputs resulted in drastic variations.

In general it can be mentioned that the capacity of the individual may not solely be attributed to the diadachokinetic rate, since it is a task which is structured and easy to perform. Also, the motor correlates for execution of the articulatory movements are widely varied in this task, especially when compared to the complex task of continuous speech. The instruction given prior to the performance of the DDK task again requires the individual to perform the task as fast as possible. Contrary to this, articulatory rate calculation is not instruction based and thus would reveal the reason for existence of no significant difference between the groups.

Chapter V

SUMMARY AND CONCLUSION

Speech motor control refers to systems and strategies that regulate the production of speech, including the planning and preparation of movements and the execution of movement plans to result in muscle contractions and structural displacements.

A widely used clinical assessment of the oral-motor mechanism is an investigation of diadochokinesis whereby, the rapid rate of movement or maximum rate of syllable production in non-linguistic utterances is considered as an index of motor skill. The rate of oral diadochokinesis (DDK), defined as the rate of maximally rapid syllable repetition, is a standard component of motor speech assessment. The task used to derive oral DDK rate is a speech-like task involving rapid monosyllabic repetitions. The rate of speech and articulatory rates are important aspects of measurements focussing on the performance and capacities of the individuals. It is reported by few researchers that CWS speak faster than they are capable of and some timing control mechanisms are involved in the onset of stuttering. There is dearth of studies focussing on the two types of rate to support this hypothesis and more so in the Indian context. The rate of speech is highly variable with respect to several factors like age, gender, language and speaking tasks. Hence it is interesting to study this aspect in young CWS compared to their peers.

The primary aim of the current study was to investigate whether children with stuttering (CWS) differ in terms of coordinating speech articulators during speech task

(rate of narrated speech) and non speech task (DDK rate) when compared with children with no stuttering (CWNS) in Kannada speaking population. The study totally included 60 participants aged 6 years to 10 years and they were broadly divided into CWNS and CWS and were further subdivided into four groups each with respect to age (6-7 years, 7-8 years, 8-9 years and 9-10 years), in which each CWNS age group consisted of 10 members with equal distribution of males and females and in CWS group each age group consisted of 5 members with 4 male and 1 female participants. The rate of speaking was obtained from each participant in narration and spontaneous speaking tasks and AMR and SMR under the DDK task. The DDK task measured the AMR rate and SMR rates in which participants had to say /pa/, /ta/, /ka/ and /pataka/ as soon as possible and clearly and sample was analyzed using the MSP software which provided five different measures. The second task was to narrate a story using the given stimulus and participants were engaged in general conversation. The rate of speech in syllables per minute was calculated manually using recorded audio sample in PRAAT software for narration and conversation samples.

The data obtained was statistically analyzed using the SPSS software 17 version to obtain results on overall effect of age and groups with respect to different rate measures. Descriptive statistics were employed to compare the groups across various parameters. Mann-Whitney test was carried out to know the significant difference across the groups. Cronbach's alpha test was obtained for determining the test-retest reliability.

The result of the current study revealed several interesting findings.

- All the AMR parameters like average DDK period (DDKavp), average DDK rate (DDKavr), coefficient of variation of DDK Period (DDKcvp), perturbation of DDK period (DDKjit) and coefficient of variation of DDK peak intensity (DDKcvi) did not show any significant difference across age groups except for /ka/.
- DDK parameters for /ka/ like average DDK period (kDDKavp) at 6-7 years age range, average DDK rate (kDDKavr) at 6-7 years age range and coefficient of variation of DDK peak intensity (kDDKcvi) at 7-8 years age range showed significant difference across CWNS and CWS groups, wherein CWS performed poorer in the articulatory rate of /ka/ compared to CWNS.
- On observation, it was found that the mean values for all the three AMR repetitions, the parameters DDKavr increased with age in both CWNS and CWS groups, whereas DDKavp mean values reduced with increase in the age from 6-7 years to 9-10 years in both CWNS and CWS groups.
- For SMR task, the mean values for all parameters were found to be showing no significant difference across groups. The mean values for CWS were almost similar to that of CWNS. It was noted that all of the SMR parameters like average DDK period (DDKavp), average DDK rate (DDKavr), coefficient of variation of DDK period (DDKcvp) , perturbation of DDK period (DDKjit) and coefficient of variation of DDK peak intensity (DDKcvi) for SMR did not show any significant difference between CWNS and CWS groups. Hence this signifies the younger children perform similar on SMR task when compared to older

children.

- It was noted that the mean values for the parameters like ptkDDKavp reduced as the age increased. The mean value for ptkDDKavr was more for CWNS group than CWS group and increased with age, This could be because of the neural maturation that is taking place with age leading to better coordinated control over musculatures, whereas the ptkDDKavp was lesser for CWNS than CWS group. Thus, SMR is superior in older CWNS (9-10 years) compared to CWS.
- From all the above parameters investigated in the study, both AMR and SMR does not exhibit uniform pattern across age groups in both CWS and CWNS.
- The rate of speech of CWNS and CWS showed significant difference between the CWNS and CWS groups at 6-7 years 7-8 years and 9-10 years age range in conversational speech. A significant difference was also seen in story narration task for 6-7 years age group in rate of speech. Hence there is effect of age on rate of speech, wherein there was decrement in the rate of speech in both CWNS and CWS.
- Mann Whitney test was employed to investigate the difference between CWNS and CWS for different variables irrespective of age. The results revealed significant difference in conversational speech. Whereas, story narration did not show any significant difference across CWNS and CWS groups.
- Based on comparison of mean scores, speech rate was noted to be slower in CWS. It is well known that the rate of speech is a highly variable measure with

regard to age and gender of the individuals. Children, as they mature, show increased motoric and linguistic capacities to produce well coordinated and rapid articulatory movements. Rate in general has high inter and intra individual variability and it also depends on the languages (some languages and dialects are spoken faster than others), tasks (reading, narration, conversation) and other speaking conditions. The rate of speech is one important variable operating in individuals with stuttering. It is reported by many researchers and clinicians that the rate is often faster in individuals with stuttering, at least perceptually. It is also debated as to whether they use faster rate as a coping strategy to overcome stuttering or use of faster rate for some reason precipitates stuttering. More vast research in this area is warranted to explore the relationship between the two.

Implication of the study:

- The results of this study guides during assessment, diagnosis and therapy for CWS in the age range of 6 years to 10 years and to compare their abilities in speech motor skills in Indian context.
- The outcomes of the current study will give an insight to the theoretical understanding of stuttering as having a deficit in speech motor control. The findings also have a clinical significance in the assessment and rehabilitation of CWS.
- Very few Indian studies establish a link between a child's capacity and performance for fluent speech measured in terms of DDK and articulatory rate. So this study helps for further research which in turn might be useful for theoretical as well as clinical importance.

Limitations of the present study:

- The sample size in both CWS and CWNS groups is very less to make any generalization or conclusions based on the results
- While recording at school setup the sound treated rooms were not available, the background noise could not be adequately controlled.
- Test retest reliability was not found in DDK task due to factors in MSP software recording and analysis like background noise, even a slight variation in recorded sample outputs drastic variation in results.

Future directions:

- In future research larger number of participants can be considered for arriving at better results and conclusions.
- The various speech motor skills can be studied under different subgroups of CWS, with respect to gender and severity of stuttering.
- The study can be done to compare DDK and rate of speech in normal and stuttering adult population across age and gender.
- Study can be done to compare DDK and rate of speech in different disordered population.
- To study on accuracy and fluent measures of DDK production by CWS and CWNS.

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