RATE OF SPEECH IN ADULTS WITH FLUENCY DISORDERS

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September 2023

CERTIFICATE

This is to certify that this dissertation titled "Rate of Speech in Adults with Fluency Disorders" is a bonafide work submitted in part fulfilment for the degree of Master of Science (Speech-Language Pathology) by the student holding Registration No.: P01II21S0004. This has been carried out under the faculty member of the Institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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September, 2023

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CERTIFICATE

This is to certify that this dissertation titled "**Rate of Speech in Adults with Fluency Disorders**" is a bonafide work submitted in part fulfilment for the degree of Master of Science (Speech-Language Pathology) by the student holding Registration Number: P01II21S0004. This has been carried out under my supervision and guidance. It is also certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled "**Rate of Speech in Adults with Fluency Disorders**" is the result of my own study under the guidance of Dr. Sangeetha Mahesh, Associate Professor, Department of Clinical Services, 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.

Registration No. P01II21S0004

Mysuru

September, 2023

Dedicated to,

My late grandmother G. Subhashini,

Mummy, Pappa and My Dearest Brother.

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CHAPTER I

INTRODUCTION

Rate of speech is defined as "the speed with which the articulatory movements important for producing speech are executed" (Robb, Gilbert, Reed, & Bisson, 2003). It is one of the suprasegmental features which defines fluency. An individual's speaking rate can influence the overall intelligibility of speech. According to Hall, Amir and Yairi (1999), speech rate is an indicator of speech-motor performance because it reflects the coordination of the respiratory, phonatory and articulatory processes involved during speech.

Few theories have been put forth to describe how speaking rate and stuttering are related. The psycholinguistic model posits that persons who stutter (PWS) require more time to process phonological and linguistic information (Kent & Curlee, 1991). This can lead to reduced rate of speech in PWS. Another theory suggests that stuttering is a neuromotor and timing disorder affecting articulation rate, which reflects speech-motor control (Kent & Forner, 1980). However, Hall, Amir and Yairi (1999) found that the Speech Rate was higher in children with persistent stuttering than in children who recovered from stuttering. Ingham, Martin and Kuhl (1974) found that stuttering frequency decreases when the speech rate is reduced in adults who stutter (AWS).

The prevalence of cluttering in the German and Dutch populations was 1.2% and 1.1%, respectively (Van Zaalen,2017). In a project done at All India Institute of Speech and Hearing (AIISH), the prevalence of various fluency disorders was found. Prevalence of Stuttering was found to be 96.80%, Cluttering 0.50% and Cluttering-Stuttering 0.20%.

This epidemiological data was collected from January 2010 to December 2014 (Geetha & Mahesh, 2015). St. Louis and Schulte (2011) defined cluttering as "a fluency disorder where the segments of conversation in the native language of the speaker are either too fast or too irregular or both". Individuals with cluttering cannot adjust their speech rate based on the linguistic or motoric demands of the speech task (Van Zaalen & Winkelman ,2009). Cluttering is not a clearly defined disorder, as there is no separate entry of the same in DSM V. Hence, the diagnosis is completely based on the cluster of traits common to the pathology. Clinically, the perceived speech rate can misdirect the diagnosis due to inter-rater variability. So, the rate of speech should be quantified for accurate diagnosis. The systems approach for the management of cluttering focuses on targeting a single dimension, especially rate, which in turn benefits other dimensions. Hence, knowledge of speech rate in persons who clutter (PWC) is vital for accurate diagnosis and rate control management.

Various techniques have been used to measure the rate of speech; however, there is no uniformity in the same. In an AIISH funded ARF project, 401 normal subjects in the age range of 3-90 years, speaking four different Dravidian languages- Kannada, Telugu, Tamil and Malayalam were taken. A descriptive task for children and a reading sample for adults was obtained. Rate of speech was calculated in syllables per second (SS), syllables per minute (SPM) and words per minute (WPM) for reading sample only. The highest rate was found in the Malayalam language (Savithri & Jayaram, 2004). In another study conducted at AIISH, the rate of speech in children who stutter (CWS) was estimated by giving picture description tasks and narration tasks. The articulation rate was calculated in syllables per minute (SPM), excluding all the disfluencies. A high

articulation rate was found in the control group compared to CWS (Sruthi,2016). Venkatesh et al. (1983) found the rate of speech as 282 syllables per minute for 64 adult Kannada speakers.

The speaking rate can also change with the mode of delivery (Howell & Kadi-Hanifi, 1991). Crystal and House (1982) found that the speaking rate increases during "less formal productions" due to temporal syllable reductions. Reading tasks are found to enhance fluency as compared to other tasks like monologue in individuals with stuttering. In a study, it was found that stuttering frequency decreased and rate of speech increased in choral reading as compared to oral reading and monologue tasks (Ritto et al., 2016)

Articulatory rate measures can give us an estimate of the speed with which articulators can produce sound segments without pauses (Pindzola et al.,1989; Hall et al., 1999). According to Fletcher (2010), articulation rate can be obtained by calculating the total number of syllables divided by the elapsed time, excluding the pauses. Miller et al. (1984) found variability in articulation rate within adults. In PWC, Van Zaalen (2009) reported a high articulation rate of 56% for spontaneous speech. Articulation rate was found to vary with age, gender and speaking situations in adults born in Wisconsin and North Carolina (Jacewicz et al., 2009).

Articulation rate was calculated using Mean Articulation Rate (MAR) for spontaneous speech via transcription in one of the studies. In the first step, all the utterances of the speaker were considered. In the second step, the non-fluent utterances found in the first transcript were excluded (Jacewicz et al., 2009). Another method of calculating articulation rate was done by annotating the boundaries of speech sounds

and pauses using PRAAT. Ten utterances, excluding pauses, which were syntactically correct, were analysed for each participant (Bóna & Khári, 2021).

St. Louis et al. (2007) found that even if speech rate is recognised as fast in individuals with cluttering, the actual articulatory rate can be normal. Telescoping errors and normal disfluencies can contaminate the perception of speech. Van Zaalen (2009) found that the articulation rate in children with cluttering and learning disability was comparable to fluent age- matched controls. Van Zaalen (2009) defined Mean Articulatory Rate (MAR) "as the mean of five rate measures in minimally 10 to maximally 20 consecutive syllables in perceptually fluent speech without pauses". He found MAR values as 4.4-5.5 syllables per second (SPS) for fluent speakers, 2.5-5.3 SPS for PWS and greater than 5.2 SPS with increased NDFs in PWC. St. Louis (2003) found rapid bursts of speech ranging from 6-7 SPS. He considered deviant rate variability as a key symptom in PWC. Van Zaalen (2009) defined variation in MAR (MAR-v) as "a variation in articulatory rate $\geq 1SD$ above the mean articulatory rate variation". This was considered as an important indicator for the diagnosis of cluttering.

Need of the study

Rate of speech quantifies the rate at which articulators move to achieve a speech target. It varies across languages; hence, language-specific normative data is crucial for diagnosis. However, there is a lack of research on the same in the Indian context. Speaking rate is generally found to be affected in individuals with fluency disorders. However, no definite pattern has been observed. No studies have been conducted to measure the rate of speech in cluttering, and limited studies have been conducted in adults who stutter (AWS) in Indian languages. The rate of speech in individuals with stuttering

was found to be inconsistent in several studies. Speaking rate is a prominent characteristic feature of cluttering, so quantifying the same can strengthen the diagnosis and aid in management. The method of calculating the speaking rate in dysfluent speakers is also not clearly defined in the literature.

In this study, we explore different methods of calculating the speaking rate in addition to the one which is widely used. These rates will be compared across groups to have a better understanding so they can be used for clinical decision-making in terms of differential diagnosis as well as management.

Aim of the study

To measure the rate of speech in Adults with Stuttering, Cluttering and Cluttering-Stuttering and Controls using Speech Rate (SR), Articulation Rate (AR) and Mean Articulatory Rate (MAR) in Kannada.

Objectives of the study

- To measure the Speech Rate (SR) in spontaneous speech across groups.
- To measure Articulation Rate (AR) in spontaneous speech across groups.
- To measure the Mean Articulatory Rate (MAR) in spontaneous speech across groups.
- To compare SR, AR and MAR within and across groups.

CHAPTER II

REVIEW OF LITERATURE

Speech production is a complex process in which coordination of the articulators is necessary. It is the process by which thoughts, feelings and ideas are converted into a series of sounds produced by vocal cords and modified by the sequential movements of articulators. There are three components of speech: articulation, voice and fluency. Fluency is "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" (Bergamo de Souza et al., 2013). It is also a multifaceted phenomenon, composed of various elements such as disfluencies, effort/strain, speech rate and silent pauses. Fluency can be affected by many factors like the length of an utterance, phonological structure, the type of speech task employed, a speaker's sex, and dialectal diversity (Crystal & House,1982).

Speech Rate (SR)

It is the overall time taken to produce or deliver a message. It is typically measured in words per minute (WPM) or syllables per minute (SPM). 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". If the speech rate gets affected, the intelligibility also gets affected especially in children with speech disorders (Sturm & Seery, 2007).

Speech rate can vary widely depending on various factors such as language, dialect, age, gender, speaking style etc. Duchin and Mysak (1987) found significant difference for Speech rate across various speech tasks. SR was found to be in the decreasing order of oral reading, conversation, and picture description. In an AIISH-funded ARF project, speech rate was calculated in 401 normal subjects speaking four different Dravidian languages-Kannada, Telugu, Tamil and Malayalam the metrics syllables per second (SS), syllables per minute (SPM) and words per minute (WPM) for reading task. Malayalam language had the highest rate (Savithri & Jayaram, 2004). In another study, speech rates were calculated in syllables per second (SPS) and compared across seven languages. The mean rates were found to be 5.18 SPS in Mandarin, 5.97 SPS in German, 6.19 SPS in English, 6.99 SPS in Italian, 7.18 SPS in French, 7.82 SPS in Spanish and 7.84 SPS in Japanese (Pellegrino et al.,2011).

Generally, a moderate speaking rate is around 120 to 160 words per minute, allowing for effective communication and comprehension without overwhelming the listener. However, it's important to note that the appropriate speech rate can vary depending on the context and the individual's communication goals.

Articulation Rate (AR)

Rate of speech can be measured in various ways depending on the aspect of fluency which is of interest. "Articulation rate" refers to the rate at which phonemes or syllables are produced when measured without interruptions. It refers to how quickly articulators move when producing speech. It is the time-dependent aspect of speech and the capacity of the motor system to transition throughout speech production (Chon et al., 2012). Unlike speech rate which includes disfluencies, articulation rate is calculated by excluding them

(Jacewicz et al., 2009). AR controls variables like speech planning and breathing. However, it also fluctuates due to several other variables, like age. There is a significant effect of age on AR due to the impact of age on motor skill development. Children are less skilled, so their articulation is slower and variable compared to adults. Gestural overlap is greater in adult speech than in children's speech (Katz et al., 1991).

The articulation rate is controlled by a brain clock or timekeeping function shared by all motor actions, including speech actions. There are two types of timing control which determine the articulation rate- intrinsic timing control and extrinsic timing control. According to Tsao et al.'s (2006a) theory, intrinsic timing control is the individual variations in the biological adjustment of the brain clock leading to inter-speaker diversity in articulation rate. They specifically contend that speakers with consistently quick articulation speeds have faster clocks than speakers with usually slow ones. The default rate at which people speak without instructions is "habitual" in this context. The individual variations due to personality or the pressure of a biological clock reflect the extrinsic timing control.

A duration-dependent undershoot model explains how an undershooting of speech target by the articulators occur due to reduced time leading to unclear speech output (Lindblom, 1963). If the speech plan for upcoming articulatory configuration is executed before the realisation of the current one, as in quick speech or when the acoustic target is especially short, an articulatory configuration in this paradigm is not completely realised. This approach has also explained the changes in articulation related to intelligible speech (Lindblom, 1990).

Mean Articulatory Rate

Mean Articulatory Rate (MAR) is calculated by finding the mean of five rate measures in for 10-20 fluent utterances without pauses (Van Zaalen et al., 2009). MAR might be a reliable indicator of articulation rate. Unlike the standard method, there is no manipulation of disfluencies or consideration of the entire speech sample in the MAR technique. As a result, the MAR technique appears to be more effective and may have uses in clinical settings. However, it is important to ensure that this alternate method measures what it is meant to measure. MAR method has been used in a few studies; however, the technique's validity has not been established yet.

Cosyns et al. (2018) compared two methods of calculating articulatory rate: the Mean Articulatory Rate method and the Global method. The speech sample was modified as part of the "global" procedure, which applies the MAR method once again after considering the complete speech sample. A significant positive correlation between the two approaches was discovered, lending the MAR method congruence validity. Although both methods measure the same idea, the results also revealed a considerable discrepancy between the two approaches, demonstrating that they do not provide the same numbers. The MAR technique seems to consistently yield greater articulation rate figures than the global method. More investigation is required before the MAR technique may be regularly used in clinical practice.

Stuttering and rate of speech

Speech rate is a crucial indicator of speech fluency since it is negatively correlated with the degree of stuttering. It is also a parameter that permits evaluation of the motor

speech processing. As a result, it's critical to describe speech rate for both fluent and persons who stutter (PWS). Rate of speech is an important component that should be assessed as well as adjusted during treatment for PWS (Guitar, 1998). Differences in articulation rate during a conversation (measured in phones per second) between stuttering and non-stuttering children have been documented by Hall et al. (1999). Flipsen (2003) claimed that the articulation rate is one component of speaking rate; the speaker's pauses make up the other element. According to several psycholinguistic theories of stuttering, people who stutter may need more time to process language before they can plan and deliver fluent speech output (Kolk & Postma, 1997; Peters, Hulstijn, & Starkweather, 1989). This concept can also be utilised in therapy. According to the American Speech-Language-Hearing Association's Special Interest Division on Fluency and Fluency Disorders (ASHA, 1995), modifying speaking rate is one of the procedures that clinicians might use in an effort to lessen stuttering frequency. Similarly, fluency-shaping therapy techniques used with employ teaching PWS to reduce their rate of speech (Guitar, 2006). According to Logan and Caruso (1997), children who stutter can construct and/or generate speech more fluently if the conversation's tempo is slowed. This is in contrast to the situation if no changes are made to the conversation's overall speed. Speaking rate may significantly influence the beginning, progression, and maintenance of stuttering.

Kelly and Conture (1992) found no significant difference in rate of speech between children who stutter (CWS) and controls in conversational speech. In a dissertation done at AIISH, the articulation rate in Kannada-speaking CWS was estimated by giving picture description and narration tasks. A sample not less than 300 words was taken for study. Articulation rate was calculated in syllables per minute. Children with no stuttering

(CWNS) showed a faster rate of speech than CWS, and older children showed a faster speech rate than the younger group (GR, 2016).

Two adult bilingual persons who spoke Kannada and English were subjected to linguistic analysis (Jayaram ,1976). In an informal interview, the participants were given reading passages and subjects to discuss in both languages. Questions were also posed to elicit spontaneous speech in both languages. Results showed that both individuals' speech rates were the same in both languages, except for the reading task, which exhibited a slower speech rate. For the reading task, subject 1's speech rate was 169.60 WPM in English and 101.3 WPM in Kannada, while subject 2's was 67.50 WPM in Kannada and 110.60 WPM in English. This finding demonstrates that stuttering is an entirely motor phenomenon.

According to Tasko et al. (2007) and Jessen (2016), syllable rate was a predictor of post-treatment naturalness scores. In many studies, it was found that rate of speech decreases post-treatment in PWS. However, the results may vary as well. Hausman (2019) found that syllable rate did not significantly alter between pre and post-treatment evaluations, and neither pre nor post-treatment samples' syllable rates were associated with the ratings of speech naturalness. This finding was rather unexpected given that other research (Jessen, 2016; Tasko et al., 2007) had shown a correlation between slower speech and ratings of unnatural speech.

Costa et al. (2016) conducted a study in which 24 native speakers of Brazilian Portuguese of both sexes between the ages of 18 and 59, who were born in the Belo Horizonte metropolitan area in the state of Minas Gerais, participated in the study. They used Speech Fluency Assessment Protocol's approach to collect the speech samples. The syllable-based speech rate metrics varied significantly from one another. All three metrics

were different, as evidenced by the repeated comparisons. Age had no impact on the metrics that were examined. These results support findings from earlier research. Calculating rate of speech in phonemes per second (PPS), including or excluding disfluencies can be beneficial.

Cluttering and rate of speech

Cluttering is a fluency disorder where the segments of conversation in the speaker's native language is either too fast or, irregular or both (St. Louis & Schulte, 2011). Cluttering is ‘‘a speech and language processing disorder frequently resulting in rapid, dysrhythmic, sporadic, unorganised, often unintelligible speech (St. Louis & Schulte, 2011; Daly, 1993)". The presence of articulation errors, excessive normal disfluencies and atypical pauses are few of the features seen in the speech of PWC (St. Louis & Schulte, 2011). Three defining characteristics of Cluttering include“ (1) a rapid and/or irregular articulatory rate (Daly, 1993; St. Louis, 1992; Louis, Raphael, Myers, & Bakker, 2003); (2) a higher than average dysfluency rate that is dissimilar to that seen in stuttering, and (3) reduced speech intelligibility due to bursts of fast speech and indistinct articulation" (St. Louis, Raphael, Myers, & Bakker, 2003; Louis, Myers, Bakker, & Raphael, 2007; Ward, 2006). In addition, telescoping errors due to over-coarticualiton are also present. It is the collapsing and omission of syllables within a word (e.g. :tevision" for ‘‘television") (Ward, 2006). A lack of awareness is also a common characteristic feature in Cluttering (Guitar, 2006).

The prevalence of pure Cluttering in Dutch and German population was found to be 1.1 % and 1.2 % respectively (Van Zaalen, 2017). Cluttering is not a clearly defined disorder as there is no separate entry of the disorder in DSM V. Hence, the diagnosis is

completely based on the cluster of traits that are common to the pathology. Rate of speech is a major characteristic feature of cluttering and the quantification of the same can strengthen the diagnosis. Clinically, the perceived rate of speech can misdirect the diagnosis due to inter-rater variability. The systems approach for management of Cluttering focuses on targeting a single dimension, especially rate which in turn benefits other dimensions. Hence, knowledge of speech rate in PWC is vital for accurate diagnosis and rate control management.

Cluttering has high likelihood of co-occurrence with other disorders (Ward, 2006). Lack of an objective criteria to differentiate cluttering and stuttering has proven to be a major challenge in accurate diagnosis and appropriate rehabilitation of the same. Differentiating the two using rate of speech as a measure can make the diagnosis more reliable and treatment more effective.

Coppens et al. (2013) used the norms for fluent adults and children to assess the disfluencies in the spontaneous speech of 28 adults with mild and moderate intellectual impairments (IQs 40–70) who had poor speech intelligibility. Participants were categorised into Cluttering, Cluttering-Stuttering and Stuttering based on the rates obtained and their dysfluency profiles. They found that 25% of the group who exhibited cluttering features also had a normal MAR and minimal articulatory rate fluctuation who were then labelled as ‘cluttering with normal MAR’. 13 of the 21 (62%) persons in the study were given a diagnosis of cluttering (also known as "cluttering" or "cluttering with normal MAR or high MAR"). The remaining 38% were determined to be a combination of Cluttering and Stuttering.

Linguistic and cultural factors may influence articulation rate; hence it is crucial to create norms for the average articulation rate in each language. Van Zaalen (2009) found that the fast articulatory rate which is at least one standard deviation (SD) above the MAR of disfluent speakers was not significantly different. The choice to exclusively study perceptually fluent or understandable speech may partly explain this conclusion. In PWC, dysfluent utterances tend to have a fast articulatory rate. Future research should consider these aspects and determine how to measure such fast bursts of speech accurately.

Despite being fast, PWC's articulatory rate can be considered normal (St. Louis et. al., 2007). Telescoping, coarticulation, or a high frequency of typical disfluencies could skew the listener's impression. Therefore, the clinician should keep in mind that speech pace may not be higher than that of people without communication difficulties when examining clients for potential cluttering.

Cluttering-Stuttering and rate of speech

Speech language pathologists have commented in a study that “Stuttering and cluttering are two distinct disorders which may overlap in some people.” (St Louis & Hinzman, 1986). Cluttering rarely occurs in isolation (St. Louis & Schulte, 2011). According to Diagnostic Battery utilised at the University of Blagoevgrad, individuals with cluttering-stuttering show average/rapid speech rate (Georgieva & Miliev, 1996). The mixed group can include either Cluttering-Stuttering where Cluttering predominates or Stuttering-Cluttering where stuttering predominates. Mean Articulatory Rate (MAR) was calculated for individuals who were diagnosed with Cluttering, Stuttering Cluttering-Stuttering and Controls. The mean rate was found to be 4.7 SPS in monologue, 4.6 SPS in reading and 4.8 SPS in story retelling for Cluttering-Stuttering group. The results were

found to be significantly different from the Stuttering group (Van Zaalen et al., 2009). In a case study, speech rate was calculated for an 18-year-old young professional who exhibited symptoms of both Stuttering and Cluttering. The rate was found to be 185 WPM for reading task and 188 WPM for conversational speech which was above the normal conversational range of 115-165 WPM for adults. Rate control strategies were advised for him as a treatment option (Deena & Wener, 1996).

A criterion was given by Coopens-Hofman et. al. (2013) to diagnose Cluttering and Cluttering-Stuttering based on the study done by Van Zaalen et al. (2009). The criteria for the diagnosis of Cluttering-Stuttering was given as " % Other Disfluencies (OD) > 10, % Stuttering-like disfluencies (SLD) > 3, in combination with either a ratio OD/SLD > 2.7 and normal Mean Articulatory Rate (MAR) and variation of Mean Articulatory Rate (MAR-v), or a ratio OD/SLD between 1 and 2.7."The diagnostic label of 'Cluttering-Stuttering' was also given when " % OD < 10, % SLD > 3, ratio OD/SLD < 1, MAR > 5.2 SPS or MAR-v > 3.3 SPS" This study was done in adults with mild and moderate intellectual disabilities who had poor speech intelligibility indicative of stuttering, cluttering or cluttering-stuttering like features.

The key findings obtained from the literature reveal that different methods as well as different metrices, were used to calculate the rate of speech. Although each method measures the same concept, the values may differ, leading to inconsistency in results, thus making it difficult to use it as a diagnostic measure. Rate of speech may also sound perceptually faster but, when measured objectively, may yield different results. Also, due to the high intra-personal variability of the rate due to many factors, the accuracy of the rate measure is questionable without considering those variables. The literature on

comparison of these methods is limited, especially in the Indian context. A careful consideration for the choice of method is required when calculating rate of speech especially in individuals with fluency disorders.

CHAPTER III

METHOD

The current study was aimed to measure different rate measures and compare them across and within control and clinical groups in Kannada language. The study was carried out as described below:

3.1 Participant details

The study included total of 40 native Kannada-speaking participants in the age range of 18-35 years. They were divided into two major groups- the Control group and the Clinical group. The Control group was age and gender-matched with the Clinical group. The Clinical group and the Control group included 20 males each.

3.1.1 Clinical group

The clinical group was again divided into three subgroups: Stuttering, Cluttering and Cluttering-Stuttering group. A total of 20 males were included in the clinical group out of which ten participants were diagnosed with Stuttering, five with Cluttering and five with Cluttering-Stuttering. The severity of stuttering varied, ranging from mild-very severe. All the participants were Kannada speakers within the age group of 18-35 years. They were selected based on convenient sampling. The diagnosis of the group was based on Predictive Cluttering Inventory-Revised (PCI-R) and Stuttering Severity Instrument-4 (SSI-4). Individuals with co-occurring conditions like Autism spectrum disorder (ASD), Attention-deficit hyperactivity disorder (ADHD), Learning disability (LD), Central auditory processing disorder (CAPD), cognitive deficits, psychological and neurological deficits, orofacial anomalies and other acquired conditions were excluded

from the study. The participants in the clinical group were recruited from Department of Clinical Services, AIISH, Mysuru, who availed the OPD or speech therapy services.

Table 3.1

Participant details

Sl No.	**Age(yrs.)**	**Gender**	**Diagnosis**
1.	24	Male	Stuttering
2.	18	Male	Stuttering
3.	22	Male	Stuttering
4.	20	Male	Stuttering
5.	18	Male	Stuttering
6.	22	Male	Stuttering
7.	18	Male	Stuttering
8.	24	Male	Stuttering
9.	35	Male	Stuttering
10.	23	Male	Stuttering
11.	32	Male	Cluttering
12.	30	Male	Cluttering
13.	25	Male	Cluttering
14.	21	Male	Cluttering
15.	19	Male	Cluttering
16.	31	Male	Cluttering -Stuttering
17.	21	Male	Cluttering-Stuttering
18.	30	Male	Cluttering-Stuttering
19.	24	Male	Cluttering-Stuttering
20.	26	Male	Cluttering-Stuttering

3.1.2 Control group

The control group included 20 normal individuals who were age and gender-matched with the clinical group within the age range of 18-35 years. They were native Kannada speakers with no history of speech, language, or hearing issues or any other medical conditions mentioned in the exclusionary criteria. The participants in the control group were selected from different backgrounds and included UG and PG students, lecturers and IT professionals from Mysuru-Bengaluru region. A spontaneous speech sample was elicited and recorded for each of them.

3.2 Instrumentation and Materials

1. A checklist was used to record the demographic data of the participants considering the exclusionary criteria for the selection of participants.
2. Stuttering Severity Instrument- 4 (SSI-4, 2009) was used to diagnose and rate the severity of stuttering.
3. Predictive Cluttering Inventory (PCI-R) was used for the diagnosis of Cluttering.
4. PRAAT software 64-bit edition was used to record and analyse rate of speech.
5. SPSS software version_26.0 was used for statistical analysis.

Spontaneous speech on topics like jobs, hobbies, education, daily activities and interests was considered for the study. Irregular speaking rate, a common characteristic feature of Cluttering, should also be taken into account. Hence, spontaneous speech sample was preferred over a reading sample to calculate the different rate measures.

3.3 Procedure

Detailed information regarding the procedure was given to the participants. Ethical consent was obtained from them to participate in the study. WHO checklist was used to screen for any associated problems mentioned in the exclusionary criteria. Recording was done in a soundproof room using PRAAT software. A spontaneous speech sample of 3-5 min containing not less than 300 syllables was elicited. A maximum of 600-800 syllables was obtained to account for accurate analysis of different rate measures. The participants were instructed to elaborate on the topic of choice, and further questions were asked if needed. One language, Kannada was considered for the study as the rate can vary within different languages (Grinfeld & Amir, 2006). Data was collected on the initial day of assessment or prior to or in the initial stages of therapy for the disordered population. The measurement was done in syllables per second (SPS) because in previous studies it was found that SPS metric is more sensitive to age differences in conversation task compared to words per minute (WPM) metric or phones per second (PPS) metric. Articulation rate (AR) is usually calculated in SPS and Speech rate (SR) in WPM (Amir & Grinfeld, 2011). But a uniformity was required to compare all the measures of rate of speech, hence SPS metric was chosen.

3.3.1 Data analysis

Speech Rate (SR): The Speech Rate was calculated using PRAAT software. The speech sample was transcribed manually to calculate the total number of syllables, including disfluencies like Normal disfluencies (NDs) and Stuttering-like disfluencies (SLDs). The duration of the sample was calculated in seconds. Phrases or sentence in other

languages were excluded. Coughing, laughing, inhalations etc. were also excluded while calculating total duration. Durational measures were obtained from PRAAT at the onset and offset. Van Zaalen (2009) defined onset and offset as the first and last peak that corresponds to a burst of spectral energy and termination of spectral energy, respectively. The edited sample was saved and labelled as Patient name_SR for further analysis.

$$\text{Speech Rate (SR)} = \frac{\text{Total number of syllables including the disfluencies}}{\text{Total duration in seconds}}$$

Articulation Rate (AR): It is the rate at which fluent utterances are produced in syllables per second. Articulation rate was calculated by excluding all the disfluencies and pauses greater than or equal to 250 ms. from the speech sample.

$$\text{Articulation Rate (AR)} = \frac{\text{Total number of syllables excluding the disfluencies}}{\text{Total duration in seconds}}$$

The sample obtained for speech rate was taken. This sample was further edited excluding disfluencies which included both Stuttering like disfluencies (SLDs) and Normal disfluencies (NDs) (Appendix A). Total duration was calculated after excluding all the disfluencies and pauses greater than or equal to 250 ms. This edited sample was saved as Patient name_AR. Pauses include silent pauses and filled pauses. Silent pauses are the silent periods present in an utterance which is usually greater than 200 ms (Tjaden & Wilding, 2004). Filled pauses are non-lexical vocalisation or sound hesitation such as ‘‘um’’ ‘‘uh’’ and so forth of any length (Clark & Fox Tree, 2002).

Mean Articulatory Rate (MAR): The sample obtained after analysis of SR was taken. Further analysis focused on five utterances which were randomly selected from the beginning, middle and end of the speech sample. Each utterance contained a minimum of 10-20 perceptually fluent syllables. In cases where five fluent utterances could not be obtained, a minimum of three utterances were considered to calculate the mean rate. The articulation rate of these five or three utterances was calculated as the total number of syllables produced in an utterance divided by the time taken for the production of those syllables in seconds. Further, the mean of these five measurements was determined, which was the MAR.

$$\text{Mean Articulatory Rate (MAR)} = \frac{R1+R2+R3+R4+R5}{5}$$

, where R1 is the rate of first utterance, R2 is the rate of second utterance and likewise.

3.3.2 Reliability

Inter and Intra-judge reliability was made for all the rate measures. 10% of randomly selected sample from each group was subjected to analysis by two native Kannada-speaking Speech-langauge pathologists (SLPs) for inter-judge reliability. The data was reanalysed by the examiner within one week of initial analysis for intra-judge reliability.

3.3.3 Statistical Analysis

The control group was compared with the clinical group in terms of SR, AR and MAR. The values were entered in SPSS (Statistical Package for Social Sciences) software version_26. Cronbach Alpha test was done and verified with correlation for determining inter-judge and intra-judge reliability.

Descriptive Statistics was done to observe the mean, median, standard deviation

and inter-quartile range across groups. All the data was subjected to normality test. The Shapiro-Wilk test was employed to determine the normality of the data distribution. Non-parametric test was done for between group comparisons due to unequal distribution of participants across groups. Kruskal -Wallis Test was done as there were more than two groups. Pairwise comparisons were obtained for each rate measure across groups. Parametric test: Repeated measures ANOVA was done to explore significant difference within Stuttering and Control groups as these two groups followed normal distribution. Non-parametric test: Friedman's Two way Analysis of Variance was done for Cluttering and Cluttering-Stuttering groups.

CHAPTER IV

RESULTS AND DISCUSSION

The study aimed at comparing the difference in rate of speech across and within Clinical and Control groups. This was done by measuring and comparing the three rate measures- Speech Rate (SR), Articulation Rate (AR) and Mean Articulatory Rate (MAR). The results of the study are discussed under the following headings:

4.1 Participant details

4.2 Reliability

4.3 Comparison of rate measures across groups

4.4 Comparison of rate measures within groups

4.1 Participant details

Forty Kannada-speaking individuals between the age range of 18-35 years were recruited for the study. Two major groups were considered for the study: the Control group and the Clinical group. The Clinical group consisted of the Stuttering group, Cluttering group and the Cluttering-Stuttering group. The Stuttering group included ten participants, and the Cluttering group as well as the Cluttering-Stuttering group included five participants each. The Control group was age and gender-matched with the Clinical group and had twenty participants. The study included only male participants, as the clinical group consisted of only male participants. Hence, gender was not taken as a variable for the study.

4.2 Reliability

Inter-judge and Intra-judge reliability was determined for all the rate measures. 10% of randomly selected sample from each group was analysed by two native Kannada-speaking Speech-language pathologists (SLPs) for inter-judge reliability. The data was reanalysed within one week of the initial analysis for intra-judge reliability.

For Intra-judge reliability, Cronbach's alpha value was obtained and verified with correlation. 1 and 2 are the first and second analyses respectively for the three rate measures. SR (1)- SR (2) = 0.939; AR (1)- AR (2) =0.983, MAR (1) -MAR (2) = 0.993, showing good reliability. For Inter judge reliability as well, Cronbach's alpha value was obtained and it was verified with correlation. 1 and 2 are the first and the second evaluators respectively. SR (1)-SR (2) = 1; AR (1)-AR (2) =0.983, MAR (1)-MAR (2) =0.993, showing good reliability.

4.3 Comparison of rate measures across groups

Speech Rate (SR), Articulation Rate (AR) and Mean Articulatory Rate (MAR) were obtained for all four groups. Speech rate (SR) is the overall rate of a speech sample, including all the disfluencies; however, Articulation Rate (AR) and Mean Articulatory Rate (MAR) are the rate measures that exclude disfluencies from the speech sample. Articulation rate (AR) is calculated by excluding all the disfluencies from the entire speech sample. Mean Articulatory Rate (MAR) is measured by taking five random utterances from the sample and calculating their rate after which their mean is calculated. Hence, all the three rate measures are calculated differently. According to previous studies, this plays an essential role when we consider measuring rate in individuals with fluency disorders. Table 4.1 provides details of Mean, Standard Deviation, Median and

Interquartile Range of SR, AR and MAR across the groups.

Table 4.1

Mean, Median, SD and Interquartile Range of the rate measures across the groups

Rate measures	**Sl No**	**Groups**	**Mean**	**SD**	**Median**	**Interquartile Range**
Speech Rate	(a)	Control (10)	3.88	.68	3.84	.86
	(b)	Stuttering (10)	2.98	.52	2.91	.91
	(c)	Cluttering (5)	4.21	.66	3.94	1.29
	(d)	Cluttering-Stuttering (5)	4.06	.22	3.96	.41
Articulation Rate	(a)	Control (10)	5.47	.54	5.53	.72
	(b)	Stuttering (10)	4.95	1.00	4.84	1.07
	(c)	Cluttering (5)	5.56	.84	5.33	1.59
	(d)	Cluttering-Stuttering (5)	5.50	.80	5.24	1.50
Mean Articulatory Rate	(a)	Control (10)	6.21	.68	6.18	1.26
	(b)	Stuttering (10)	5.67	.83	5.90	1.10
	(c)	Cluttering (5)	7.13	.63	7.21	1.16
	(d)	Cluttering-Stuttering (5)	7.25	1.50	7.08	2.49

Descriptive statistics was carried out. Mean, Standard Deviation, Median and Interquartile range were found for the groups. On observation, it can be noted that the

mean values for all the rate measures were lowest for the Stuttering group and highest for the Cluttering and Cluttering-Stuttering group. Since there were differences in group size, further comparison was done using non-parametric test. The details of significant differences are provided in further sections. Kruskal Wallis Test was done to compare the four groups for all the rate measures.

This is in agreement with the literature depicting lower rate of speech in individuals with stuttering due to the presence of disfluencies. A decreasing trend based on the severity of stuttering was also observed in one of the studies with 146.31 syllables per minute in very mild stuttering and 80.77 syllables per minute in very severe stuttering. Hence, speech rate was found to be an indicator of fluency in the study (Furquim de Andrade et al.,2003). Van Zaalen et al. (2009) measured MAR in syllables per second (SPS) and found a lower rate for Persons who Stutter (PWS) compared to Persons who Clutter (PWC), Persons with Cluttering-Stuttering (PWCS) and Controls. In addition, a significant difference for the rate was found for the task of retelling a memorised story as compared to other tasks like monologue or reading

In individuals with Cluttering, fast rate of speech may or may not be present when measured objectively (Bretherton-Furness & Ward, 2015; Van Zaalen et al., 2009). According to the Lowest Common Denominator (LCD) definition, “Cluttering is a fluency disorder wherein segments of conversation in the speaker’s native language typically are perceived as too fast overall, too irregular, or both. The segments of rapid and/or irregular speech rate must further be accompanied by one or more of the following: (a) excessive ‘normal’ disfluencies; (b) excessive collapsing or deletion of syllables; and/or (c) abnormal pauses, syllable stress, or speech rhythm (St. Louis &

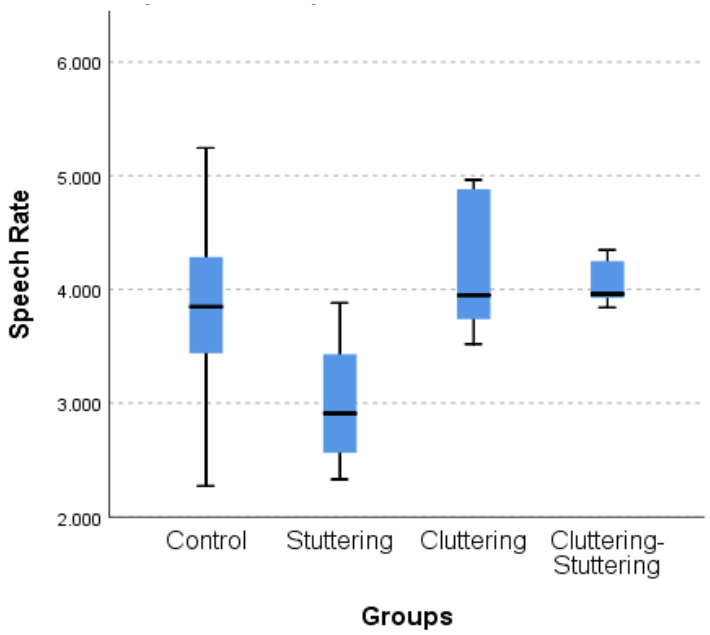
Schulte, 2011, pp. 241–242).” St. Louis and Schulte (2011) have further extended his definition as “cluttering need not occur frequently but sufficiently often to exceed that seen in normal speakers”. However, in this study the rate measures depict faster rate for Cluttering and Cluttering-Stuttering group as compared to the Control group and the Stuttering group.

4.3.1 Comparison of groups in terms of Speech Rate (SR)

Speech rate was calculated by dividing the total duration from the total number of syllables including the disfluencies measured in syllables per second (SPS). It was hypothesised that the distribution of Speech rate is the same across categories of groups. Results of Independent-Samples Kruskal Wallis indicated $\chi 2$ (3) = 14.828, $p<0.05$. Hence, there is significant difference for the distribution of Speech rate across groups. Figure 4.1 indicates the descriptive statistical comparisons of SR across groups.

Figure 4.1

Median and Range of Speech rate (SR) across groups



Further results of pairwise comparisons are indicated in Table 4.2. The results revealed that Stuttering group was significantly different from other groups in terms of Speech Rate (SR). However, no significant difference was found while comparing Control group with Cluttering group and Cluttering-Stuttering group as well as while comparing Cluttering group with Cluttering-Stuttering group. It suggests that these groups exhibited speech rate in a similar pattern.

Table 4.2

Pairwise comparisons of groups on Speech Rate(SR)

Sl No.	Group comparisons	Std. Test Statistic	Test Sig.
(a)	Stuttering-Control	3.103	.002*
(b)	Stuttering-Cluttering	-2.983	.003*
(c)	Stuttering-Cluttering-Stuttering	-2.983	.003*
(d)	Control-Cluttering	-.864	.388
(e)	Control-Cluttering-Stuttering	-.864	.388
(f)	Cluttering-Cluttering-Stuttering	.000	1.000

Note.*Significant at 0.05 level

This could be due to increased number of disfluencies in Stuttering group as compared to other groups, reducing the speech rate. This can significantly decrease the speech rate, contributing to the difference observed. This is also in line with previous studies. In one of the studies, PWS showed highest number of disfluencies like

prolongations and blocks as compared to PWC and Controls while describing a picture. However, PWC had shown the highest number of total disfluencies. Speaking rate of PWC was not found to be significantly faster than the other two groups but there was an increase in the mean rate (Bretherton-Furness & Ward, 2015). Bloodstein (1944) found a lower mean rate for reading task in AWS which was 122 .7 words/min as compared to fluent speakers which was 167.3 words/min. However, there are also studies where it was found that PWS have a higher speaking rate due to their difficulty in planning and execution of an utterance. Bloodstein (1987) has observed that increase in speech rate can lead to stuttering. Perceptually, speaking rate may appear to be fast but objectively the overall rate can show a reduction due to the presence of disfluencies in stuttering. According to covert-repair hypothesis (Postma & Kolk, 1993), PWS tend to recompute their speech plans to produce a fluent utterance which can lead to a reduction in speech rate when disfluencies occur. This is in agreement with the results obtained in the current study.

No significant difference was obtained in Controls, Cluttering and Cluttering-Stuttering groups. This could be due to increased number of normal disfluencies in cluttering which is somewhat close to that of controls. Also, in the upcoming results of within group comparisons, it was found that the Cluttering-Stuttering group had predominantly cluttering features. This may have led to similar results for the speech rate in the three groups.

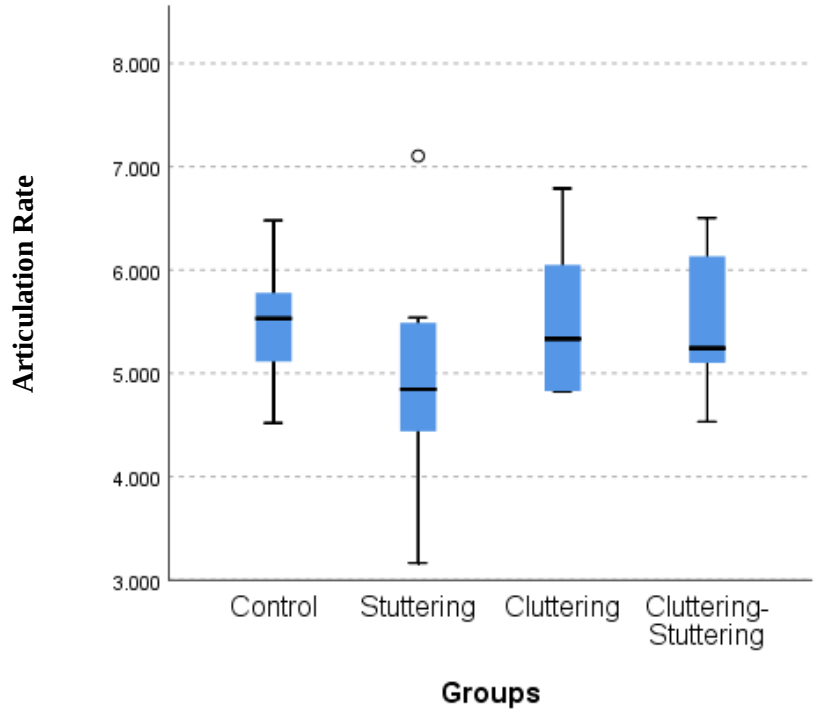
These findings can be helpful in directing the usage of speech rate as one of the measures to differentially diagnose stuttering from fluency disorders.

4.3.2 Comparison of groups in terms of Articulation Rate (AR)

Articulation rate (AR) is calculated by dividing total duration from the total number of syllables excluding disfluencies and pauses ≥ 250 ms. It was hypothesised that the distribution of AR is same across categories of groups. Independent-Samples Kruskal Wallis Test results indicated $\chi 2$ (3) = 4.652, p > 0.05. Hence, there is no significant difference for the distribution of AR across groups. So, multiple comparisons were not done because the overall test did not show any significant difference across samples. Although significant difference did not exist, the mean values of AR were slightly lower in stuttering (4.95 SPS) as compared to Cluttering (5.56 SPS), Cluttering-Stuttering (5.50), Controls (5.47). Figure 4.2 indicates the descriptive statistical comparisons of MAR across groups.

Figure 4.2

Median and Range of Articulation Rate (AR) across Groups



When disfluencies are excluded from the entire sample and the focus is more on fluent utterances, the articulation rate can be equal across groups. The result depicts that AR cannot be used as a measure to differentiate across the groups. However, we cannot conclude this statement due to the reduced sample size. Limited studies have been reported where AR is calculated and compared in AWS and Controls. Chon and Loucks (2021) found that AR in PWS was slower than Controls for the task of repeating sentences of different lengths and syntactic complexity. This was attributed to reduced speech motor control in PWS. Also, the rates had increased in both the groups with practice. Hower, faster rates have also been reported in AWS as compared to Controls in social stress situations (Bauerly et al.,2019). The literature on AR across various groups have been mainly conducted in children with long-standing history of stuttering, and the results were found to be inconsistent. However, a slower AR was noted in children at a very early stage of stuttering when compared with Controls (Hall et al.,1999; Meyers & Freeman,1985) Equal speech rate was also found in children who stutter and normal children in one of the studies (Chon & Lee, 2016). Hence the overall results in previous studies have shown an inconsistent pattern.

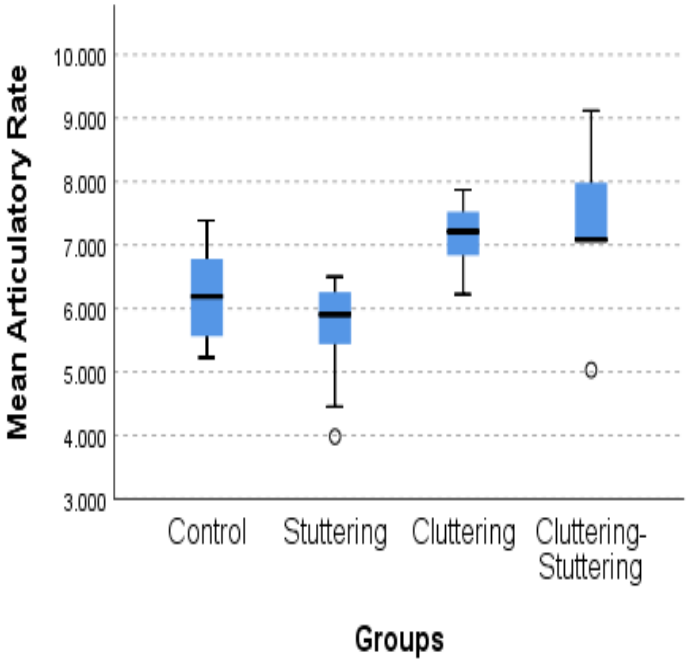
According to St. Louis (2003), a high or irregular articulation rate in PWC help to differentiate them from PWS. However, PWC's Articulation Rate can be considered normal even though it is regarded as being fast. Telescoping, coarticulation, or a high frequency of typical disfluencies are just a few examples of variables that could potentially skew the listener's impression (St. Louis, 2007).

4.3.3 Comparison of groups in terms of Mean Articulatory Rate (MAR)

MAR is obtained by calculating the articulation rate of five randomly selected and perceptually fluent utterances in the unit of syllables per second and then taking the mean of these five rate measurements. It was hypothesised that the distribution of MAR is the same across groups. Results of Independent-Samples Kruskal Wallis reveal $\chi 2$ (3) = 11.106, $p<0.05$. Hence, there is significant difference for the distribution of Mean Articulatory Rate (MAR) across groups. Figure 4.3 indicates the descriptive statistical comparisons of MAR across groups.

Figure 4.3

Median and Range of Mean Articulatory Rate (MAR) across groups.



Further, pairwise comparisons were done which is indicated in Table 4.3. It was found that Stuttering group was significantly different from Cluttering and Cluttering-Stuttering group; and Cluttering group was significantly different from Control group.

No significant difference was observed when comparing Stuttering and Control groups, Control and Cluttering-Stuttering groups and Cluttering-Stuttering and Cluttering groups.

Table 4.3

Pairwise Comparisons of Groups on Mean Articulatory Rate (MAR)

Sl No.	Group comparisons	Std. Test Statistic	Test Sig.
(a)	Stuttering-Control	1.270	.204
(b)	Stuttering-Cluttering-Stuttering	-2.436	.015*
(c)	Stuttering-Cluttering	-2.842	.004*
(d)	Control-Cluttering-Stuttering	-1.685	.092
(e)	Control-Cluttering	-2.130	.033*
(f)	Cluttering-Stuttering-Cluttering	.352	.725

Note.*=Significant at 0.05 level

Mean values of MAR were found to be close to each other in the Stuttering group (5.67 SPS) and the Control group (6.21 SPS) indicated in Table 4.1. As only fluent utterances are taken, no difference was observed between the two groups. Also, since the Stuttering group has reduced mean value of MAR (5.67 SPS) compared to Cluttering (7.13 SPS) and Cluttering-Stuttering (7.25) groups, the significant difference could have been observed between these groups. The high rate in Cluttering group as compared to controls could be due to fastest burst of speech which is randomly occurring in the Cluttering group and absent in Control group (St. Louis, 2003).

MAR rates were compared across groups in previous studies. In one study, the MAR of PWS was slower (mean SPS = 3.7) compared to PWC (mean SPS = 4.9) and controls (mean SPS = 5.9) for the task of retelling a memorised story. Interestingly, mean SPS of Controls was faster than PWC (Van Zaalen et al., 2009). In another study, ten utterances were randomly selected without considering the entire speech sample to measure the articulation rate and a higher rate was observed in PWC (mean SPS=7.94) compared to Controls (mean SPS= 6.25) (Bóna & Kohári, 2021).

4.4 Comparison of rate measures within groups

Speech rate (SR), Articulation Rate (AR) and Mean Articulatory Rate (MAR) were compared within all the groups. This was required to understand whether it is important to use different rate measures to calculate the rate of speech in different groups. In addition, the rate measure best suited for comparison of all the three groups can also be found.

Due to unequal distribution of participants in the groups, parametric and non-parametric tests were done. Shapiro Wilk's Test of normality was administered for Control and Stuttering groups. Since the Control and Stuttering groups followed normal distribution, parametric test was done. One way-repeated measures ANOVA was done to compare the rate measures in Control and Stuttering group. Non-Parametric Test called the Friedman's Test was done to compare the rate measures in Control, Cluttering-Stuttering and Cluttering groups due to unequal and reduced group size.

4.4.1 Comparison of rate measures within Control group

In the Control group, repeated measures ANOVA was carried out. Results revealed F (2,38) =115.375, $p<0.05$ suggesting significant difference while comparing different rate types. So pairwise comparisons were done and results are indicated in Table 4.4.

Table 4.4

Pairwise comparisons of rate measures within Control Group

Sl No.	Rate comparisons	Sig.[c]
(a)	SR-AR	.000*
(b)	SR-MAR	.000*
(c)	AR-MAR	.000*

Note. SR: Speech Rate, AR: Articulation Rate, MAR: Mean Articulatory Rate

*Significant at 0.05 level

c.Adjustment for multiple comparisons: Bonferroni

Significant difference was found for all the rate measures. In Bonferroni's test, it was evident that the three rate measures were different from one another. Hence, there is a need to develop norms for different rate measures.

Since Speech Rate (SR) includes all the disfluencies and Articulation Rate (AR) and Mean Articulatory Rate (MAR) considers only fluent utterances, they were found to be different. The difference in AR and MAR is also in accordance with a study that compared both these methods in 80 typically fluent adults (Cosyns et. al., 2018). Despite measuring the same concept, the two rate measures yield different results. MAR values

were found to be higher than AR values according to the study. The current study reveals the same result. This could be due to speaker's fatigue at the end of the sample reducing the Articulation rate. Due to its time-saving nature, MAR was preferred over AR in previous studies. It was found that the variation among fluent speakers could be due to the differences in the biological setting of a neural clock which controls the timing of the speech output (Tsao et al.,2006). There is a habitual speech rate which is either fast or slow among speakers. The neural clock runs fast in speakers who speak habitually fast than speakers who speak habitually slow.

. Amir (2016) found a lower speaking rate (mean SPS=5.60) and a higher articulation rate (mean SPS=6.26) in 78 Hebrew adult speakers. Similarly, Cangi et al. (2020) found a lower Speech rate (mean SPS=5.33) and higher Articulation rate (mean SPS=6.75) in 19–24 year-old Turkish speakers for the task of spontaneous speech. Turkish is a syllable-timed language. Most Indian languages are also syllable-timed (Hemakumar G & Punitha P, 2013). Comparison of rate measures within Kannada speakers have not been done yet. Hence, the rate measures were found to vary in different languages as well.

4.4.2 Comparison of rate measures within Stuttering group

In Stuttering group, repeated measures ANOVA was carried out. Results revealed $F(2,18) = 34.602$ ($p<0.05$). Significant difference was found and pairwise comparisons were done. Table 4.5 depicts the details of statistical comparisons of rate measures within Stuttering group.

Table 4.5

Pairwise Comparisons of rate measures within Stuttering Group

Sl No.	Rate comparisons	Sig.[c]
(a)	SR-AR	.001*
(b)	SR-MAR	.000*
(c)	AR-MAR	.308

Note. SR: Speech Rate, AR: Articulation Rate, MAR: Mean Articulatory Rate

*.Significant at 0.05 level

c.Adjustment for multiple comparisons: Bonferroni

Significant difference was found when Speech Rate (SR) was compared with Articulation Rate (AR) and Mean Articulatory Rate (MAR). No significant difference was found when comparing AR and MAR in Bonferroni's test. However, both the rate measures were found to be different from SR. Consideration of only fluent utterances in the Stuttering group may contribute to similar results with respect to AR and MAR. However, in SR the overall rate reduces significantly due to increased number of disfluencies in Stuttering group. Hence, SR would be a good measure to calculate rate of speech in PWS.

There is less awareness among SLPs regarding calculation of speaking rate. 84% of SLPs were not aware of speaking rate measures in stuttering (Pellowski, 2010). In one study, speech rate was calculated in syllables per minute (SPM) and words per minute (WPM), including 70 Brazilian Portuguese-speaking adults. The rates ranged from 80.61 WPM and 146.31 SPM in very mild stuttering and 44.98 WPM and 80.77 SPM in severe

stuttering, reflecting a decrease in rate as the severity increases (Furquim de Andrade et al., 2003). Articulation rate studies have mostly been done in children comparing the same with adults.

4.4.3 Comparison of rate measures within Cluttering group

It was hypothesised that the distribution of SR, AR and MAR is the same. Friedman's Test was carried out and it was found that $\chi 2\ (2) = 10.000$, $p<0.05$. Hence, there is significant difference for the distribution of all the rate measures within the Cluttering group. So pairwise comparisons were done. Table 4.6 depicts the details of statistical comparisons of rate measures within the Cluttering group.

Table 4.6

Pairwise Comparisons of rates measures within Cluttering Group

Sl No.	Rate comparisons	Std. Test Statistic	Adj. Sig.[a]
(a)	SR-AR	-1.581	.342
(b)	SR-MAR	-3.162	.005*
(c)	AR-MAR	-1.581	.342

Note. SR: Speech Rate, AR: Articulation Rate, MAR: Mean Articulatory Rate

*Significant at 0.05 level

a.Adjustment for multiple comparisons: Bonferroni multiple tests

Pairwise comparisons revealed significant difference for Speech rate (SR) and Mean Articulatory rate (MAR). Since irregular rate of speech is evident in Cluttering, MAR can show significant difference as random utterances from entire sample is taken for calculating this rate. These random utterances may include rapid bursts of speech in the speech sample of individuals with Cluttering. SR was found to be significantly

different from MAR because the overall rate of speech includes disfluencies which may reduce the rate of those utterances. This may nullify the effect of rapid rates found randomly in an utterance and thus leading to a lower rate than MAR. No difference was found for the remaining pairs which includes SR-AR and AR-MAR. The number of disfluencies could be lesser in the Cluttering group leading to no significant difference when SR and AR were compared. No significant difference for AR compared to MAR measures could be because fluent utterances are considered in both techniques.

In previous studies, MAR has been used to calculate the rate of speech in Cluttering. Diagnosis of the same has also been indicated in one study based on MAR. Spontaneous speech of 28 adults with Intellectual Disability was taken and they were diagnosed based on correlation between their dysfluency profiles and MAR. Mean rate was found to be 5.9 SPS in the Cluttering group. Also, another Cluttering group was identified with all the characteristics of Cluttering but a normal MAR where the mean rate was found to be 4.1 SPS. (Coppens-Hofman et al., 2013). In another study, MAR for Cluttering group was also calculated for three different tasks, which were monologue, reading and story retelling and the mean rates were found to be 5.3 SPS, 4.5 SPS and 4.9 SPS, respectively (Van Zaalen et al., 2009). Hence, the rate also varied depending on the speech task.

4.4.4 Comparison of rate measures within Cluttering-Stuttering group

It was hypothesised that the distribution of SR, AR and MAR in Cluttering-Stuttering is the same. Friedman's Test was carried out and it was found that $\chi 2\ (2) = 10.000$, $p<0.05$. Hence there is significant difference for the distribution of all the rate measures within Cluttering group. So pairwise comparisons were done. Results of the

same are displayed in Table 4.7.

Table 4.7

Pairwise Comparisons of rate measures within Cluttering-Stuttering Group

Sl No.	Rate comparisons	Std. Test Statistic	Adj. Sig.[a]
(a)	SR-AR	-1.581	.342
(b)	SR-MAR	-3.162	.005*
(c)	AR-MAR	-1.581	.342

Note. SR: Speech Rate, AR: Articulation Rate, MAR: Mean Articulatory Rate

*Significant at 0.05 level

a.Adjustment for multiple comparisons: Bonferroni multiple tests

Pairwise comparison revealed significant difference for Speech rate (SR) and Mean Articulatory rate (MAR). No difference was found for the remaining pairs. This finding is similar to Cluttering group suggesting Cluttering features to be predominantly present in Cluttering-Stuttering group. SR and MAR measures were found to be different from each other in Cluttering-Stuttering group because SR tends to have a reduced value due to the presence of both Normal disfluencies (NDs) as well as Stuttering-like disfluencies (SLDs). This factor is eliminated in the calculation of MAR. Also, the mean of five random utterances taken from the sample can account for the variation in rate that occurs over time which can lead to a higher value. There are no studies comparing various rate measures in Cluttering-Stuttering group. However, in one of the studies, MAR was calculated for the task of story retelling and the mean value was found to be 4.9 SPS (Van Zaalen et al., 2009). In another study, MAR was found to be 5.1 SPS in

adults with ID who exhibited features of Cluttering-Stuttering (Coppens-Hofman et al., 2013).

To conclude, Speech rate (SR), Articulation Rate (AR) and Mean Articulatory Rate (MAR) were measured in Controls and individuals who were diagnosed with Stuttering, Cluttering and Cluttering-Stuttering. These rate measures were compared across and within groups. Similar results were obtained for Cluttering and Cluttering-Stuttering. It was found that SR is different from MAR. Whereas in Control group, all pairs were found to be different. In Stuttering group, SR was found to be different from AR and MAR.

Overall, it was found that majorly SR and MAR were different for all the four groups. Also, Stuttering group had the lowest rate whereas Cluttering and Cluttering-Stuttering group had the highest rate. Alm (2011) proposed a model for the neurological basis of cluttering which states that: “the core of the problems in cluttering is located in the medial wall of the left frontal lobe which helps in motor speech execution and monitoring of speech”. The anterior cingulate cortex (ACC), pre supplementary motor area (pre SMA), supplementary motor area (SMA) and basal ganglia outputs form an “executive hub”. Speech rate is controlled by SMA, cerebellum and basal ganglia. Basal ganglia selects the target word and suppresses competitors. Monitoring of the auditory consequences of speech production is controlled by ACC and SMA. Alm (2011) emphasizes that cluttering might be due to dysregulation and hyperactivation of the medial frontal cortex as a result of disinhibition of the basal ganglia output. Involvement of dysregulation in SMA may contribute to irregular/increased speech rate. The hyperactivation could be due to reduced efficiency of neural processing as more effort is

required to plan and execute speech output in PWC. Overactivity in subcortical structures were also noted (Ward & Wener ,1996). The extra demands for speech production are reflected in both the cognitive and motoric structures of basal ganglia which are the caudate nucleus and putamen respectively.

Loucks et al. (2022) conducted a kinematic study in PWS who underwent Comprehensive Stuttering Programme (CSP) where a comparison of speaking rate along with other variables was made across different treatment stages. A higher SPM was noted Post-treatment Casual manner compared to Pre-treatment and Fluency skills condition. Casual manner indicated speaking casually without using any techniques and Fluency skills condition employed rate control strategies along with other fluency shaping techniques. The speaking rate for conversation was 182.0 SPM (S.D. = 53.6) pre-treatment which increased to 200.7 SPM (S.D. = 21.5) for the Post-treatment Casual condition, but taking on an intermediate value in the Fluency Skills condition, 191.6 SPM (S.D. = 39.1). This increase in speaking rate post treatment could be attributed to decrease in kinematic duration and a decrease in Spatial-temporal Index (STI) of lower lip kinematics. Thus, the decreased rate seen in PWS could be due to higher STI indicating higher kinematic variability.

Rate of speech is highly variable among individuals based on many factors like language, age, gender, speech task etc. Hence, uniformity in the method of calculating rate of speech is required. Different methods can be utilised depending on our needs. Speech rate is the universal method of calculating rate of speech. However, since significant difference has been obtained for MAR, this method can also be incorporated as a test measure for accurate rate calculation.

CHAPTER V

SUMMARY AND CONCLUSION

Speaking rate has been a valuable clinical measure for documenting the speech characteristics in individuals with speech disorders. It varies among fluent speakers as well as disfluent speakers due to a multitude of factors. The pattern in which it varies and the application of the same can be utilised in several ways to facilitate clinical judgments. A high variability in the methods of calculating rates among SLPs can also affect the application of the same in assessment as well as management of fluency disorders.

Thus, the present study was carried out to understand different methods to calculate rate of speech across fluent and disfluent adult speakers. All the methods that have been studied previously in several studies have not been discussed extensively in Indian context.

This study included calculation of three rate measures namely Speech Rate (SR), Articulation Rate (AR) and Mean Articulatory Rate (MAR) . Both the Clinical group and the Control group were considered for comparison. The clinical group included adults with Stuttering, Cluttering and Cluttering-Stuttering. The study included a total of 40 Kannada speaking individuals within the age range 18-35 years. The Control group included 20 participants age- and gender-matched with the Clinical group, which included ten persons who stutter (PWS), five persons who clutter (PWC) and five persons with cluttering-stuttering. A spontaneous speech sample was obtained from all the participants of the groups, recorded and analysed using PRAAT software. The

measurement was done in syllables per second (SPS) for all the rate measures. The rate measures were obtained by dividing the total duration from the total number of syllables by either including the disfluencies or excluding the disfluencies. Speech rate included the disfluencies and Articulation rate as well as Mean Articulatory rate excluded the disfluencies. These rates were compared between as well as within all the four groups.

The data obtained was tabulated and statistically analysed using SPSS Version_ 26. Shapiro-Wilk test was done to check for normality. Both parametric and non-parametric tests were carried out. Kruskal-Wallis test was done for between group comparisons. Repeated measures ANOVA and Friedman's test was done for within group comparisons.

The results of the study revealed the following findings:

- Good inter-judge and intra-judge reliability for the calculation of rate measures was obtained.
- Descriptive statistics for the comparison of rate measures across groups revealed the lowest mean rates for Stuttering group and highest for Cluttering and Cluttering-Stuttering groups.
- For between group comparisons, Stuttering group was found to be significantly different from all other groups in terms of Speech Rate (SR). No significant difference was found for Articulation Rate (AR) across groups. For Mean Articulatory Rate (MAR), a significant difference was found while comparing Stuttering group with Cluttering and Cluttering-Stuttering group. A significant difference was also obtained when the Control group was compared with the Cluttering group.

- For within-group comparisons, all the three rates were measured in each of the four groups. In the Control group, all the rate measures varied significantly from each other. In the Stuttering group, Speech Rate (SR) showed a significant difference when compared to other rates. The comparison between Speech Rate (SR) and Mean Articulatory Rate (MAR) showed significant difference in the Cluttering and Cluttering-Stuttering groups.

Since the majority of findings suggested a significant difference for the three rate measures, it is essential that we consider various rate methods when differentially diagnosing the clinical groups. Due to a lack of uniformity in the usage of a method for calculating rate of speech, the exploration of these rate measures has given an insight on the usage of the same across different clinical groups. The findings of the present study give some insight among Speech-Language Pathologists to use a rate measure which is the most suitable to differentially diagnose clinical groups.

Implications of the study

- The study's findings can help differential diagnosis of fluency disorders in adults in Kannada language.
- The objective measures of rate of speech obtained can aid in rehabilitating individuals with fluency disorders. Monitoring of rate of speech during the course of therapy can help quantify the extent of progress.
- Very few studies have been done in spontaneous speech in both clinical and control groups in Kannada language to calculate rate of speech. Hence, the results obtained can be beneficial, especially during the generalisation phase of therapy for Kannada speakers.

Limitations of the study

- This study had unequal distribution of participants in all the four groups due to less number of participants in Cluttering and Cluttering-Stuttering group.
- The measures were obtained at different time points of therapy depending upon the availability of the participants.
- The severity of stuttering varied from mild to very severe stuttering. A homogenous representation of each severity level could not be incorporated.
- The severity of cluttering was also not considered in the study.

Future directions

- Equal number of participants for all the groups and on a larger sample size can be considered.
- Development of normatives in Kannada language for all the rate measures can be done since a significant difference was obtained for Controls for the same.
- Rate of speech with respect to the severity of stuttering can also be documented.
- Comparison of rate measures for different speech tasks like reading and narration can also be done for the rate measures within and across the groups.
- Comparison of rate measures for different units of measurement like syllables per minute (SPM), syllables per second (SPS), words per minute (WPM), words per second (WPS) and phonemes per second (PPS) for the rate measures within and across groups.
- Improvement of rate measure based on this study can be documented at different time points of therapy and further research could be done in this aspect.

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APPENDIX A

List of disfluencies excluded for the calculation of Articulation Rate

Sl. No.	Stuttering-like Disfluencies (SLD)	Normal Disfluencies (ND)
1.	Phoneme repetitions	Word repetitions
2.	Syllable repetition	Phrase repetitions
3.	Part word repetitions	Revisions
4.	Prolongations	Interjections
5.	Blocks	