Perspective Article

Development of Fluency in Children

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Abstract

The scope of this perspective article is to review the available literature on the development of fluency. The available evidence suggests that sophisticated types of disfluencies take over repetitions, prolongations, and pauses in children in the ages of 2 years to 7 years. Further, the studies report that children initially use stress on each syllable and later learn the stress pattern of their respective native languages. In addition, the development of speech rhythm of a particular language, as per most of the studies commences in infancy and adult-like rhythm develops by 12 years of age. A review of studies on speech rhythm indicates that the definition of speech rhythm is yet to be established and the results of studies are contradicting.

INTRODUCTION

This article will address the development of fluency in typical children. The word fluency is derived from Latin root fluere, which means flowing. In communication, fluency refers to the smooth and easy flow of utterance. Technically, fluency is the effortless production of long continuous utterances at a rapid rate (Starkweather, 1980). According to Starkweather (1980), fluency is the general phenomenon of the flow or rate of speech, influenced by variables such as duration of individual sounds and syllables, in relation to adjacent sounds and syllables, duration of pauses, presence of stress contrasts, and degree of coarticulation. Starkweather (1982) added a fourth component, the rhythm structure of speech.

Disfluency is defined by the American Speech-Language and Hearing Association (ASHA) Special Interest Division (SID) 4 as speech that exhibits deviations in continuity, smoothness, and ease of rate and effort (ASHA SID 4, 1999). Terms disfluency or nonfluency imply disruptions in the timing and flow of non-stuttered speech such as interjections and phrase repetitions which are frequently perceived as being part of the normal interruptions of speech. Hence, in very simple terms, one could consider disfluency as the opposite of fluency.

Dysfluency signifies abnormality of fluency. It includes, but is not limited to stuttering (Wingate, 1984). Stuttering refers to "disorders in the rhythm of speech in which the individual knows what he wishes to say, but is unable to say it because of an involuntary, repetitive prolongation or cessation of a sound." (WHO, 1977).

Having understood the meanings of fluency, disfluency, and dysfluency, one has to note the evolution of various components of fluency. We shall now cognize the development of some of the parameters of fluency such as the pauses, repetitions, prolongations, false starts, parenthetical remarks, rate of speech, stress, and rhythm.

Development of repetitions, pauses, prolongations, false starts and parenthetical remarks

As early as in 1981, Kirk Patrick postulated that word repetition is seen in children who do not show any evidence of stuttering. In 1904, Edward Conradi inferred that speech disfluency occurs due to playful pleasure children take in repeating certain sounds. Brandenbury (1915) and Nice (1920) each studied one child and reported the incidence of repetitions of a word or sentence. However, these studies did not show definitions or different types of repetitions, nor did they offer age- and gender-wise analysis. Thus, the need for quantification of disfluencies was justified.

Quantification of disfluency began at the University of Iowa in the late 1930s and early 1940s as Wendell Johnson (1942) was emerging with the diagnosogenic theory of stuttering. Johnson (1948) reported that non-fluencies decreased in general from infancy to adulthood. Johnson et al. (1959) noted that word repetitions, interjections, phrases, etc. were the most commonly occurring disfluencies in a child's speech. But the above studies had several limitations such as sampling method adopted, number of subjects included in the study, and type of recording used (Yairi, 1981). Results of studies by Yairi and Clifton (1972) were in contradiction to Johnson's findings. They reported that the total disfluencies decreased from preschool to high school age, but then advanced along age into geriatric groups, where disfluencies had increased.

Research on wide age ranges of children that quantified disfluencies include those of Branscom etal. (1955), Egland (1955), Yairi and Clifton (1972), Kowal etal. (1975), Haynes and Hood (1977), Bjerkan (1980), Yairi (1981), Nagapoornima (1990), Indu (1990), Yamini (1990), Rajendra swamy (1991) and Anjana & Savithri (2007). The above authors studied fluency development in normal children in the age range of 65-72 months and reported that sound or syllable repetitions were more, followed by word repetitions and phrase repetitions. Branscom et al. (1955) studied 193 children in the age range of 2 to 6 years for disfluencies in two different contexts, free play and fluency testing. The results revealed that syllabic repetitions occurred less than half as often as word repetitions and less than a third as often as phrase repetitions.

Kowal et al. (1975) investigated disfluencies in 168 children and reported that repetitions at senior year had reduced to about one-sixth of kindergarten level and were relatively less in absolute terms. Part-word repetitions were more in kindergarten children and second graders, but, dropped out of the picture for fourth graders. Kowal et al. (1975) also reported that at younger ages, children used more of unfilled and filled pauses, but as they grew, they used more sophisticated types of disfluencies such as false starts and parenthetical remarks. The results implied that overall, disfluency rates continued to fall through the period of later language development, from roughly a 7–8% disfluency rate in kindergarten through 4th grade, to a 5– 6% disfluency rate from the 6^{th} to 12^{th} grades. Nonetheless, they noted that stutter-like disfluencies (SLDs) showed more intense changes by age. For example, repetitions ranged from a high of 25 per 1,000 syllables among the kindergartners to only 4 per 1,000 syllables among high schoolers. Thus, it appears that study of certain types of disfluencies, such as repetitions, which occur frequently in young language learners and are barely present in young adults, may provide insight into the development of fluent speech production. Similarly, the results obtained by Yairi (1981) are provided in Table 1.

In addition, Yairi (1982) analyzed spontaneous verbal output of 500 words of 33 children of age 2 years (18 girls and 15 boys). The children were divided into two groups. Group I consisted of 13 younger children in the age group of 24-26 months. Group II comprised of the older children (10 boys and 10 girls), in ages between 29 to 33 months. Four spontaneous speech samples were taken for each child in group I and three samples for each child in group II and all were audio-recorded at 4-month intervals. The classification of disfluencies of Yairi (1981) was used in this study to calculate frequency of disfluency per 100 words. As no significant gender difference was reported in the previous study of Yairi (1981), data for boys and girls were combined. Results showed that for the entire group, there was a reduction in disfluency throughout the 8-month span during which the three speech samples were recorded. The average total number of disfluencies, declined from 6.5 disfluencies per 100 words at the beginning of the study (29 months), to 5.10 (33 months) to 4.1 (37 months). Group I revealed a general trend of increase in the number of disfluencies from the beginning to the end of the third year of their lives. But, the children in group II exhibited a relatively sharp reduction in disfluencies during the 8-month period. Suffice it to state, that the results showed that the number of disfluencies at the beginning of the third year was low, but it increased gradually with time. The normal disfluency peaked in the final part of the year. The data also showed that increase in disfluency in group I was due to two disfluencies, revision and phrase repetition. In group II, there was consistent reduction across all disfluency types, although it was noticed more for part-word repetitions and interjections. Hence "taken together, the overall picture obtained from these observations is that the year between the ages 2 and 3 is a volatile period in speech development as far as the parameters of disfluency is concerned" (Yairi, 1982). During this period instability in the fluency of ongoing speech and brief episodes of fluency disruption, lasting up to several weeks, which may occur in some children and which parents or other observers may regard as stuttering (Yairi, 1982). Yairi concluded, that two-year-old children should not be treated as a homogenous group in studies of disfluency.

Table 1: Mean percent disfluency per 100 words identified in speech of 33 children of age 2 (15 boys, 18 girls) (Yairi, 1981)

Disfluency type	Boys	Girls	Combined
Part-word repetition	1.53	0.96	1.22
Single-syllable Word repetition	1.56	1.12	1.32
Poly-syllabic Word repetition	0.07	0.07	0.07
Phrase repetition	0.54	0.60	0.57
Interjection	1.95	0.92	1.38
Revision	1.32	0.87	1.07
Disrhythmic phonation	0.48	0.36	0.43
Tense pause	0.50	0.34	0.43
Total Disfluency	7.95	5.24	6.49

The above studies included English-speaking children in the age range of 24 to 33 months. However, other investigators (Wexler & Mysak, 1982: 36, 2, 4, 6 year olds; De Joy & Gregory, 1985: 60, 3.5 and 5 year olds) have studied the development of fluency in younger children. "The relatively lower disfluency frequencies observed for the types that may appear to have a motor component, i.e., part-word repetitions and disrhythmic phonations, especially in the speech of the youngest age group, tend to support the motor hypothesis" (Wexler and Mysak, 1982). Two disfluency types that discriminated significantly between the older and younger children were part-word repetitions and disrhythmic phonations, which De Joy and Gregory (1985) (Table 2) hypothesized to reflect "motor factor" (supporting study by Wexler and Mysak, 1982, cited earlier).

Table 2: Summary of means and SD for nine individual types of disfluency and total disfluency per 100 words spoken (De Joy & Gregory, 1985)

Disfluency types	3.5-year-old children		5-year-old children	
	Mean	SD	Mean	SD
Part-word repetitions	0.79	0.43	0.48	0.36
Word repetitions	1.37	0.73	0.78	0.53
Phrase repetitions	1.16	0.62	0.78	0.36
Grammatical pauses	0.22	0.21	0.41	0.30
Ungrammatical pauses	1.93	1.52	1.82	0.84
Revisions	2.73	1.26	2.40	0.90
Interjections	1.78	1.45	1.66	1.15
Incomplete phrases	0.88	0.50	0.60	0.42
Disrhythmic phonations	0.90	0.62	0.50	0.31
Total disfluency	11.40	4.68	9.30	3.31

The above studies provided information about disfluency characteristics of normally speaking children. There are other studies (Yairi & Lewis, 1984: 10, 2 year old, 10, 3 year-old children with stuttering − CWS, 10 age matched non-stuttering children - CWNS; Myers, 1986: 12, 4-5 year old CWS and 12 CWNS; Zebrowski,1991: 10, 4-year old CWS, 10 age matched CWNS) which compared the speech disfluencies of children with stuttering and other children to help a speech pathologist differentiate between normal disfluency with dysfluency or stuttering. Yairi and Lewis (1984) found that overall, stutterers were three-and-a-half times more disfluent than the CWNS (Mean=21.54 for CWS, versus, Mean= 6.16 for the CWNS). Results of Myer's (1986) study showed that CWS exhibited a higher percentage of stuttering behaviour (Mean = 13.5%, SD = 6.4%) than did CWNS (Mean = 0.2%, SD = 0.4%). Considering other findings, Meyers concluded that in terms of stuttering behaviours, her results supported a hypothesis that stuttering children (4 to 5 years) are quantitatively and qualitatively different from nonstutterers. This is the first research report on stuttering-type and normal-type disfluencies. Zebrowski (1991) found CWS to be more disfluent (Mean = 13%) than CWNS peers (Mean = 5%). They found no significant difference between the two groups in either the average duration of sound/syllable repetitions and sound prolongations or the average number of repeated units.

The above studies have several limitations such as small number of children and the small size of the speech samples. The diversity among studies prompted Ambrose and Yairi (1999) (90, 2-5 year old CWS, 54 age matched CWNS) to find out a normative reference for early stuttering which would provide a basis for the differential diagnosis of stuttering from normal disfluency. Ambrose and Yairi combined part-word repetitions, single syllable word repetitions, and dysrhythmic phonation (comprising of prolongations, blocks and broken words), and called it as Stuttering like Disfluencies (SLD) and combined interjections, revision or abandoned utterances and multisyllable or phrase repetitions to name as Other Disfluencies (OD). Also, no statistically significant age difference was found between groups. However, part-word repetitions and repetition units tended to significantly decrease with age. Other disfluencies tended to increase with age, though not significantly.

Some longitudinal studies and measures were conducted (Hall, 1996; 9, children from 7-9 years: Ambrose and Yairi, 1999; Pellowski and Conture, 2002 ; 36, CWS and 36 age matched CWNS). Hall reported that the overall rate of disfluency fell substantially as the children moved from preschool to the older grades, but that some SLDs, defined as part-word repetitions, prolongations, tense pauses, and broken words, increased in frequency. Ambrose and Yairi (1999) developed a weighted measure for SLD (repetitive disfluencies * mean number of iterations + disrhythmic phonations * 2) and using this measure, with a cut off of 4%, all children were correctly diagnosed. The weighted SLD scores were found to be continuous across age groups and to lie below 4.00 for CWNS and above 4.00 CWS. Pellowski and Conture (2002) revealed a statistically significant difference between the groups for SLD's and total disfluencies (81% and 42% SLD in CWS and CWNS, respectively) while OD was 19% and 58% in CWS and CWNS.

All the above studies are in English. However, as stuttering is observed across languages and cultures (Van Riper, 1971), one must be cautious in generalizing findings on English-speaking children to other linguistic and cultural groups (Carlo and Watson, 2003). Yet, studies have been conducted in languages other than English (Carlo & Watson, 2003: 15 Spanish speaking 3.5-4 year old CWNS & 17, 5-5.5. years old; Natke, et. al. 2006; 24 German speaking preschool CWS and 24 age matched CWNS; Boey et al., 2007: 693 Dutch speaking CWS, 79 Dutch speaking CWNS; Valente & Jesus, 2011: 8 Portuguese school CWS and 8 Portuguese school with CWNS.

Results of the study by Carlo and Watson (2003) showed no statistically significant difference in the total speech disfluencies exhibited by boys and girls or by the younger and older age groups. High amounts of variability were also observed in the types of speech disfluencies within each age group (represented by the high standard deviations). They also found no statistically significant difference in the proportions of disfluency types exhibited by the two age groups. Natke, et. al. (2006) used the computer program CLAN (Child Language Analysis; MacWhinney, 2000), and a special post-coding system for disfluencies. Wilcoxon signed-rank tests revealed no significant t differences between mean frequencies of SLD and OD. SLDs were significantly more frequent in CWS (mean = 9.2%) than in CWNS (mean = 1.2). A cut-off of 3% SLD was shown to be a powerful measure for the diagnosis of stuttering in German-speaking children. Boey et al. (2007) found that the frequency of SLD in the CWS (Mean= 15. 71) was significantly higher than in the CWNS (Mean= 0.42); a 3% SLD criterion for distinguishing CWNS from CWS resulted in high sensitivity (0.95). Valente and Jesus (2011) identified a total of 75 SLDs in the group of children with stuttering and 8 SLDs in the normally fluent group. They found that SLDs were statistically higher in CWS than in CWNS.

Among the Indian languages, Kannada, Tamil, both Dravidian languages, and Hindi, an Indo-Aryan language, have been studied (Geetha, et. al., 2000; 25 CWS and 21 CWNS in the age of 6 years: Rathika, et al., 2012; 48 CWS in the age range of 4-8 year). Geetha et al. (2000) using Artificial Neural Network (ANN), a computer program, attempted to classify CWS from CWNS. She reported a score of 3-20 in CWS and a score of '0' in CWNS. There are other studies in Kannada by Indu (1990) (Six 4-5 year CWN, Nagapoorima (1990) (Six 3-4 year CWNS), Yamini (1990) (Six 5-6 year CWNS), and Rajendra Swamy 1991 (Six 6-7 year CWNS). These studies have measured each instant of disfluencies. For instance, in all other studies one instance of repetition (b b b boy) was considered to be one repetition, while, those who measured disfluencies in Indian languages considered it as 3 repetions. Overall, 20-30 dysfluencies were considered normal and above 30 was considered as stuttering. Rathika et al. (2012) reported the total percentage of disfluencies in Tamil as ranging from 17.1 (7-8 years) to 30 (5-6 years). Anjana and Savithri (2012), studied the speech of 30 Kannada speaking CWNS in the age range of 2.1 - 6 yrs. They reported a Weighted % SLD as 1.44 in CWNS, and % OD of 34.6, and 1.11 in CWS and CWNS, respectively. Table 3 shows total disfluencies, SLDs, OLDs, and the measures reported by various authors.

From these studies, it is evident that various disfluencies are investigated both in the speech of CNS and CWNS. This analysis may also aid in the differential diagnosis of normal disfluency from stuttering. The specific features to differentiate normal disfluency from stuttering include frequency of speech disfluency, type of speech disfluency and proportion of type and duration of instances of disfluency in terms of number of repeated units and other temporal aspects of sound, syllable or word repetitions.

The data from all studies, reflects that SLD reduces, and OD (false starts, parenthetical remarks) increases, in children, with progression in age. That is, sophisticated types of disfluencies take over repetitions, prolongations, and pauses in children in the ages of 2 years to 7 years. The total disfluencies, averaged across studies, was 5.53 in CWNS; SLDs in CWNS was 2.40 and OD was 7.43. Hence, a cut-off of 5% disfluencies can be used to differentiate normal non-fluency from stuttering in children.

Since we are learning about development of fluency we shall look into the development of each component of fluency in the following paragraphs.

Development of repetitions

When a child is developing language, it passes through stages of disfluencies that are very much normal and should not be confused as stuttering. These disfluencies are at a peak between 2 year six months to 4 years of age and are characterized by repetitions of whole words and phrases and occasional interjections like 'ur,' 'em,' etc. (Perkins, 1971). This is a transitional stage that most children pass through during language acquisition. Yairi and Lewis (1984) state that some children go beyond word repetitions to forced prolongations with signs of physical struggle that can be called stuttering. Ryan (1974) says that some children begin to repeat parts of words rather the whole words. When the frequency and duration of these disfluency episodes rise above normal expectations, the child can be diagnosed to have stuttering. Bloodstein (1950) reports that the simple repetitions in the early years transform to more complicated patterns as stuttering evolves. Disfluencies shift from function words to content words in stuttering.

A speech pathologist, however, must differentiate between such disfluencies and stuttering. Pindzola and White (1986) suggest that, if more than 5% of a child's speech is characterized by repetitions of sounds or words and more than 1% is abnormally prolonged, then the child can be diagnosed to have stuttering. Also, signs of unusual struggle or concern about the process of talking are negative signs that should be diagnosed as stuttering.

SLDs include part-word or sound/syllable repetitions (e.g., "Look at the b-b baby"), prolongations (e.g., "Ssssssssometimes we stay home"), and blocks (i.e., inaudible or silent fixations or inability to initiate sounds). In addition, compared with typical disfluencies, SLDs are usually longer than average duration, effort, tension, or struggle. Perception of severity include frequency and type of stuttering and the ability of the PWS to communicate effectively (Yairi,

Table 3: Total disfluencies, SLDs, ODs (%) and measures recorded by various authors

Authors	Total % disfluencies		SLDs %		OD's %	
	CWNS	CWS	CWNS	CWS	CWNS	CWS
Johnson et. al (1969) Age: 2-8 yrs						
Male	7.28	17.91	1.88	11.51	5.40	5.40
Female	7.90	16.25	2.21	6.40	5.69	5.69
Yairi & Lewis (1984) Age: 2-3 yrs	6.18	21.46	3.02	16.43	3.10	5.09
Indu, (1990) Nagapoorima, (1990) Yamini (1990) Rajendra Swamy (1991) Age: 3-7 yrs	3-4 yrs: 29.15 4-5 yrs: 24.86 5-6 yrs: 20.13 6-7 yrs: 31.02					
Hubbard & Yairi (1999) Age: 2-4 yrs	5.89	22.45	2.832	6.88	5.57	2.82
Ambrose & Yairi (1999) Age: 2-5 yrs	5.65	15.78	10.37	4.32	5.41	
Geetha et. al. (2000) Below 6 years	2-3	30				
Pellowski & Conture (2002) Age: 3-6 yrs	2.60	10.70	1.10	8.70	1.50	2.20
Zackheim & Conture (2003)	5.49	12.70	0.50	12.00	4.99	0.50
Logan (2003)	3.30	9.64	1.50	7.74	1.80	1.90
Natke, et. al. (2006) Age: 2-5 years			1.20	9.2		
Boey et. al. (2007)			0.42	15.71		
Valente and Jesus (2011) Age: 10 yrs			8	75		
Anjana & Savithri (2012) Age: 2.1 - 6 yrs. Weighted %SLD			1.44	34.6	1.11	
Average	5.53	15.86	2.40	12.14	7.43	2.95

2007). Typical disfluencies include whole phrase repetitions ["Where is ... where is the baby?"], single whole word repetitions ["Where ... where is the baby?"], interjections ["Where... um is the baby?"], revisions ["What ... where is the baby?"], and hesitations (a long pause when talking), and SLDs include repetition of sounds ["sh-sh-shoe"], repetitions of syllables ["ba-ba-baby"], **prolongation** or stretching of sounds ("Wh——-re is the baby?"), **blocks or** a tense stop in the flow of speech; child may open his or her mouth to speak but no sound comes out or there is a noticeable stoppage of airflow at some point in the upper airway (oral tract). Applying a criterion of 3% SLD to distinguish stuttering from normally fluent children resulted in a high degree of sensitivity (0.9452) and specificity (0.9747) (Boey et al., 2007). Rita et al. (2011) used a mean of 1.0 to indicate the following as normal nonfluency. Physical tensions were 0.0 in normal children. Thus, their study indicated a cut-off 1.0 SLD and sound-syllable repetition of 0.9 to differentiate normal non-fluency from stuttering. Table 4 shows the SLDS.

Table 4: Stuttering-like Disfluencies (Rita et al., 2011)

SLD total	M+SD
Monosyllabic whole-word repetition	0.5±0.5
Sound/syllable repetition	0.5±0.8
Prolongation	0.0±0.0
Blocks	0.0±0.0
Broken words	0.0±0.0

May 2011, Buenos Aires, Argentina.

Methods used to measure stuttering have relied usually on listener judgments of the number of disfluencies that occur in various speech samples (Bloodstein, 1995 among others). They include judgments of the type of fluency behaviors within a speech sample or a global rating of it. The emphasis here will be on measures that have used judgments of certain types of speech behavior. Over 50 years, researchers have favored measuring stuttering by recording instances of one of three superficially related but different types of speech events (Cordes & Ingham, 1994): (a) Johnson et al.'s (1959) different disfluency types, or variations thereof; (b) Wingate's (1964) kernel characteristics of stuttering (a restricted range of disfluency types); or (c) events that are simply perceived to be stuttering events (Martin & Haroldson, 1979).

Development of pauses

Pauses can be filled or unfilled. Filled pauses are those where sounds like mm, or rr, occur. Unfilled pauses are silences of about 270 ms. Developmental changes in the frequency of pauses and hesitation (1) vary positively with syllabic rate (2) and length of utterance (2), which suggest a relationship between (1) and (2). Increased rate and length of utterance, reflecting the development of articulatory, semantic, and syntactic skills, may exert the ability to control the timing in speech. Cultural and social demands may play a role in controlling rate of speech. In addition, the drive to communicate is also a factor controlling the rate of speech. The drive to communicate at a fast rate, may try to reduce unfilled pauses and instead use filled pauses such as 'mm', 'rr' or parenthetical remarks such as 'you know,' 'I think,' etc. Sometimes the urge to speak faster may cause the speaker to start speaking even before preparations are made for the sentence. All of the dysfluencies may appear as a consequence of the fast rate or a means for achieving it. Initially, the child exhibit unfilled pauses which turn into filled pauses and later as false starts or parenthetical remarks.

Development of false starts and parenthetical remarks

False starts refer to interruption in the flow of speech to restart the utterance. For example, [this is a red, no blue bus]. The repetition can range from a portion of a syllable to several words. In the case of a false start, the modification may be either a substitution of a new word as in the above example, or an insertion of a word in a word sequence, as in the example, [this is a bus, blue bus].This category includes those in which the content of a phrase is modified, or in which there is a grammatical modification. Changes in the pronunciation of a word are also considered as a revision. For example, [I was I am going]. Thus, a false start can be (a) a repetition, (b) substitution of a new word, (c) negation, (d) changes in pronunciation, or (e) insertion of a new word.

Parenthetical remarks are words or phrases that are irrelevant and not required for a sentence. For example, I mean, you know, etc. They are meaningful and do not break the continuity from a literal meaning, but they distract the listener and break the continuity in information. In the early ages, that is 2-4 years, the CWNS use repetitions and pauses; later they start using sophisticated disfluencies like false starts and parenthetical remarks. Even an adult use parenthetical remarks, may be because he or she is unsure of the next word and hence take time by the use of parenthetical remarks.

Development of rate of speech

"Speaking rate" is the speed with which one speaks. It influences audience perceptions about the speaker. In general, a slower rate is easier to understand for the listener than a faster rate as it would allow more time for the listener to understand the message. However, if the articulation is clear enough, then the speech can be delivered at a faster rate. Speaking rates will differ depending on the speech one is delivering, the environment, the speaker's mood, and audience attributes. Speech rate is also influenced by quantity and pause.

Normal adult speakers of English speak at an average of 5 syllables per second during continuous conversational speech (Walker & Black, 1950,). Adult speakers of English speak at an average rate of 5 to 6 syllables per second (Walker & Black, 1950). When rate is measured in words per minute, most of the variation is attributable to the duration and frequency of pauses. When these pauses are excluded, the variability of speech rate is much reduced (Goldman-Eisler, 1968). The normal rate of speech is 80-180 words per minute.

Malecot, Johnston, Kizziar (1972) report conversational speech rate to be 5.73 syllables per second in French and that the rate did not vary much between languages. Though not significantly, the rate of speech was more variable and utterances longer in female speakers than male speakers. Walker and Black (1950) report a speech rate of 5-6 syllables per second on adult speakers of English. Johnson (1961) reported higher range and docile values for adult females than for adult males in two spontaneous speech tasks and one reading task.

Rathna et al. (1979) reported 361 syllables per minute and 104 words per minute in spontaneous speech, and 427 syllables per minute and 94 words per minute in reading, in Kannada. Venkatesh et al., (1983) investigated rate of speech in 64 Kannada speakers in the age range of 17-66 years. They reported 282 syllables per minute in adult Kannada speakers.

Values of approximately 200 syllables per minute (SPM) or 150 SPM are frequently used in setting goals for rate of speech (Perkins, 1973; Boberg & Kully, 1985) because mean rates of adult discourse tend to converge around these values (Luchsinger, 1965).

Among Spanish and English, Spanish yielded faster speech and articulation rates than did English (4.24> 3.66, 6.08> 5.00 syl/sec, respectively) and greater length of vocal hesitations per syllable than English (0.102> .071 syl) (de Johnson, O'Connell, & Sabin, 1979).

Table 5: Total number and percent of disfluencies in Spanish and English (de Johnson, O'Connell, & Sabin, 1979)

Type of vocal hesitation	Spanish N	Spanish %	English N	English %
Parenthetical remarks	253	93	49	62
False starts	143	84	89	78
Repeats	177	77	48	42
Filled pauses	27	35	182	95

Savithri and Jayaram (2005) investigated the rate of speech in 401 participants (Kannada = 136, Telugu = 69, Tamil = 103, Malayalam = 93) in the age group of 10-100 years. Cartoons (4-6 years), pictures depicting Panchatantra stories (7 years and above), and standardized reading passages were used to elicit spontaneous speech or reading. Pictures of cartoons and Panchatantra stories were taken from Indu (1990), Nagapoornima (1990), Yamini (1990), and Rajendra Swamy (1991). Passages in four languages developed by the experimenters had 304, 306, 414, and 307 words in Kannada, Telugu, Tamil, and Malayalam, respectively. Children of 4-10 years were instructed to describe the cartoons and story, and adults to read the passage at a comfortable pitch and loudness. All samples were audio-recorded and digitized at 16,000 Hz sampling frequency. Pauses, if any, were removed from the waveform using Cool Edit software. Each syllable and word was highlighted using the waveform and the duration was measured using the software. The number of syllables per second (SS), syllables per minute (SPM) and words per minute (WPM) were calculated by using the following formulas:

$$SS = \frac{Total\ number\ of\ syllables}{Total\ time\ taken\ (seconds)} \ldots.. (1)$$

$$SPM = \frac{Total\ number\ of\ syllables}{Total\ time\ taken\ (minutes)} \ldots..(2)$$

$$WPM = \frac{Total\ number\ of\ words}{Total\ time\ taken\ (seconds)} * 60 \ \ldots. (3)$$

The results are shown in Tables 6, 7 and 8. Malayalam speakers had higher syllables per seconds and syllables per minute. However, Tamil speakers relatively had higher words per minute compared to speakers of the other three languages.

Table 6: Syllables per second in 4 languages

Age range	Kannada	Telugu	Tamil	Malayalam
3-3.11	5			
4-4.11	4			
5-5.11	4		5	
6-6.11	4		5	
7-10	4		7	
11-15	6	7	5	8
16-20	7	7	6	9
21-30	6	8	7	9
31-40	7	6	5	8
41-50	7	7	6	8
51-60	7	6	5	8
61-70	7	6	6	8
71-80	6	5	6	7
81-90	7	5		7
91-100				4
Average	6	6	6	8

Table 7: Syllables spoken per minute in four languages

Age range	Kannada	Telugu	Tamil	Malayalam
3-3.11	291			
4-4.11	252			
5-5.11	252		299	
6-6.11	261		278	
7-10	250		402	
11-15	343	431	272	474
16-20	425	439	384	529
21-30	385	466	391	558
31-40	434	384	326	492
41-50	410	389	353	477
51-60	415	392	326	483
61-70	403	336	340	448
71-80	390	309	354	423
81-90	337	309		398
91-100				257
Average	346	384	342	469

The average speech rates as reported by various authors are as follows: During presentation it is 100-150 wpm, conversation is 120-150 wpm, audiobooks & radio hosts and podcasters. 150 – 160 wpm, auctioneers is 250 wpm, and sports commentators is 250 – 400 wpm.

Development of stress

Stress refers to emphasis, extra airflow, or extra effort in the speech system. Stress is defined as extra force with which a syllable or word is uttered. It is also defined as the degree of prominence a syllable has. The terms stress and accent are often used synonymously in that context. However, they are sometimes distinguished. For example, when empha-

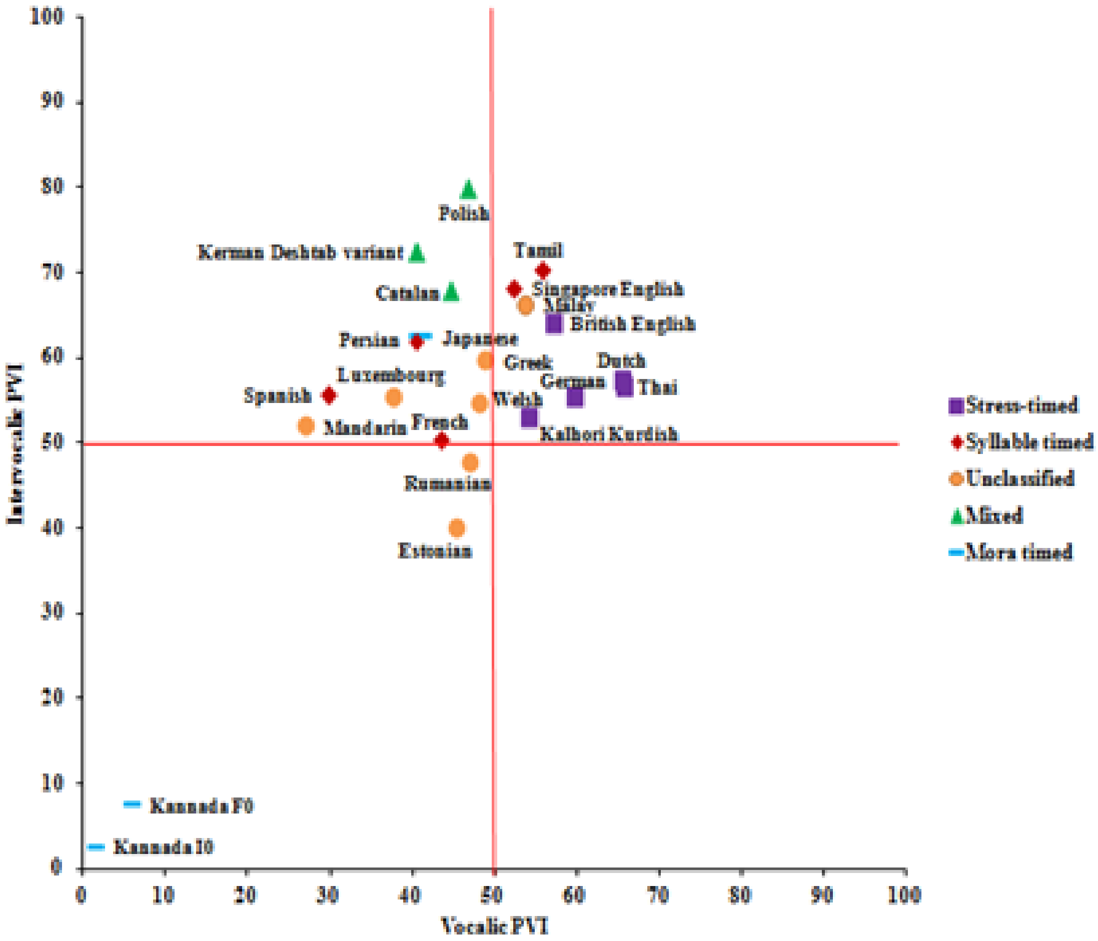

Figure 1: Vocalic and intervocalic PVIs in Kannada (F0, I0) and other languages (duration) of the world.

Table 8: Words per minute in four Dravidian languages

Age range	Kannada	Telugu	Tamil	Malayalam
3-3.11	129			
4-4.11	91			
5-5.11	120		114	
6-6.11	92		86	
7-10	85		124	
11-15	104	123	95	115
16-20	127	125	133	128
21-30	116	133	136	135
31-40	131	116	114	119
41-50	124	117	122	116
51-60	124	110	115	117
61-70	124	96	118	110
71-80	118	89	123	102
81-90	102	89		96
91-100				63
Average	113	111	117	114

sis is produced through pitch alone, it is called pitch accent, and when produced through length alone, it is called quantitative accent. When caused by a combination of various intensified properties, it is called stress accent or dynamic accent; English uses what is called variable stress accent.

The stress placed on syllables within words is called word stress or lexical stress. For example, in English, the word [insert] might have stress either on the first syllable ([INsert]) or the second syllable ([inSERT]) with a change in meaning. Hear, it is acting as a grammatical function marker – Verb ([inSERT]) vs. Noun ([INsert]). There are some languages in which the position of the stress can be predicted by a simple rule and it is termed as fixed stress. For example, in Czech, Finnish, Icelandic, and Hungarian, the stress almost always comes on the first syllable of a word. In Armenian, the stress is on the last syllable of a word (Mirakyan, Norayr, 2016). In Quechua, Esperanto, and Polish, the stress is almost always on the penultimate syllable (second-last syllable). In Macedonian, it is on the antepenult syllable (third-last syllable). Other languages, like English and Russian, have variable stress, where the position of stress in a word is not predictable. Languages in which the position of stress in a word is not fully predictable are said to have phonemic stress. For example, English, Russian, Italian, Portuguese, and Spanish. Stress is usually lexical and must be memorized as part of the pronunciation of an individual word. In some languages, such as Spanish, Portuguese, Lakota and, to some extent, Italian, stress is even represented in writing using diacritical marks, for example in the Spanish words [*célebre*] and [*celebré*]. Sometimes, stress is fixed for all forms of a particular word, or it can fall on different syllables in different inflections of the same word. Prosodic stress, or sentence stress, refers to stress patterns that apply at a higher level than the individual word – namely within a prosodic unit. It may involve a certain natural stress pattern characteristic of a given language but may also involve the placing of emphasis on particular words because of their relative importance (contrastive stress). For example, a natural prosodic stress pattern in French, stress is placed on the final syllable of a string of words (or if that is a schwa, the next-to-final syllable). Prosodic stress is also often used pragmatically to emphasize particular words or the ideas associated with them. This can change the meaning of a sentence. For example, [***I*** didn't take the test yesterday.] (Somebody else did.), [I ***didn' t*** take the test yesterday.] [I did not take it] (San Duanmu, 2000). The main stress within a sentence, often found on the last stressed word, is called the nuclear stress (Iggy Roca, 1992).

Sometimes more than one level of stress, such as ***primary stress*** and ***secondary stress,*** may be identified in a sentence. The stress placed on words within sentences is called ***sentence stress*** or ***prosodic stress***. It includes ***phrasal stress*** (the default emphasis of certain words within phrases or clauses), and ***contrastive stress*** (used to emphasize an item, a word or part of a word, that is given particular focus). In some languages, the placement of stress is determined by rules, and thus, not a phonemic property of the word. In Mandarin Chinese, which is a tonal language, stressed syllables have been found to have tones realized with a relatively large fluctuations in fundamental frequency, while unstressed syllables typically have smaller fluctuations (Monrad-Krohn, 1947).

In most of the Indian languages (Dravidian and Indo-Aryan), there is no stress and it is emphasis only. Though a word is emphasized it may be only for negation or highlighting or confirmation. Universally, it is agreed that initially the child uses syllable-timed rhythm and later develop the rhythm of their language. It means that the child initially uses stress on each syllable and later learns the stress pattern of its language.

Development of speech rhythm

Speech rhythm plays an important role in early language acquisition. A child, in the uterus, becomes familiar with her mother's language through the muffled lower frequencies that can pass through flesh (Clark, 2003). Though the child misses on a lot of phonetic information that is present in normally-perceived speech, prosodic information including the rhythmic pattern of the language being spoken is still perceived. Mehler et al. (1988) found that infants as young as four days old could differentiate the language of their parents from other languages. Similar infant perception studies by Nazzi et al., (1998); Ramus et al., (2003) support the notion that prosodic knowledge is acquired while being in the uterus. Nonetheless, studies on development of rhythm of a language has received relatively less attention. Allen and Hawkins (1978) found that by default, rhythm of young children is largely syllable- timed irrespective of the rhythm of the native language. This is because children experience difficulty in mastering consonant clusters and vowel reduction which are chief attributes of a stress-timed language. A child, in the early stages of language acquisition, saves a phonological process to articulate a word along with consonant cluster. This results in speech rhythm being more syllable-timed than stress-timed. There have been numerous interval-based rhythm studies in children which have confirmed to these observations.

With respect to adult speakers, languages are organized under stress-timed, syllable-timed and mora-timed based on the Rhythm Class Hypothesis (henceforth: RCH) as proposed by Pike (1945). Attempts have been made (Dauer, 1983; Ramus et al., 1999; Low et al., 2000) to expand the dichotomy by including mora-timed rhythm. The mora-timing was suggested by Bloch (1950), Han (1962), and Ladefoged (1975). An example of mora-timing language is Japanese. Traditionally, morae refer to subunits of syllables that consist of a short vowel and any preceding consonant/s. The successive morae are said to be of near-equal duration. Mora-timed languages are more alike syllable-timed languages rather than stress-timed languages.

RCH states that each language belong to one of the prototypical rhythms. When a language has simple syllabic structure, for e.g. VC or CCV, the durational difference between the simplest and most complicated syllable is very less. Under these conditions, the rhythm of the language is said to be a fast syllable-timed. If the syllabic structure is still simpler, for e.g. VC or CV, then the durational difference between syllables is negligible and it is called a mora-timed rhythm. When a language has complex syllabic structure, for e.g. V (/a/) and CCCVCC (/strength/ = /strent/), the difference between syllables can be extremely wide. In such a condition one has to use a slow stress-timed rhythm.

The development of concept on rhythm measurement was started with the concept of isochrony, i.e. each syllable has equal duration. The first attempt to test Rhythm Class Hypothesis was made by Abercrombie (1967) by using the average syllable duration but was not found to be effective in classifying rhythm types. The measurements finding out speech rhythm used in include syllable duration (Abercrombie, 1965), inter-stress interval (Roach, 1982), %Vocalic, the proportion of time taken by the vocalic intervals in the sentence omitting the word boundaries; DVocalic, the standard deviation of the

Table 9: Mean, SD and median of vocalic and intervocalic NPVIs in boys across age groups

	NPVI F0				NPVII0		
Age	Mean	SD	Median	Age	Mean	SD	Median
3-4	0.052	0.015	0.050	3-4	0.022	0.005	0.021
4-5	0.063	0.022	0.056	4-5	0.025	0.007	0.024
5-6	0.058	0.012	0.054	5-6	0.018	0.004	0.018
6-7	0.065	0.020	0.064	6-7	0.011	0.005	0.009
7-8	0.055	0.026	0.042	7-8	0.009	0.003	0.009
8-9	0.061	0.017	0.057	8-9	0.010	0.003	0.009
9-10	0.048	0.008	0.048	9-10	0.010	0.003	0.010
10-11	0.057	0.009	0.057	10-11	0.013	0.006	0.010
11-12	0.046	0.015	0.050	11-12	0.012	0.003	0.011
Avg.	0.056	0.017	0.054	Avg.	0.014	0.007	0.011

Table 10: Mean, SD and median of vocalic and intervocalic NPVIs in girls across age groups

	NPVI F0				NPVII0		
Age	Mean	SD	Median	Age	Mean	SD	Median
3-4	0.088	0.024	0.082	3-4	0.040	0.014	0.035
4-5	0.087	0.023	0.083	4-5	0.050	0.015	0.052
5-6	0.071	0.019	0.072	5-6	0.023	0.009	0.021
6-7	0.069	0.013	0.067	6-7	0.017	0.012	0.014
7-8	0.078	0.033	0.067	7-8	0.049	0.008	0.048
8-9	0.071	0.015	0.071	8-9	0.013	0.005	0.012
9-10	0.061	0.014	0.062	9-10	0.012	0.004	0.012
10-11	0.071	0.014	0.068	10-11	0.016	0.007	0.014
11-12	0.060	0.023	0.055	11-12	0.024	0.005	0.024
Avg.	0.073	0.022	0.068	Avg.	0.027	0.017	0.021

vocalic intervals; DConsonant, the standard deviation of the consonantal intervals (Ramus, Nespor and Mehler,1999), and Pairwise Variability Index (Low, 1998). The Pairwise Variability Index (PVI) is a quantitative measure of acoustic correlates of speech rhythm, and it computes the patterning of successive vocalic and intervocalic/consonantal intervals denoting how one linguistic unit varies from its neighbor (Low, 1998). Grabe & Low (2002) used "normalized Pairwise Variability Index" (nPVI) for rhythmic analysis of the vocalic durations. Among the durational measures, PVI is found to be the best predictor of speech rhythm due to the following facts: (a) only PVI takes into account the variability between the successive units, and (b) PVI has a normalization component which helps in eliminating the between-speaker differences. The PVI can be obtained as raw PVI or rPVI wherein differences between successive pairs of units are averaged and normalized PVI or nPVI in which each difference is expressed in terms of proportion of average of the two units involved. The rPVI was used for the rhythmic analysis of intervocalic intervals and nPVI for vocalic intervals (Low, 1998). Sirsa and Redford (2011) used varcoC. VarcoC=100 *ΔC / μ_c, where μ_c is the mean consonantal interval duration in the sample. Bertini and Bertinetto (2010) developed a control and compensation index (CCI) based on the principle of PVI. While both indices calculate durational difference between successive vocalic or intervocalic intervals, CCI is novel in that, first, the duration of each interval is divided by the number of segments in the respective interval and then the PVI is calculated (Equation 4).

$$CCI = \sum_{k-1}^{m-1} \left| \frac{d_k}{n_k} - \frac{d_{k+1}}{n_{k+1}} \right| /(m-1) \; ....(4)$$

In the equation, m is the number of vocalic or intervocalic intervals, d_k is the duration of the k^{th} interval, n_k refers to the number of segments in the respective interval. Quene (2004) proposed just noticeable difference (JND) for tempo in speech as a measure of type of rhythm.

The way in which children acquire adult-like prosodic structure is essential because it plays an important role in various aspects of linguistic function, beginning from lexical stress to grammatical structure to emotional affect; therefore, it is essential for the transmission of meaning and enhancing intelligibility. Neurotypical children, by the age of 2–3 years, start to master phrasal stresses, boundary cues, and meter in their speech production (e.g., Clark, Gelman, & Lane, 1985). Gradually, by the age of 5 years, they are capable of imitating the adult-like patterns (Koike & Asp, 1981). Savithri et al. (2013) studied the development of speech rhythm in typical Kannada-speaking children within the age range of 3-12 years by using normalized PVIs and reported that the rhythm class changed from syllabic to mora-timed with advancement of age.

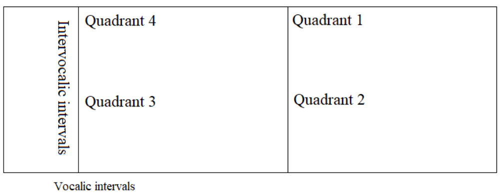

Figure 2: Illustration of quadrants.

Savithri et. al. (2017) also investigated NPVI for F0, and intensity The results of NPVIf0, NPVII0, in all age groups studied, are depicted in Tables 9 and 10. The results revealed that, both the genders in all the age groups from 3-12 years showed considerably low vocalic and intervocalic PVIs. Considering F0 and I0 as the identifying feature of rhythm, low vocalic and intervocalic PVIs indicated pronounced use of mora-timed rhythm in Kannada speaking children in the age range of 3-12 years. PVIs for F0 were significantly higher compared to those for intensity. Figure 1 depicts the vocalic and intervocalic PVIs in Kannada (F0, I0) and other languages (duration) of the world. Table 11 shows the PVIs in Kannada (F0, A0) and other languages of the world (PVI for duration).

Table 11: Rhythm in several languages

Investigator	Language	Measurement used	Rhythm
Abercrombie, 1967	English	Syllable duration	Stress-timed
	Russian		
	Arabic		
	French	Syllable duration	Syllable-timed
	Telugu		
	Yoruba		
	Japanese	Syllable duration	Mora-timed
Roach, 1982	English	Inter-stress interval, % V, DV, DC	Stress-timed
Rubach & Booij, 1985	Germanic	Inter-stress interval	Stress-timed
Steever, 1987	Slavonic		
	Arabic		
Ramus, Nespor & Mehler, 1999	Romanic languages	Inter-stress interval	Syllable-timed
	Japanese	Inter-stress interval	Mora-timed
	Tamil		
Grabe & Low, 2002	French	rPVI, nPVI for duration	Syllable-timed
	Mandarin		
	Spanish		
	British English	rPVI, nPVI for duration	Stress-timed
	Japanese	rPVI, nPVI for duration	Mora-timed
Grabe & Low, 2002	English	PVI for duration	Stress-timed
	Dutch		
	German		
	French	PVI for duration	Syllable-timed
	Spanish		
	Japanese	PVI for duration	Mora-timed
Savithri et al., 2006	Kannada	PVI for duration	Mora-timed
	Assamese		
	Punjabi		
	Telugu		
	Bengali	PVI for duration	Syllable-timed
	Hindi		
	Malayalam		
	Tamil		
	Kashmiri		
	Marathi	PVI for duration	Mora-timed
	Oriya		
	Kodava	PVI for duration	Syllable-timed
	Rajasthani		Unclassified
	Gujarati		
Mok, 2015	Three-year-old monolingual and bilingual children learning Cantonese (syllable-timed) and English languages	C, VarcoC, rPVI-C, nPVI-C, VarcoV, nPVIV, %V, VarcoS and nPVI-S	Syllable-timed

A review of studies on speech rhythm indicates that the definition of speech rhythm is yet to be established and the results of several studies are contradicting. Likewise, there is no proper demarcation of high-high, high-low, low-low intervocalic and vocalic intervals. Attempts were also made to use F0, intensity, inter-stress intervals, foot, and F_1, apart from duration, in classification of speech rhythm of languages, but were criticized strongly due to the disparity in the durational differences and F0 or intensity differences. The range of F0 in speech can be 80 Hz to 240 Hz, and the range of intensity can be 30 dB (Fant, 1960).

Similarly, there may be many more rhythm classes, than the presumed syllable time, stress-time, and mora-time, which is evident from Figure 1(quadrants illustrated in Figure 2), as some of the languages fall in the left 4^{th} quadrant showing high intervocalic intervals and low vocalic intervals. The way in which the worlds' languages are classified as stress-timed, syllable-timed and mora-timed is not clear. Referring back to Figure 1, one can observe that Persian and Japanese (both in the fourth quadrant) are very close together, but Persian is classified as having syllable-timed rhythm, and Japanese is classified as having mora-timed rhythm. In addition, Tamil has been classified as syllable-timed language but is far away from Persian, which is also classified as having syllable-timed rhythm. Thus, a considerable research is required on rhythm and its development in various languages.

Considering the studies cited above, it becomes clear that various characteristics of disfluencies have been investigated both in the speech of CWNS. Analysis of these features may also aid in the differential diagnosis of normal disfluency from stuttering. Specific features for differential diagnosis of normal disfluencies from dysfluency (stuttering) include frequency of speech disfluency; type of speech disfluency and proportion of type and duration of instances of disfluency in terms of number of repeated units; and other temporal aspects of sound, syllable or word repetitions.

It can be inferred that SLD reduces, and OD (false starts, parenthetical remarks) increases, in children with progression in age. That is, sophisticated types of disfluencies take over repetitions, prolongations, and pauses in children in the ages of 2 years to 7 years. The total disfluencies, averaged across studies, was 5.53 in controls; SLDs in controls was 2.40 and OD was 7.43. Hence, a cut-off of 5% disfluencie$s$ can be used to differentiate normal non-fluency and stuttering in children.

Looking at the studies conducted, it is understood that information on development of fluency is unavailable in all languages of the world. Owing to differences in languages it is imperative that normative data be available in all languages. It is suggested that the All India Institute of Speech and Hearing can take up a single corpus of multi-centric, and multi-linguistic, multi-researchers group working on 14 Official languages of India on development of fluency. Table 12 summarizes the development of rhythm in several languages as found by various authors.

Table 12: Development of rhythm in several languages

Investigator/s	Language, age group	Measurement	Results
Sirsa & Redford, 2011	Monolingual American English (development in 10 five-year and 10 eight-year-old speakers)	Normalized PVIs varcoC, and %V	PVI increased with increase in age
Savithri & Sreedevi, 2012	Kannada (development of speech rhythm in children aged 3-12 years).	PVI for duration	Increase in PVI from 3-4 years to 11-12 years.
Payne, et. al., 2012	English Spanish Catalan 27, 2-, 4- and 6-year old	%V, VarcoV, nPVI-V, ΔC and rPVI-C	Cross-linguistic differences were evident by age 2. Children's speech is syllable-timed
Polyanskaya & Ordin, 2015	10 native British English speakers (six females; parents, 25–50 years) (1)12 Children 1. (a) 2. (b) 3. (c)	nPVI, %V and Varco Mean durations of speech intervals	Mean durations of S, V, and C intervals were shorter. Durational variability increased with age Thus, speech became increasingly more stress-timed with age. Acquisition of rhythmic patterns was complete by age 11-12

CONCLUSIONS

The article dealt about the definition of fluency, disfluency, and dysfluency. The parameters of fluent speech such as number or % of disfluencies, effort, rate of speech, speech rhythm were covered and studies relevant to these parameters were discussed. The development of fluency as reported by various researchers in terms of the parameters of fluency was compared. The review of these studies indicated that information on development of fluency is unavailable in all languages of the world. Owing to differences in languages, in terms of syllabic structure, stress, and rhythm, it is imperative that normative data be available in all languages. It is suggested that the All India Institute of Speech and Hearing can take up a single corpus of multi-centric, and multi-linguistic, multi-researchers group working on 14 Official languages of India on development of fluency.

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