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*RESEARCH ARTICLE*

# Articulatory Stability of Non-sense Labiodental Sequences in Persons with Stuttering.

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## *Abstract*

The study aimed at understanding the articulatory stability differences fornonsense labiodental sequences in persons with stuttering and age, gender matched typical adults. Group 1 consisted of 5 [*3M,2F*] Persons with Stuttering (PsWS) in the age range of 18-30 years who were diagnosed to have stuttering from a qualified Speech-Language Pathologist using Stuttering Severity Instrument. Group 2 consisted of age, gender matched typical adults. Articulograph AG501 captured the articulatory movements of Lower Lip (LL) and Jaw in the superior-inferior dimension (Z dimension). Bisyllabic labiodental sequences such as /fafa/ (unvoiced), /vava/ (voiced) and /fava/ (mixed) were used as the study stimuli. Participants were instructed to repeat the target bisyllabic nonsense labiodental sequences in their habitual speaking rate and loudness. A derived kinematic measure called 'Spatiotemporal Index' (STI) was used to analyze the articulatory stability of LL and Jaw. Additionally, the articulatory stability was also compared with the total number of behavioral disfluencies of participants for voiced and combined (voiced-unvoiced) Kannada reading passages. Comparison of mean STI scores of LL and Jaw within each of these groups revealed no significant differences between the stimuli types. Interestingly, PsWS showed greater articulatory instability of LL and Jaw for unvoiced labiodental sequences. Even though between group comparisons of STI scores were insignificant, PsWS showed greater mean STI scores than age, gender matched typical adults. Behavioral disfluencies of combined reading passage correlated positively with the articulatory stability of Jaw for the mixed (/fava/) stimuli. The obtained findings werediscussed with respect to the discoordination hypothesis and the possible implications for future research.



## Introduction:-

Speech is a complex motor behavior that requires coordination of various speech subsystems and any discoordination among these may lead to breakdown in fluency. Past studies carried out on Persons with Stuttering (PsWS) have shown that such discoordination could be the underlying factor for fluency breakdown (Adams, 1978).

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Among various speech subsystem disturbances investigated in PsWS, laryngeal and articulatory discoordination were prominently studied using perceptual and acoustic methods (Prins, & Hubbard, 1990). Studies in this area were motivated following the well-known hypothesis of Airway Dilation Reflex proposed by Schwartz (1974) which also posited that aberrant vocal cord movements were compensated at the supra-laryngeal level by tense posture of the articulators promoting disfluencies in PsWS. As laryngeal adjustments were thought to be the underlying factor for disfluencies, few studies have analyzed the behavioral disfluencies when laryngeal adjustments were made in the context of a reading passage which consisted of either voiced only or mixed (voiced/unvoiced) speech sounds (Adams & Reis, 1971, 1974). Adams & Reis (1971) reported greater adaptation and lesser disfluencies in Persons with Stuttering (PsWS) in a reading passage that contained voiced sounds. However, a follow up study by the investigators did not show differences in dysfluencies between voiced and mixed (voiced and unvoiced) reading passages although the adaptation effect was robust for voiced only passage (Adams & Reis, 1974). Findings of Hutchinson and Brown (1978) contradicted the earlier findings showing greater fluency breakdown in voiced only passage compared to the combined one. But, their study did not examine stuttering adaptation and they also cautioned that their findings are not an adequate case to support laryngeal aberrations underlying stuttering. Later studies those attempted to replicate the earlier findings contradicted the past findings-Adams, Riemenschneider, Metz &Conture (1974), reported that a passage consisting of all voiced continuant passage showed more disfluencies than voiced-unvoiced stops plus continuant passages.

Following the weak support for laryngeal aberrations underlying stuttering in the perceptual studies, investigations based on reaction time were attempted (Adams & Hayden, 1976; Cross &Luper, 1979; Cross, Shadden, &Luper, 1979; Reich, Till, Goldsmith, &Prins, 1979**)**. These studies, in their methodology, did not attempt to address laryngeal deviations as the primary precipitating factor for stuttering but these studies corroborated that PsWS have discoordination between laryngeal and articulatory subsystems of speech (Archibald & De Nil, 1999; Bakker &Brutten 1990; Max &Gracco, 2005; Watson & Alfonso, 1983; Yoshioka &Löfqvist, 1981). Venkatagiri (1982) addressed the discoordination between phonation and articulatory subsystems by reporting the reaction time to produce voiced (/z/) and unvoiced fricative (/s/) consonants in PsWS. It was concluded that there were no significant differences in reaction time during the production /s/ and /z/ compared to typical adults. It was concluded in few of the subsequent studies that excessive tension and simultaneous co-contraction of antagonistic muscle group were the few of the potent factors underlying laryngeal and oral stuttering behaviors (Shapiro, 1980; Freeman & Ushijima, 1978; Smith, 1989).

**Need for the study**

Current study addresses the articulatory aberrations when complex laryngeal adjustments were made using a novel articulatory variability measure called Spatiotemporal Index (STI, Smith, Goffman, Zelaznik, Ying, &McGillem, 1995). Articulatory variability will be computed for labiodental voiced and unvoiced non sense sequences by analyzing the lip and jaw movements. It is hypothesized that laryngeal and articulatory subsystems coordinate with each other and it should not be surprising if movements aberrations of laryngeal mechanism transcends to articulatory level. Till date hardly any study had the objective to analyze discoordination between articulatory and laryngeal subsystems through physiological measures and hence this would be an exploratory study which attempts to understand the physiological differences, if any, between Persons with Stuttering and comparing their data with age, gender matched typical adults.

**Aim of the Study**

Study aims to analyze and compare the articulatory movement variability of Lower Lip (LL) and (Jaw) across voiced, unvoiced and mixed nonsense labiodental sequences in PsWS and Typical adults. Furthermore, the behavioral disfluencies counted while reading a voiced and a combined (voiced-unvoiced) reading passage will be correlated with the articulatory variability of LL and Jaw.

**Objectives of the study**

1. To compare mean STI (Spatiotemporal Index) scores of Lower Lip and Jaw for voiced, unvoiced and mixed labiodental nonsense sequences in Group I (Persons with Stuttering) and Group II (Typical Adults).
2. To compare mean STI (Spatiotemporal Index) scores of Lower Lip and Jaw for voiced, unvoiced and mixed labiodental nonsense sequences between Group I (Persons with Stuttering) and Group II (Typical Adults).
3. To compare mean STI scores of LL and Jaw for voiced and mixed nonsense labiodental sequences with total number of disfluencies for voiced and mixed reading passages.

## Method:-

### Participants

Five Persons with Stuttering (N=5; 3 males, 2 females) and five age, gender matched typical adults (N=5) in the age range of 18-35 years were recruited. Participants with a developmental history of Stuttering whose severity was rated using Stuttering Severity Instrument-IV (Riley& Bakker, 2009) by a qualified Speech-Language Pathologist (SLP) were included. All the participants were native Kannada speakers who resided in old Mysuru region of Karnataka. Recruited participants had never received any form of fluency therapy before they were enrolled into our study. A written informed consent was obtained from all the participants before they were enrolled into the study. Those participants with a history of speech and language delay, hearing problems, oro-structural anomalies and psychological problems were ruled out from the study. Details of the participants are provided in table 1.

**Table 1:-**Details of the participants involved.

| Participants | Groups | Age/Gender | Severity of Stuttering |
|---|---|---|---|
| 1 | Group 1 | 18.4years/Male | Moderate |
| 2 | Group 1 | 22 years/Male | Moderate |
| 3 | Group 1 | 18 years /Female | Very mild |
| 4 | Group 1 | 18 years/ Female | Mild |
| 5 | Group 1 | 18.3 years/Male | Mild |
| 6 | Group 2 | 19 years/Female | |
| 7 | Group 2 | 19 years/Female | |
| 8 | Group 2 | 20 years /Male | |
| 9 | Group 2 | 19 years / Male | |
| 10 | Group 2 | 18.1 years/Male | |

### Stimuli

Current study used 2 pairs of non-sense labiodental syllable sequences. This included /fafa/ (unvoiced sequence), /vava/ (voiced sequence) and /fava/ (combined sequence). The first pair is a labiodental sequence that differed in their voicing gesture whereas the second pair had a combined voiced and unvoiced labiodental non sequences. Nonsense Labiodental sequences were constructed as lower lip and jaw articulatory movements were measured and additionally these stimuli reduced the cognitive and linguistic dependency of the participants (Alfonso & Van Lieshout, 1997; McClean, Kroll, & Loftus, 1990). For recording the percent syllable stuttered, a voiced only and a combined (voiced and unvoiced) reading passage were used. There were 139 syllables and 39 words in the voiced passage and the combined passage had 118 syllables and 38 words.

### Apparatus

Study used Articulograph AG501 (Figure 1) to capture the movements of Lower Lip (LL) and Jaw. Articulograph works with the principle of electromagnetic induction and computes the articulatory movements in X (Anterior-Posterior), Y (Latero-Medial) and Z (Superior-Inferior) dimensions. The articulatory movements in real time could be estimated by measuring the magnetic strength induced on the electromagnetic sensitive coils attached on the articulators of the participants. Movement data is sampled at 1250Hz and the acoustic data at 44.1 kHz with 16 bits precision. For the purposes of this study, movement data of the articulators in Z dimension (for LL and Jaw) is reported.

**Figure 1:-**Articulograph AG501 (CarstensMedizinelektranik, Germany).

**Procedure**

For the first two objectives of the study, the articulatory kinematic variability as indexed through Spatiotemporal Index (STI) is compared between Group I and Group II. As a first step, the sensors of the Articulograph AG500 were calibrated according to the prescribed standards of manufacturers (Carstens, Medizinelektronik). Later, these sensors were dipped into latex solutions and dried for 20 minutes. This was followed by placement of sensors. For this study, 2 reference (one on left mastoid and other on nasal bridge) and 2 test sensors (one on Lower Lip and another on Jaw) were used. Stimuli tokens of nonsense labiodental sequences were presented using Microsoft PowerPoint written in English Orthography. Participants repeated the target tokens in their habitual speaking rate and loudness without stressing on any syllable. Repetitions of the target tokens were continued until 10 fluent iterations were collected from each participant. The order of stimuli tokens were counterbalanced across participants.

For the third objective,total number of disfluencies was calculated by counting the number of disfluencies for voiced and combined Kannada reading passages separately for each participant. Disfluencies include sound/part word repetitions and dysrhythmic phonation (Prolongations, blocks and broken words) (Yairi& Ambrose, 1999). This was correlated with the STI values of nonsense labiodental sequences for further understanding.

**Analysis**

After the post processing of the kinematic data using tailor made softwares, the displacement trajectories will be imported into MATLAB environment (MathWorks, Inc., 2012) where further processing were carried out. The Displacement plots per subject per iteration was checked for artifacts due to dislocated sensors, interrupted recordings, non fluent utterances and these were excluded. Errors due to head movement were removed using the 'Normpos' module provided by the manufacturers (Carstens, Medizenelektronik). The displacement plots of LL and Jaw were later imported into the MATLAB (MathWorks, Inc., 2012) software and the data was further processed using custom made scripts. Baseline drifts in the recorded plots were filtered by passing the movement data through a band pass digital butterworth filter with a cut off frequency of 0.5Hz to 6Hz. This was followed by the differentiation of the LL displacement signal (using 3 point differentiation technique) to obtain plots of velocity versus time function. Similar to the procedure followed for the displacement signal, the derived velocity was also filtered. The velocity data was used as the reference to segment the displacement trajectories of individual iterations. In order to carry out this procedure, at first the LL and Jaw displacement plots along with LL velocity plots were

lined one below the other. The initial and final negative velocity peaks from the LL velocity plots were marked for each iteration which represented the opening movements of initial and final labiodental sound of each stimuli (Smith et al., 1995). For instance, the first negative peak associated with the labiodental opening /fa/ of /fafa/ and the last labiodental opening movement of /fa/ in /fafa/ was used to segment the plots of /fafa/.

This procedure was carried out to segment all the iterated utterances of the stimuli in Kannada and English languages separately. Followed by the segmentation procedure, amplitude and time normalization of the plots was carried out (Smith et al.1995; Smith, Johnson, McGillem, &Goffman, 2000). In this process, each segmented plot was extrapolated to a known factor of 1000 points using cubic spline interpolation procedure and the amplitude was normalized by dividing the mean of the plot by the Standard Deviation (Smith &Goffman, 1998; Smith et al., 1995). On these amplitude-time normalized traces, standard deviations were calculated at every 20th point upto 1000 points making upto 50 standard deviations for 10 fluent iterations and summed up to obtain the Spatiotemporal Index (STI). Therefore, STI values were obtained separately for each stimuli of each language for LL of each participant. The analysis for STI values were followed by superimposition of segmented displacement plots to obtain the graphic representation of the STI as a plot. Standard deviations were computed on a time and amplitude normalized displacement trajectories for selective time points of 10 fluent iterations. These were added to obtain the STI values for LL and Jaw separately.

**Statistical Analysis**

As the data was non-normally distributed non parametric tests were used ($p < 0.01$). Friedman's Test compared the within group differences and Mann-Whitney U test compared the between group varaitions. To correlate the kinematic data with the behaviouraldisfluencies Spearman's Rank Correlation co-efficient was utilized.

## Results:-

For the first objective, a within group comparison of articulatory variability of Lower Lip (LL) and Jaw was carried out for PsWS and Typical Adult group. For PsWS, Friedman's test revealed no significant differences between the stimuli types for mean STI scores of LL and Jaw articulators [LL, $\chi^2 = 2.80$, $p = 0.24$; Jaw, $\chi^2 = 1.20$, $p = 0.54$]. For Typical adult group, trends were similar as the variability of articulators did not differ across the stimuli types [LL, $\chi^2 = 1.60$, $p = 0.44$; Jaw, $\chi^2 = 2.80$, $p = 0.24$]. The mean STI scores for LL and Jaw across the groups are represented in figure 2 and figure 3. Pictorial representations raise two noteworthy points. First, the mean STI scores were higher in PsWS compared to Typical Adults. Typical adults showed greater variability in voiced utterances and least variability was observed for mixed labiodental sequences. On contrary, PsWS showed greater variability for unvoiced utterances and a replicable trend of lowest variaibility was found for mixed labiodental stimuli.

**Figure 2:-** Mean STI scores of Lower Lip (LL) and Jaw for Persons with Stuttering

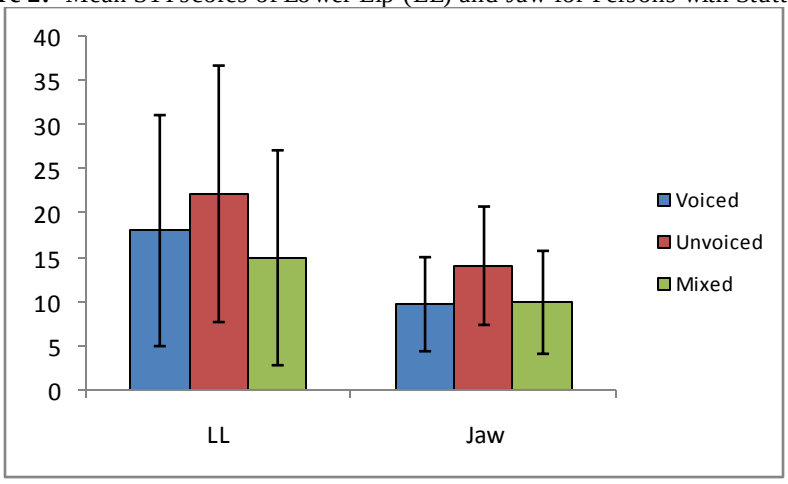
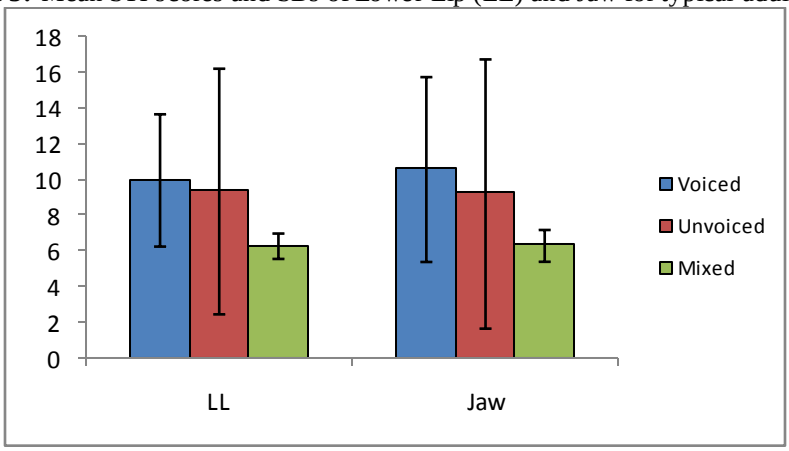


**Figure 3:-**Mean STI scores and SDs of Lower Lip (LL) and Jaw for typical adult group




For the second objective, the mean STI scores were compared between Group I and Group II. Mann Whitney U test revealed no significant differences between the groups for LL and Jaw across voiced [LL, U =9, /z/ = 0.73, *p* = 0.46; Jaw, U = 11, /z/ = 0.31, *p* =0.75], unvoiced [LL, U =6, /z/ = 1.35, *p* = 0.17; Jaw, U = 7, /z/ = 1.14, *p* = 0.25] and mixed utterances [LL, U =4, /z/ = 1.77, *p* = 0.07; Jaw, U = 7, /z/ = 1.14, *p* = 0.25].

Third objective correlatedthe behavioural dysfluencies of voiced and mixed reading passages of PsWS with that of their articulatory variability of LL and Jaw. A statistically significant correlation was observed between the mixed STI score of Jaw with the mixed reading passage using Spearman Rank Correlation Co-efficient [rho = 0.90, *p* = 0.03].

## Discussion:-

Overall findings of comaparing the mean STI scores of LL and Jaw articulators for voiced, unvoiced and combined non-sense labiodental sequences revealed weak support for dyscoordination hypothesis which was proposed to be operative in PsWS. This was incongruent with some of the earlier findngs which failed to show any discoordination between the subsystems of PsWS (Archibald & De Nil, 1999; Bakker &Brutten 1990; Max &Gracco, 2005)

There was no significant differences for the mean STI scores between the utterance types for PsWS and typical adults. However, it was intriguing to note that the mean STI scores were highly variable in PsWS for unvoiced labiodental non-sense sequences. This was irrespective of target articulators wherein the mean STI scores of both LL and Jaw were less stable in unvoiced utterances of PsWS. This may partially support the notion that a fraction of these population may have peculiar difficulty in coordinating aerodynamic forces with articulatory execution. Past studies corroborate this line of argument wherein greater number of dysfluencies were reported in PsWS while producing unvoiced segments of speech (Jayaram, 1983).

Although statistically insignficant, mean STI scores were more variable in PsWS compared to age, gender matched typical adults. Even with overlapping movement variability across trials with typical adults, PsWS on a whole has an unstable articulatory system which operates at the higher end of the stability-instability continuum (Van Lieshout et al., 2004). Any further increase in the articulatory planning or programming demands may destabilize the system that may precipitate to produce observable dysfluencies. Behavioral dysfluencies of the combined/mixed reading passage was found to positively correlate with the mean STI score of Jaw for the mixed nonsense labiodental sequence. This indicated that as a group PsWS may have difficulty in stabilizing the Jaw movement sequences when complex on-off vocal cord adjustments are necessitated and as a consequence of which they exhibit fluency breakdown. However, this was not seen in the case of LL movements. The finding corroborates the already prevalent literature of finer articulatory motor aberrations of Jaw consequence to oral proprioceptive deficits hypothesized to be active in PsWS (Loucks, DeNil & Sasisekaran, 2007).

## Conclusion:-

Current study attempted to understand whether articulatory variability is influenced by vocal cord adjustments by measuring the Spatiotemporal Index (STI) of voiced, unvoiced and mixed labiodental nonsense sequences in PsWS and age, gender matched typical adults. Although complex vocal adjustments did not influence the articulatory variability in PsWS, there was a trend of higher motoric variability of LL and Jaw articulators for unvoiced utterances. Behavioral dysfluencies correlated positively with the Jaw movement variability indicating jaw motion aberrations in PsWS. The limitation of this study includes lesser sample size and limited variety of PsWS with regard to their stuttering severity. Future studies can also increase the syllable length as this study explored on only bisyllabic utterances.

## References:-


1. Adams, M. R. (1978). Stuttering theory, research, and therapy: The present and future. *Journal of Fluency Disorders*, *3*(2), 139-147.
2. Adams, M. R., & Hayden, P. (1976). The ability of stutterers and nonstutterers to initiate and terminate phonation during production of an isolated vowel. *Journal of Speech, Language, and Hearing Research*, *19*(2), 290-296.
3. Adams, M. R., & Reis, R. (1971). The influence of the onset of phonation on the frequency of stuttering. *Journal of Speech, Language, and Hearing Research*, *14*(3), 639-644.
4. Adams, M. R., & Reis, R. (1974). Influence of the onset of phonation on the frequency of stuttering: a replication and reevaluation. *Journal of Speech and Hearing Research*, *17*(4), 752-754.
5. Adams, M. R., Riemenschneider, S., Metz, D., & Conture, E. (1974). Voice onset and articulatory constriction requirements in a speech segment and their relation to the amount of stuttering adaptation. *Journal of Fluency Disorders*, *1*(3), 23-29.
6. Alfonso, P.J., & Van Lieshout, P.H.M.M. (1997). Spatial and temporal variability in obstruent gestural specification by stutterers and controls: Comparisons across sessions (pp. 151-160). In W. Hulstijn, H.F.M. Peters, &P.H.H.M.VanLieshout, P.H.H.M. (Eds.). *Speech production: Motor control, brain research and fluency disorders*. Amsterdam, The Netherlands: Elsevier Publishers.
7. Archibald, L., & De Nil, L. F. (1999). The relationship between stuttering severity and kinesthetic acuity for jaw movements in adults who stutter. *Journal of Fluency Disorders*, *24*(1), 25-42.
8. Bakker, K., &Brutten, G. J. (1990). Speech-related reaction times of stutterers and nonstutterers: Diagnostic implications. *Journal of Speech and Hearing Disorders*, 55, 295–299
9. Cross, D. E., &Luper, H. L. (1979). Voice reaction time of stuttering and nonstuttering children and adults. *Journal of Fluency Disorders*, *4*(1), 59-77.
10. Cross, D. E., Shadden, B. B., &Luper, H. L. (1979). Effects of stimulus ear presentation on the voice reaction time of adult stutterers and nonstutterers. *Journal of Fluency Disorders*, *4*(1), 45-58.
11. Freeman, F. J., & Ushijima, T. (1978). Laryngeal muscle activity during stuttering. *Journal of Speech, Language, and Hearing Research*, *21*(3), 538-562.
12. Hutchinson, M. R., & Brown, D. (1978). The Adams and Reis observation revisited. *Journal of Fluency Disorders*, *3*, 149-154.
13. Jayaram, M. (1983). Phonetic influences on stuttering in monolingual and bilingual stutterers. *Journal of Communication Disorders*, *16*(4), 287–297
14. Loucks, T. M. J., De Nil, L. F., &Sasisekaran, J. (2007). Jaw-phonatory coordination in chronic developmental stuttering. *Journal of Communication Disorders*, *40*(3), 257–272. https://doi.org/10.1016/j.jcomdis.2006.06.016
15. MathWorks, I. (2012). MATLAB and statistics toolbox release. *Natick, MA: The MathWorks*.
16. Max, L., &Gracco, V. L. (2005). Coordination of oral and laryngeal movements in the perceptually fluent speech of adults who stutter. *Journal of Speech, Language, and Hearing Research*, 48(3), 524-542
17. McClean, M. D., Kroll, R. M., & Loftus, N. S. (1990). Kinematic analysis of lip closure in stutterers' fluent speech. *Journal of Speech, Language, and Hearing Research*, *33*(4), 755-760.
18. Prins, D., & Hubbard, C. P. (1990). Acoustical durations of speech segments during stuttering adaptation. *Journal of Speech and Hearing Research*, 33, 494–504
19. Reich, A., Till, J., Goldsmith, H., &Prins, D. (1979). Reaction-time experiments with stuttering and nonstuttering adults. In *Paper presented at the Annual Convention of American Speech-Language-Hearing Association*.
20. Riley, G. D., & Bakker, K. (2009). *Stuttering severity instrument: SSI-4*. Pro-Ed.

21. Schwartz, M. F. (1974). The core of the stuttering block. *Journal of Speech and Hearing Disorders*, *39*(2), 169-177.
22. Shapiro, A. I. (1980). An electromyographic analysis of the fluent and dysfluent utterances of several types of stutterers. *Journal of Fluency Disorders*, *5*(3), 203-231.
23. Smith, A. (1989). Neural drive to muscles in stuttering. *Journal of Speech, Language, and Hearing Research*, *32*(2), 252-264.
24. Smith, A., Goffman, L., Zelaznik, H. N., Ying, G., &McGillem, C. (1995). Spatiotemporal stability and patterning of speech movement sequences. *Experimental Brain Research*, *104*(3), 493-501.
25. Van Lieshout, P. H. H. M., Hulstijn, W., & Peters, H. F. M. (2004). Searching for the weak link in the speech production chain of people who stutter: A motor skill approach. In: B. Maassen, R. Kent, H. F. M. Peters, P. van Lieshout, & W. Hulstijn (Eds.), Speech motor control in normal and disordered speech (pp. 313–356). Oxford, UK: Oxford University Press.
26. Venkatagiri, H. S. (1982). Reaction time for/s/and/z/in stutterers and nonstutterers: A test of discoordination hypothesis. *Journal of communication disorders*, *15*(1), 55-62.
27. Watson, B. C., & Alfonso, P. J. (1983). Foreperiod and stuttering severity effects on acoustic laryngeal reaction time. *Journal of Fluency Disorders*, *8*(3), 183-205.
28. Yairi, E., & Ambrose, N. G. (1999). Early childhood stuttering I: Persistency and recovery rates. *Journal of Speech, Language, and Hearing Research*, *42*(5), 1097-1112.
29. Yoshioka, H., &Löfqvist, A. (1981). Laryngeal involvement in stuttering: A glottographic observation using a reaction time paradigm. *Folia Phoniatrica*, 33, 348–357