Effect of oral anesthetization on the speech characteristics of persons with and without stuttering

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Key Words

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Articulatory errors
Stuttering and normal disfluencies

Abstract

Appropriate sensory feedback from the speech structures affects articulation and prosody. The study aimed to investigate the effects of oral anesthetization on the speech characteristics in persons with stuttering (PWS) compared to normals. The participants included 18-30 year old 25 PWS and 25 age and gender matched controls. Their spontaneous speech and reading samples were video recorded prior to and after the administration of oral anesthesia. These samples were analyzed for Stuttering Like Disfluencies (SLDs), Normal Disfluencies (NDs), Articulation Errors (AE) and rate of speech. The SLDs and NDs were significantly reduced under oral anesthesia and AEs were more of distortions and not significant. The rates were significantly reduced in both the groups under oral anesthesia. The reduction in sensory input thus showed an influence on the speech behaviors and rate of speech signifying the need of appropriate sensory feedback from the articulators for fluent speech which needs further exploration.

Introduction

Speech act refers to automatic production of words. Fluency is one of the main components of speech. It is the effortless production of long continuous utterances at a rapid rate (Starkweather, 1981). Developmental stuttering is a complex disorder in which the symptoms may be manifested by a failure to convert linguistic intent into fluent output (Smith, Sadagopan, Walsh & Weber-Fox, 2010). This implies that the breakdown in speech fluency could arise from multi-factorial influences impinging on speech production (Smith & Kelly, 1997).

Sensory information is mandatory to control the speech motor action. Kinesthetic sensation is important to be integrally involved in achieving the movement goals. Oral sensory and perceptual integrity are important feedback components needed for the regulation and refinement of the patterns of oral manipulation. In the oral cavity, there is an intimate interaction of sensory and motor functions for speech production. Disturbances in oral sensory perception have been found to be associated with disturbances in speech fluency in normal individuals and PWS. Loucks and De Nil (2006) analyzed the jaw movement and kinesthetic sensation of jaw and suggested that chronic developmental stuttering involves an oral kinesthetic deficiency. The authors propose that the movement abnormalities seen during stuttering episodes, fluent speech and few non speech tasks could be explained by the oral kinesthetic deficits.

The importance of sensory information for planning and execution of speech movements has been debated for long. Somato-sensory feedback has been thought to be too slow for the on-line coordination of fast speech movements (Garber & Siegel, 1982). Research has shown significant contribution of oro-sensory information during both planning and execution of speech movements (Gracco, 1991; Gracco & Abbs, 1989). Archibald and De Nil (1999) recommended further investigations of the potential contribution of a reduced kinesthetic acuity to the temporal articulatory discoordination observed in adults who stutter. Anaomalous sensorimotor function in adult PWS has been observed in studies of oral perception, movement tracking and vocal reaction time (Neilson & Neilson, 1991; van Lieshout, Hulstijn & Peters, 1996). As PWS exhibit normal oral reflexes unlike most other sensorimotor disorders, it is suggested by authors that any sensorimotor deficit in stuttering would have a central neurological origin than reflex abnormalities.

Typically, studies have used anesthetization to check the acoustic and physiological changes of intense oral sensory deprivation (Leanderson, 1972; Putnam, 1973). The studies regarding the visual, auditory and tactile sensory information including sensations have been understood in terms of various models of motor behaviour that appreciated the importance of peripheral feedback in the execution of movement patterns. There are two schools of thought about the motor behaviors which are opposing viewpoints. The centralist viewpoint (Leanderson & Persson, 1972) claims that the motor behavior is the result of a central motor program executed without relation to the peripheral feedback. This is termed as the "open loop". Opposing this is the peripheralist viewpoint (Ringel & Steer, 1963) which claims that the loop is closed and working is dependent on the sensory information, where it is important for the order and accuracy of execution of motor events. Hutchinson and Ringel (1975) studied six individuals with mild to moderate stuttering with a mean age of 23 years. They confirmed that the tongue anesthesia condition showed a significant increase in stuttering frequency, whereas the control and placebo conditions showed nearly the same disfluency rate. Here, the control condition involved normal sensory feedback condition without anesthetization and placebo condition involved insertion of a hypodermic needle without injecting the anesthetic solution. They supported the completely closed-loop or completely feedback-dependent regulation of disfluency.

These views relative to the feedback processes in the regulation of speech lead us to consider the question as to whether PWS who have disrupted fluency possess a basic integrity of oral sensation and perception which is comparable to that of normal speakers. Svirsky, Lane, Perkell and Wozniak (1992) reported that disturbed auditory system can lead to the production of more phonetic and prosodic errors in speech. Inaccurate or distorted articulation, speech errors and unacceptable intonation information are possibly noticed in persons with these kinds of auditory disrupted system. Uthappa, Shailat and Geetha (2010) analyzed the effect of oral sensory feedback control on the speech of persons with and without stuttering using oral anesthesia. The results showed that there was a significant difference seen in PWS with and without oral anesthesia with respect to the disfluencies such as pauses, prolongations, repetitions and articulation errors. The disfluencies in PWS reduced under anesthesia, whereas the errors in articulation increased in comparison with the normal condition. The results showed that the rate of speech may be independent of kinesthetic feedback from the oral regions and it was observed that anesthetization of the oral structures may act as a fluency facilitator in PWS. The results on the perceptual analysis showed that the actual problems faced by PWS may be a lot more than what is perceived by the listeners. Fluency is altered both in persons with and without stuttering under reduction of tactile-kinesthetic feedback although the effect was more evident in PWS.

Previous research on the effect of sensory feedback on stuttering has studied the changes in fluency due to disrupted auditory feedback (Shane, 1955; Mysak, 1959; Adams, Moore, & Hutchinson, 1972). However, the effect of oral sensory feedback on stuttering is less known. Hence, the need of the present investigation was to assess the effects of oral anesthetization on the frequency and severity of stuttering behavior.

In this regard, the present study is aimed to investigate the effects of oral anesthetization on the speech characteristics in PWS compared to PWNS. This is part of a larger project studying the effects of various altered auditory and sensory feedback conditions on the speech characteristics of persons with and without stuttering. It is also well known that PWS differ with respect to their difficulty level in the context of reading and spontaneous speech, most individuals showing much reduced stuttering in reading compared spontaneous speech. As reading task provides common context for comparison across persons with and without stuttering, the objective of the study included comparison of the two groups across tasks and conditions. Therefore, the objectives of the study were to compare persons with and without stuttering with regard to some of the speech characteristics in reading and spontaneous speech in terms of the disfluencies (SLDs & ODs) with and without oral anesthesia, the rate of speech with and without oral anesthesia, and the speech errors, if any, with and without oral anesthesia.

Method

Participants: The study was undertaken on twenty five PWS and 25 age and gender matched PWNS as the control group in the age range of 18 to 30 years. The participants in the experimental group were diagnosed by qualified SLPs to have moderate and above degree of stuttering severity based on SSI-3. All the participants were native speakers of Kannada.

Materials: Sony HD Handycam was to video record the reading and narration speech samples. Xylocaine spray containing ligocaine topical aerosol 10% as oral anesthesia was used. Standard reading passages and Stuttering Severity Instrument (SSI 3; Riley, 1994) were used.

Procedure: After obtaining consent from the participants, general history including demographic data, onset and therapy related information was collected from PWS using the checklist developed for the purpose. Information was also elicited to rule out any associated hearing, psychological and neurological problems from all the participants. PWS were administered SSI to determine the severity of stuttering. All the speech samples were video

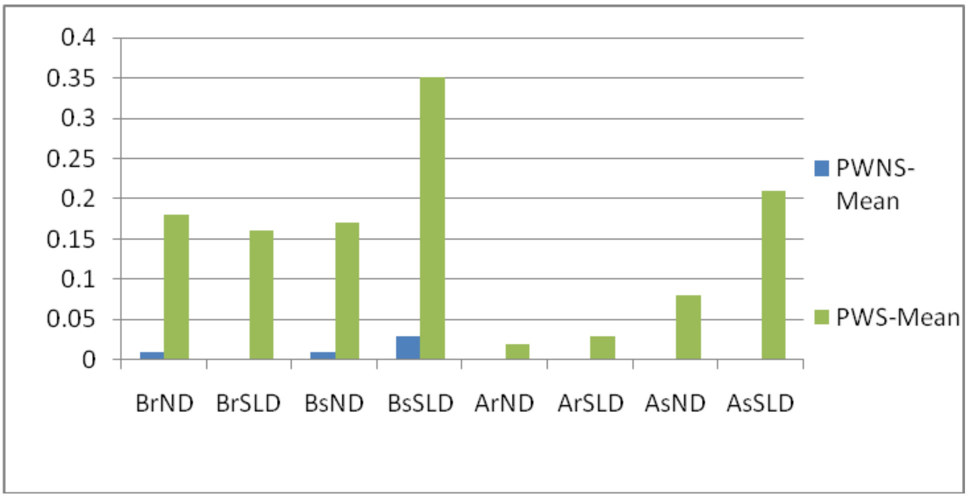

Figure 1: Mean% of NDs and SLDs in reading and spontaneous speech in PWNS and PWS

recorded in an acoustically treated room. Pre-anesthetized condition was recorded initially followed by post anesthetized condition for all the participants and reading samples were elicited prior to the spontaneous speech samples in both the conditions. The Xylocaine spray containing ligocaine topical aerosol 10% as oral anesthesia was administered by an otolaryngologist after the baseline measures. Specific Kannada reading passages were used for each condition for all the participants.

Analyses: The reading and speech samples were transcribed and analyzed for Stuttering like Disfluencies (SLDs), Normal Disfluencies (NDs), Articulation Errors (AE) and rate of speech. The SLDs include sound or syllable repetitions, part word repetitions, mono-syllable whole word repetition sound or syllable prolongations, and blocks. The NDs consisted of interjections, pauses and phrase or whole word repetitions. The oral anesthesia can have changes on the NDs in normals and both/either NDs and SLDs in PWS. It is interesting to study if normals exhibit any SLDs in the presence of oral anesthesia and if NDs and SLDs vary in quantity in PWS. Hence, both SLDs and NDs were considered separately for analysis. The rate of speech was analyzed in terms of syllables per second and words per minute. The AEs included omission, substitution, distortion, and addition errors. The SLDs, NDs, AEs and rate of speech were calculated in percentage in both with and without anesthetization for all the participants. The tabulated values were statistically analyzed using the SPSS (version 16) software package.

Results

The present study was aimed to investigate the effect of oral anesthetization on some of the speech characteristics in PWS compared to normal controls. The results are compared and discussed separately under frequency of disfluencies (SLDs and NDs), rate of speech and articulatory errors. As there were wide variability in the data as could be seen in standard deviation scores in all parameters, non parametric measures were used for comparison.

Frequency of Disfluencies: The mean of NDs and SLDs were high in PWS compared to PWNS. During the baseline condition, except for the NDs in reading and spontaneous speech and SLDs during spontaneous speech, all other parameters showed nil occurrences in the entire data. During the anesthetized condition, reduction in disfluencies was seen in both the groups.The mean percentage and standard deviation scores for NDs and SLDs during reading and spontaneous speech in PWNS and PWS are depicted in Table 1.

After administering the Mann Whitney test, it was shown that SLDs and NDs were significantly reduced after the administration of oral anesthesia in PWS during the reading task. However, during spontaneous speech the SLDs were not significantly different (p=0.15) across conditions whereas NDs were significant (p =0.00). The probable reason for this finding could be the high variability and reduction in the rate of speech in PWS, especially in spontaneous speech.

Rate of Speech: PWS showed fast rate during spontaneous speech especially compared to PWNS during baseline. Both the groups showed reduced rate of speech during anesthetized condition, more so in PWS. The rate of speech with respect to word per minute (WPM) and syllable per second (SPS) during the reading and spontaneous speech in PWNS and PWS with and without anesthetization are depicted in Table 3.

No significant difference across conditions for SPS during the reading task in the both groups

Table 1: Mean % and SD of NDs and SLDs in reading and spontaneous speech in PWNS and PWS

Conditions	PWNS		PWS	
	Mean	SD	Mean	SD
BrND	0.01	0.01	0.181088	1.64
BrSLD	0	0	0.16	7.77
BsND	0.01	0.01	0.17	2.76
BsSLD	0.03	0.02	0.35	9.48
ArND	0	0	0.02	1.07
ArSLD	0	0	0.03	2.03
AsND	0	0	0.08	2.01
AsSLD	0	0	0.21	6.30

*[BrND- NDs during baseline reading; BrSLD- SLDs during baseline reading; BsND- NDs during baseline spontaneous speech; BsSLD- SLDs during baseline spontaneous speech; ArND- NDs during anesthesia reading; ArSLD- SLDs during anesthesia reading; AsND- NDs during anesthesia spontaneous speech; AsSLD- SLDs during anesthesia spontaneous speech]

Table 2: Mann Whitney test p values of significance across conditions

Conditions	PWNS	PWS
BrND & ArND	0.12	0.003*
BrSLD & ArSLD	0.061	0.05*
BsND & AsND	0.109	0.00*
BsSLD & AsSLD	0.09	0.152

Table 3: Mean % and SD for rate of speech in WPM and SPS in reading and spontaneous speech in PWS and PWNS

Conditions	PWNS		PWS	
	Mean	SD	Mean	SD
BrWPM	4.65	15.32	5.98	14.33
BrSPS	0.19	0.72	0.21	1.05
BsWPM	4.66	13.77	4.72	19.13
BsSPS	0.46	0.72	0.96	3.18
ArWPM	3.63	8.47	2.33	14.80
ArSPS	0.19	0.64	0.25	1.37
AsWPM	3.09	9.89	3.03	13.29
AsSPS	0.21	0.24	0.24	1.23

*[

BrWPM- Word per minute during baseline reading; BrSPS- Syllables per second during baseline reading; BsWPM- Word per minute during baseline spontaneous speech; BsSPS- Syllables per second during baseline spontaneous speech; ArWPM- Word per minute with anesthesia in reading; ArSPS- Syllables per second with anesthesia in reading; AsWPM- Word per minute with anesthesia in spontaneous speech; AsSPS- Syllables per second with anesthesia in spontaneous speech]

Table 4: Mann Whitney test p values of significance across conditions

Conditions	PWNS	PWS
BrSPS & ArSPS	0.102	0.103
BsSPS & AsSPS	0.032*	0.00*

was noticed. However, significant difference between conditions was observed. Rate of speech reduced in anaesthesia condition compared to baseline. Reduced rate of speech compared to the baseline recordings.

Articulation Errors (AE): No articulatory errors were observed in both PWS and PWNS groups did not show any articulation errors during the baseline recording. However, during anesthesia, both PWNS and PWS showed articulatory errors, which were more of distortion type followed by substitution and omission errors. Addition errors were negligible. The AEs were significantly increased during the anesthetic condition both in PWS and PWNS. The p values are depicted in table 6, which show significance for both the groups for both reading and spontaneous speech in terms of articulatory errors. This shows that anesthetization had an effect on the articulation of sounds although there were no errors of articulaton in both the groups during pre-anesthetization. The mean and SD of AEs during reading and spontaneous speech in PWNS and PWS with and without anesthetization are depicted in Table 5.

Table 5: Mean % and SD of AE in reading and spontaneous speech in PWNS and PWS under two conditions

Conditions	PWNS	PWS		
	Mean	SD	Mean	SD
BrAE	0	0	0	0
BsAE	0	0	0	0
ArAE	2.11	4.02	3.01	3.88
AsAE	3.42	4.18	4.05	4.33

Table 6: Mann Whitney test p value of significance across conditions

Conditions	PWNS	PWS
BrAE & ArAE	0.017*	0.011*
BsAE & AsAE	0.05*	0.03*

Discussion

The present study was aimed to investigate the effect of oral anesthetization on the speech char-

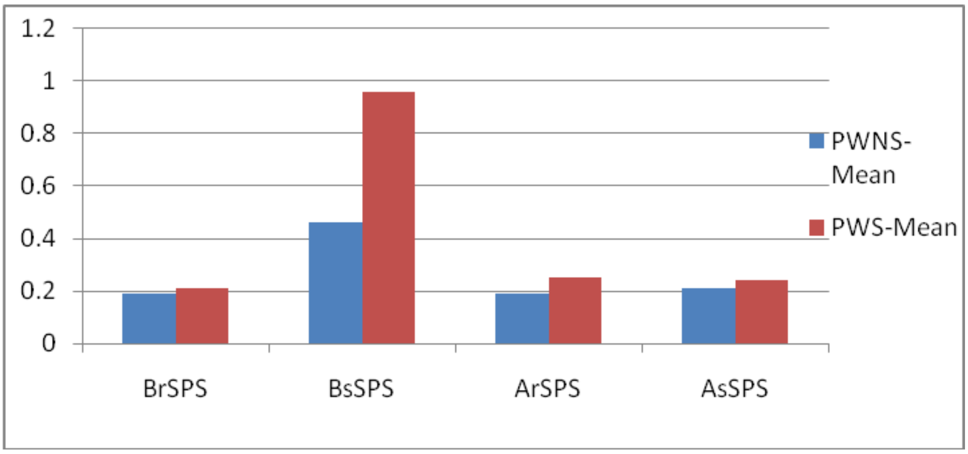

Figure 2: Mean % rate of speech in SPS during reading and spontaneous speech in PWNS and PWS.

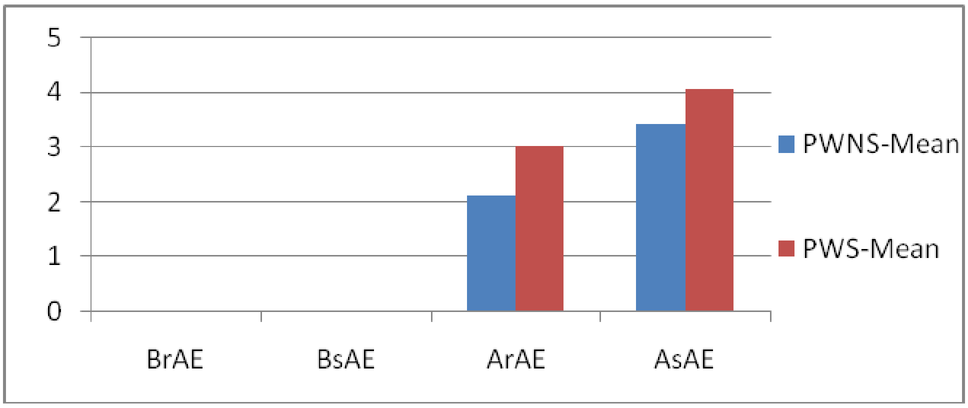

Figure 3: Mean % of AEs in reading and spontaneous speech in PWNS and PWS under two conditions.

acteristics in PWS compared to normal controls. There was significant reduction in NDs, SLDs and rate of speech after anesthetization. The findings of the present study are in agreement with that of Hutchinson and Ringel (1975), where the authors reported of reduced frequency of disfluency after trigeminal anesthesia. The oral sensory deprivation in PWS seems to have caused a reduction in the frequency of both types of disfluencies, which could have been further influenced by the reduction in rate of speech. Under oral anesthetization the PWS would be unable to monitor accurately the articulatory events and would not resort to a learned sequence of events contingent upon afferent information.

The present study also showed significance with respect to AEs which is consistent with Svirsky et al (1992) and Uthappa et al. (2010). The present study and that by Uthappa et al. (2010) assessed the kinesthetic sensation. However, Svirsky et al. (1992) provided information regarding the auditory mode and their results indicate the occurrence of AEs under the altered feedback conditions. This highlights the importance of sensory feedback for unperturbed speech production system. It is claimed by few authors that sensory feedback is potentially active for increasing precision of movement. Specifically, with regard to the oral region, Liberman et al. (1967), Scott and Ringel (197I), and Putnam (1973) have suggested that oral sensory feedback is activated to ensure precision in the attainment of certain open-loop articulatory targets.

The observed decrease in the frequency and severity of stuttering behaviour during oral anesthesia is inconsistent with the results that would be anticipated from a completely open-loop or completely feedback-dependent regulation of fluency. If disfluencies were an open-loop event, little or no change in speech characteristics would be expected when the participant was deprived of sensory feedback. Conversely, if oral sensory information is vital to the ongoing execution of fluent speech, deprivation should have caused a reduction in the frequency and severity of disfluency. Under such conditions, PWS would be unable to monitor accurately the articulatory events of the disfluency and would not resort to a learned sequence of events contingent upon afferent information. It is more in agreement with closed loop where there is a need for the sensory information to execute accurate motor events. This is consistent with the literature in this regard (Liberman, Cooper, Shankweiler & Studdert-Kennedy, 1967; Scott & Ringel, 1971; Putnam, 1973), where the authors explained the importance of sensory modalities for processing and their influence on speech production. The findings of the present study refute the findings of Gracco (1987), who supported open loop and explained that speech motor commands can be updated automatically from somatic sensory receptor information.

Being an over-learned and highly automatic activity, kinesthesia is supposed to contribute in a feed forward or predictive manner for speech production (Tremblay, Shiller & Ostry, 2003), than in a feedback manner. However, oral sensory deprivation using oral anesthetization does not bring about stuttering or normal disfluencies in normal individuals. This suggests that somato-sensory impairment, although temporary does not cause stuttering in PWNS. Loucks and De Nil (2006) view stuttering as a disorder due to complex interaction between sensorimotor function along with linguistic factors and propose to consider these factors to predict chronic stuttering and develop treatment strategies to prevent chronicity.

Conclusions

The results of the present study indicated that the reduction in sensory input through oral anesthesia influence the speech behaviours and rate of speech. The present study signifies the need of appropriate sensory feedback from the articulators for the production of fluent speech. This needs to be explored further for proper understanding of the mechanics of oral sensory feedback for the production of fluent speech and establish desensitization approaches in the treatment of fluency disorders. This needs to be explored with different strengths of anesthetization on different severity groups of PWS.

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