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Tongue Dynamics in Childhood Apraxia of Speech: A Case Study

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Abstract

Childhood Apraxia of Speech (CAS) is a subtype of speech sound disorder with unique features that include deficits in speech sound accuracy, prosody, coarticulatory transitions, and consistency on repeated attempts. Articulatory errors are abundant in apraxia such as articulatory groping, perseverative errors, and speech initiation difficulties. There are few studies conducted to see the articulatory pattern of CAS. Present study aimed to analyse the prime articulator, i.e. tongue dynamics in CAS in different place of articulation comparing with typically developing children. One child with CAS and one typically developing age matched control subject were participated in the study. The test material consisted of three meaningful words consisting stops in three different places of articulation including dental /t̪/, retroflex/ʈ/ and velar /k/. The instrument Mindray ultrasound 6600 with Articulate Assistant Advanced (AAA) ultrasound module Version 2.14 was used for data collection and analysis. The overall results showed variation across trials in CAS and this disparity between the trails were less in typical speaker's utterances compared to CAS. The placement of tongue was diverse across subject during the articulation of /k/ with respect to the tongue height and advancement. Variations were more evident in the tongue front and posterior tongue body region compared to anterior tongue body. In the case of retroflex stop /ʈ/ tongue front and posterior tongue body image was not prominent in all repetition of CAS. But in normal speaker all the three divisions were prominent and variations across trails were less. This information can be useful to set the treatment plans for CAS to resolve the articulatory errors.

Keywords: Childhood; Speech; Tongue; Etiology; Apraxia of speech

Introduction

Apraxia of speech (AOS) is a disorder of motor speech programming manifested primarily by errors in articulation and secondarily by compensatory alteration of prosody [1,2] reported that AOS is the primary communication disorder in 7.6% of 6,101 cases; the severity varies from minor sound distortions to an inability to produce speech. Stroke is the most frequent etiology resulting in AOS. It is linked to cortical and/or sub cortical damage in the language-dominant hemisphere of the brain [3], but researchers are still uncertain about the specific brain regions involved in AOS [4,5].

AOS can be classified mainly into childhood apraxia of speech (CAS) and acquired apraxia of speech (AAS).CAS is a subtype of speech sound disorder (SSD) with unique features that include deficits in speech sound accuracy, prosody, coarticulatory transitions, and consistency on repeated attempts [6]. The primary clinical characteristics considered necessary for the diagnosis of AOS include: 1) a slow rate of speech resulting in lengthened sound segments and intersegment durations, 2) speech-sound errors such as sound distortions and/or distorted sound substitutions, 3) distortion errors that are relatively consistent in type and that occur at the word level, and 4) disturbed prosody. Other speech behaviours that frequently occur with AOS include articulatory groping, perseverative errors, increased errors with increased word length, and speech initiation difficulties [3]. Each branch has a further division of verbal and non-verbal categories.

Articulation errors in AOS can be assessed by using different approaches such as spectrograms and electropalatography [7-10] conducted a study to examine the timing control of laryngeal and supralaryngeal articulatory adjustments in AOS, voice onset time (VOT) data for stop consonants in monosyllables of apraxia subjects and compared them with those of fluent aphasic and normal individuals. The results indicated that the VOT distribution patterns of the apraxic patients differed markedly from those of the other speakers. [11] studied the acoustical pattern of apraxia with results indicating that variation of segmental and prosodic characteristics in their participants included slow speaking rate with prolongations of transitions, steady states, and inter-syllable pauses; reduced intensity variation across syllables; slow and inaccurate movements of the articulators; incoordination of voicing with other articulations; initiation difficulties; and errors of selection or sequencing of segments when compared to controls.

Recently, the new ultrasound imaging technique is the tool of interest for researchers to do the analysis. Ultrasound imaging comes with the advantage of providing an explicit image of tongue configuration in real time. Ultrasound visualizes the surface of the tongue from a midsagittal or coronal view which enables the extraction of the tongue contour from one or several frames, visualization of tongue movements, comparing tongue positions and measuring the amount of tongue movement between frames, duration analysis, and 3D reconstruction. It is a safe, non-invasive, and cost-effective method of analyzing articulatory dynamics [12].

There are studies which have focused on the tongue dynamic properties of normal speakers by using ultrasound, but there have been few attempts to reveal the dynamics of articulation in disordered populations especially in CAS. Kocjancic [13] studied tongue movements by using ultrasound tongue imaging in CAS, results revealed that tongue movement was less in the vertical and horizontal

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direction than in the control groups. There is no reported study which provides temporal and spatial information regarding tongue contours in persons with CAS. Hence the present study aimed to explore the articulatory dynamics in CAS in different places of articulation using typically developing Kannada speaking children for the sake of comparison.

Method

Participants

One child with CAS and one typically developing age matched control subject participated in the study. The participant with childhood apraxia of speech was diagnosed at the age of 10 years. He was attending grade 5 and academic performances were reported to be fair. The client was reported to have unclear speech with age, adequate language skills, and normal motor milestones with no relevant significant family history to account for the observed CAS. Following a detailed case history, The Kannada Picture Articulation Test [14] and the linguistic profile test in Kannada [15] were administered. KPAT results revealed inconsistent errors in articulation of phonetic realizations in isolation of /l/ and /r/ and at word and sentence levels for /d̪/ for /k/ and /ʈ/.Errors found in connected speech were substitution, omission, distortion and cluster reduction with very mild groping behaviours. In LPT-K, syntax was analysed and revealed fairly adequate language with an age range of 8+.The Developmental Screening Test [16] findings revealed an age range of 9.5-10 years with an average intelligence quotient. The test for verbal praxis in children [17] was administered and led to the diagnosis of CAS. No non-verbal apraxia component was noticed.

Material

The test material consisted of three meaningful words containing stops in three different places of articulation including dental /t̪/, retroflex /ʈ / and velar /k/. The words were

/at̪t̪a/, /aʈʈa/ and /akka/; the consonants occurred as geminates both preceded and followed by the vowel /a/.

Instrumentation

The instrument Mindray ultrasound 6600 connected with a PC and installed with the software Articulate Assistant Advanced (AAA) ultrasound module Version 2.14 was used for the analysis with 60 frames per second. It is synchronized to the audio input with a sample rate of 22050 Hz. The transducer is a long-handled microconvex probe operating at 6.5 MHz placed beneath the chin of the participant.

Data collection

Participants were instructed to sit comfortably and the test procedure was described to them. The transducer probe placed beneath the chin was smeared with ultrasound transmission gel (*Aquasonic 100*) for better tongue imaging. The probe was fastened by a stabilization headset (*Articulate Assistant Advanced*) to reduce artifactual shifts because of head movements. A previously prepared stimulus list was presented visually on a computer screen to the participant and three repetitions of each prompt were considered for further analysis. Thus nine utterances were recorded from each participant including three repetitions of three target samples. A total of 18 utterances (9*2=18) were collected from both the CAS and the typically developing child. Figure 1 is an ultrasound image of a typical adult tongue contour while producing the consonant dental /ʈ/ from the word /aʈʈa/. The lower edge of the bright white curve is the surface of the tongue. The tongue tip is on the left and the black area below to the viewer's left is caused by the bone of the chin.

Analysis

Semiautomatic contour plotting was used in this study. The three frame images of each utterance were averaged to minimize the variation and to enhance the accuracy of the estimate by using the data from all three frames. To describe the tongue contours, Figure 2 the tongue was divided into three regions the posterior tongue body, anterior tongue body and the tongue front, if it is visible [12]. In the present study, production of /at̪t̪a/ showed more artifacts and it was excluded from further analysis since it was difficult to plot the tongue contour.

MATLAB (Version 7.10.0) was then used to calculate perpendicular lines on the tongue curve, as shown in the Figure 3. In the image, point A represents the tongue root, B represents the tongue tip, C represents the highest point of the curve of the tongue body, and D represents the base of a perpendicular segment connecting line AB to point C. Curvature degree is defined as the ratio of the segment CD divided by the segment AB. A higher degree of curvature corresponds to a tongue shape that is more peaked. Curvature location is defined as the ratio of the segment AD divided by the segment DB. Higher values for curvature correspond to more anterior constrictions [18].

Results

The present study aimed to explore articulatory dynamics in CAS in different places of articulation comparing a single case of CAS with typically developing Kannada speaking children. This is a qualitative (and quantitative) single case study aiming to learn more about the tongue dynamics of CAS for specific sounds and how tongue movements differ in CAS from the articulatory movement of a typically developing child. The overall results showed variation across trials in CAS and disparity between trials was less in the typical speaker's utterances compared to the child with CAS.

Production of voiceless velar stop /k/

All the trials showed posterior tongue body elevation during the production of /k/. As seen in Figure 4a, the placement of the tongue during the articulation of /k/ was diverse across the two subjects with respect to the tongue height and advancement. Variations were more evident in the tongue front and posterior tongue body region compared to the anterior tongue body. The tongue contour showed reduced size because of the distortion of tongue movement. This distortion was evident especially in the region of the tongue front

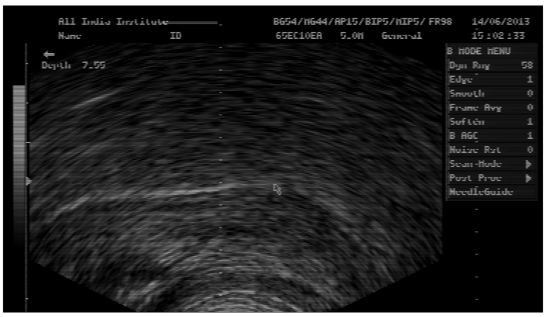

Figure 1: Ultrasound frame at the consonant dental /ʈ/ from the word /aʈʈa/ produced by an adult speaker. Left side of the figure indicates the front of the oral cavity and right side is shows back of the oral cavity.

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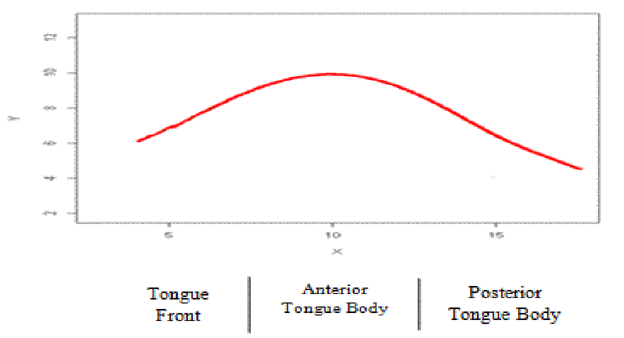

Figure 2: Schematic representation of divisions of tongue contours into three regions- the posterior tongue body, anterior tongue body and the tongue front with vertical (Y) and horizontal (X) scale in mm.

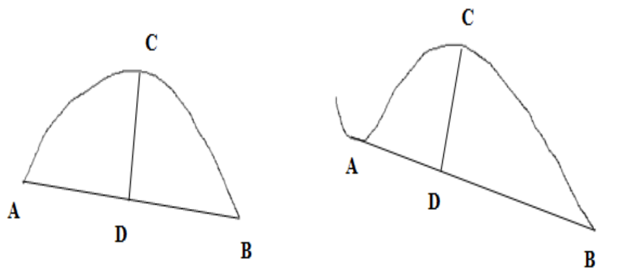

Figure 3: Schematic representation of method to calculate the degree of tongue curvature and the point of maximum displacement.

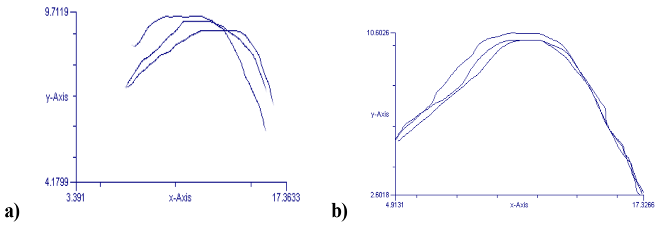

Figure 4: Tongue contours of three repetitions at the consonant dental /k/ from the word /akka/ produced by a) the CAS speaker, b) the normal speaker.

and the posterior tongue body. As seen in Figure 4b, the variations across trials were reduced in the trials of the normal speaker. The entire tongue was evident in the image because the movement was more precise in the case of the normal speaker.

As seen in Figure 5, tongue contour pattern indicated moreover similar tongue posterior body elevation towards the soft palate in both participants. The restriction of tongue height and advancement restricted in CAS, shows the impreciseness and greater variability of the articulation by the CAS speaker.

Production of voiceless retroflex /ʈ/

With respect to the CAS speaker, the pattern of /ʈ/ production was similar across trials. Figures 6a and 6b show the three repetitions of /ʈ/ in the word /aʈʈa/. Tongue front and posterior tongue body image was not prominent in all repetition of CAS. But in the normal speaker all the three divisions were prominent and there was greater consistency across the trials.

Figure 7 shows that the CAS speaker showed tongue height and advancement similar to the normal speaker, but depression in the posterior tongue body was not seen in the CAS speaker. It seems that the CAS speaker may be trying to produce the target speech sound through a compensatory articulation movement.

Tongue curvature location and curvature degree of /k/ and /ʈ/

Quantitative measurements of curvature location and curvature degree for both the normal and the CAS speaker are shown in Table 1.

Figure 8 shows the maximal curvature location and the degree it is reduced in the case of the CAS speaker as compared to the normal speaker. Especially the degree of curvature is reduced. Tongue contour on /k/ was highest for the normal speaker (showing the highest curvature location and degree) followed by /ʈ/ as produced by the normal speaker. As discussed by Ménard, et al. [18] higher curvature degree and lower curvature location is indicative of the posterior peak that does not occur in the velar sound /k/ produced by the control subject. But /ʈ/ shows anterior constriction (lower curvature degree and higher curvature location). This type of classification is not possible in the CAS speaker productions because both the location and degree values were similar throughout for that speaker.

Discussion and Conclusion

The present study aimed to explore the articulatory dynamics

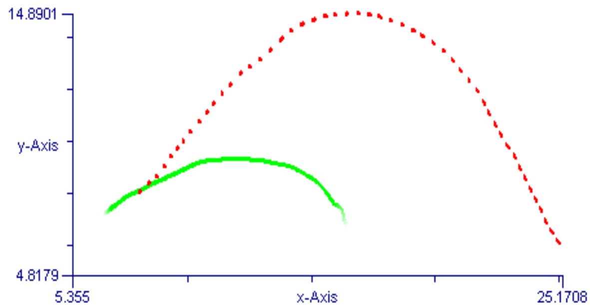

Figure 5: Comparison of tongue contour between the CAS and the normal speaker for the production of /akka/ (Green and red lines indicate tongue contours of the CAS and the normal speaker respectively).

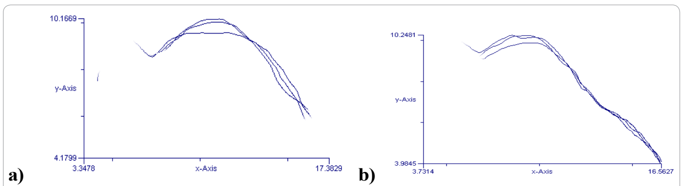

Figure 6: Tongue contours of three repetitions of the consonant dental /ʈ/ from the word /aʈʈa/ produced by a) the CAS speaker and b) the normal speaker.

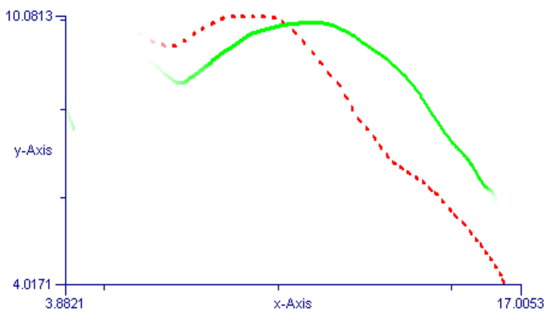

Figure 7: Comparison of tongue contour between the CAS (green line) and the normal speaker (red line) for the production of /aʈʈa/.

Participants-token	Curvature location	Curvature degree
Normal /k/	0.97	0.48
CAS /k/	0.81	0.27
Normal /ʈ/	0.85	0.32
CAS /ʈ/	0.29	0.23

Table 1: Curvature location and curvature degree of tokens produced the CAS and the normal speaker.

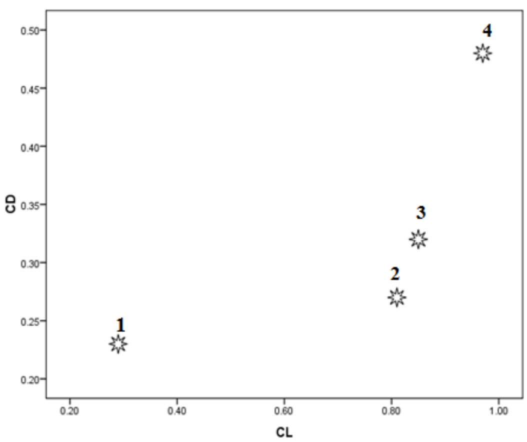

Figure 8: A graphic representation of tongue curvature location (CL) and curvature degree (CD) for the production of (1) /ʈ/ - CAS (2)/k/- CAS, (3) /ʈ/ - normal and (4) /k/-normal.

for different places of articulation comparing a child diagnosed with CAS against a typically developing child. The CAS participant showed more variation (less precise) placement in articulation compared to a typically developing child. Tongue height was reduced and tended to deviate from the targeted place of tongue constriction relative to the palate. The individual diagnosed with CAS especially showed inconsistent tongue contours in certain consonant stops across repetitions. This result indicates that CAS does affect tongue movements that are qualitatively (and quantitatively, i.e., measurably) different from those produced by a typically developing (non-CAS) child. As seen in both velar and retroflex articulation, the CAS participant moves the tongue barely enough to achieve the desired acoustic effects in the speech output.

These results are in agreement with Kocjancic [13]. Where individuals with CAS were found to produce restricted tongue movements when compared to a control group. Some acoustical studies have also found similar results such as prolongations of transitions, steady states, and inter-syllable pauses; slow and inaccurate movements of the articulators; incoordination of voicing with other articulations; initiation difficulties; and errors of selection or sequencing of segments [10,11]. Hence, it is possible to say that CAS speech output varies from typically developing children and the observed and measured variations involve deviated tongue movement.

The present study results support the notion of distorted and compensatory tongue movements in CAS. This information can be useful to developing treatment plans for CAS to resolve articulatory difficulties.

References

1. Darley FL, Aronson AE, Brown JR (1975) Motor speech disorders. Philadelphia: W. B. Saunders.
2. Duffy JR (2005) Motor speech disorders: Substrates, differential diagnosis and management. St. Louis: Mosby
3. McNeil MR, Robin DA, Schmidt RA (2009) Apraxia of speech: Definition, differentiation, and treatment. Clinical management of sensorimotor speech disorders 2: 249-268.
4. Hillis AE, Work M, Barker PB, Jacobs MA, Breese EL, et al. (2004) Re-examining the brain regions crucial for orchestrating speech articulation. Brain 127: 1479-1487.
5. Ogar J, Willock S, Baldo J, Wilkins D, Ludy C, et al. (2006) Clinical and anatomical correlates of apraxia of speech. Brain Lang 97: 343-350.
6. American Speech-Hearing Association (ASHA, 2007).
7. Dent H (1995) The application of electropalatography (EPG) to the remediation of speech disorders in school-aged children and young adults. Eur J Disord Commun 30: 264-277.
8. Carter P, Edwards S (2004) EPG therapy for children with long-standing speech disorders: predictions and outcomes. Clin Linguist Phon 18: 359-372.
9. Byun TM, Hitchcock ER (2012) Investigating the use of traditional and spectral biofeedback approaches to intervention for /r/ misarticulation. Am J Speech Lang Pathol 21: 207-221.
10. Itoh M, Sasanuma S, Tatsumi IF, Murakami S, Fukusako Y, et al. (1982) Voice onset time characteristics in apraxia of speech. Brain Lang 17: 193-210.
11. Kent RD, Rosenbek JC (1983) Acoustic patterns of apraxia of speech. J Speech Hear Res 26: 231-249.
12. Davidson I, Lisa K, Decker PD (2005) Stabilization techniques for ultrasound imaging of speech articulations. Presented at The 149th Meeting of the Acoustical Society of America, Vancouver, Canada.
13. Kocjancic T (2010) Ultrasound and acoustic analysis of lingual movement in teenagers with childhood apraxia of speech, control adults and typically developing children.
14. Deepa M, Savithri SR (2010) Kannada Picture Articulation Test (KPAT). Unpublished dissertation. University of Mysore, India.
15. Karanth P, Suchitra S (2007) Linguistic profile test Kannada (LPT-K). Unpublished dissertation. University of Mysore, India.
16. Mallhi P, Singhi P (1999) Screening young children for delayed development. Indian Pediatr 36: 569-577.
17. Radhika S, Manjula R (2008) Test for verbal praxis in children. Unpublished dissertation. University of Mysore, India.
18. Ménard L, Aubin J, Thibeault M, Richard G (2012) Measuring tongue shapes and positions with ultrasound imaging: A validation experiment using an articulatory model. Folia Phoniatrica et Logopaedica 64: 64-72.