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Speech Intelligibility in Ataxic Dysarthria Due to Lesions in Different Cerebellar Loci

Dr. V. P. Vandana
Dr. R. Manjula

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Abstract

Ataxic dysarthria is caused due to damage to the cerebellum. Articulatory inaccuracy is one of the characteristics of ataxic dysarthria. However not all lesions to the cerebellum affects the articulatory subsystem. In this study we attempted to analyse the speech intelligibility in patients with cerebellar lesions in different loci. A word list in Malayalam was prepared for this purpose and the patients were asked to read the list. This was recorded and later analysed for speech patterns. Very few vowel and consonantal errors were observed in few subjects only of the experimental groups. Errors were mostly seen for the consonants /r/, /ʁ/, /ɻ/ and /ʤ/. No lesion specific trend could be observed based on the findings. The findings throw light on the need for more detailed analysis at the level of narration and discourse sample in this population.

Keywords: Ataxic dysarthria, speech intelligibility

Academic discipline: Speech-Language Pathology

Type of study: Cross sectional standard group comparison design.

Introduction

Dysarthria is a motor speech disorder that results from neurological impairments associated with weakness, slowness, or incoordination of the musculature used to produce speech (Kent, 2000). In dysarthria, the subsystems of speech production mechanism, such as respiratory, phonatory, articulatory, resonatory and prosody are affected to a degree which is dependent on the type of dysarthria. Dysarthria caused due to damage to the cerebellar structure of the brain is called ataxic dysarthria.

Initially, ataxic dysarthria was considered as a homogenous disorder. But the contemporary view is that ataxic dysarthria is not a homogenous disorder. This observation is based on findings which suggest that the areas / loci of the cerebellum have a differential role in speech motor control (Duffy, 1995; Kent et al., 2000). Articulatory inaccuracy is one of the characteristics of ataxic dysarthria, though it may not be seen in all subjects with ataxic dysarthria.

The study aimed:

- To analyse the word intelligibility in subjects with ataxic dysarthria due to lesions in various sites of the cerebellum using auditory-perceptual analysis.
- To compare the results obtained in individuals with ataxic dysarthria against that of normal control group.

Method

Subjects

Experimental Group

Seventeen subjects with ataxic dysarthria due to lesions restricted to various sites in the cerebellum were included in the study. The subjects were selected based on neurological evaluation and diagnosis by a neurologist/ neurosurgeon/ neuro-radiologist. The neurological evaluation was also supported with findings from neuroimaging investigations [(Computerized tomography (CT) & / or magnetic resonance imaging (MRI)].

Control Group

A group of 30 normal control subjects, matched in age and gender to the experimental group were included in the study. This included two control subjects matched to each of the experimental subjects.

Preparation of Word List

A word list was prepared in consultation with a qualified linguist. The word list consisted of eighty six words. A total of 28 words were prepared for testing vowels. Short vowels /a/, /i/, /u/, /e/ and /o/ were tested in the initial (five words), medial (five words) and final (five words) positions. The schwa vowel /ʊ/ is most frequently seen only in word final position and hence stimulus word was prepared with this vowel in the final position. Long

vowels /a:/, /i:/, /u:/, /e:/ and /o:/ occur frequently in the word initial and word medial positions and were tested only in these positions (five words in the initial position and five words in the medial position). Diphthong /ai/ was tested in the initial (one word) and medial (one word) position.

A Word list was also prepared for consonants in the initial position (total twenty-four words) and in the medial position (total twenty-eight words). Consonants do not occur in the final position in Malayalam and hence were tested only in the initial and final position. The consonants tested included bilabial stops (/p/, /p^h/, / b / & /b^h/), bilabial nasal (/m/), voiced labiodental frictionless consonant (/v/), dental stops (/t̪/, /d/, /d^h/ & /t^h/), dental nasal (/n/), alveolar nasal (/ṅ/), alveolar trill (/r/), alveolar flap (/ʀ/), alveolar fricative (/s/), alveolar lateral (/l/), retroflex nasal (/ɳ/), retroflex fricative (/ś/), retroflex lateral approximant (/ɻ/), retroflex lateral (/ɭ/), retroflex stop (/ɖ/), palatal nasal (/ň/), palatal fricative (/ʃ/), palatal affricate (/ʧ/, /ʤ/), palatal continuant (/j/), velar nasal (/ŋ/), velar stops (/k/, /k^h/, /g/ & /g^h/) and glottal fricative (/h/). Words with consonant clusters (/kś/, /t̪r/,/śt/ and /kr/) were also prepared. The syllable structure of the words in the word list were of the following type: vcv, cvcv, cvvc, vvcv, cvcvc, cvvcv, cvccv, vcvcv, vcvccv, vvcvvc, cvcvcv, cvccvc, vcvcvvcv, vccvcvc, cvvcvc, cvcvvcv, cvvcvcvcvc, cvcvcvvcvc and cvcvcvcvcv.

The selected words were also tested for familiarity. The words were written on individual cards and given to twenty adult native speakers of Malayalam. The speakers included for familiarity testing were from different regions in Kerala State and were literate (matriculation to graduation). They rated the words for familiarity based on a 4 - point scale (1= very familiar, 2 = familiar, 3 = not so familiar, 4 = not familiar). A word was retained in the final list only if 85% of the subjects rated it as very familiar. Face validity of the stimuli in the word list was checked by three experienced Speech - Language pathologists. They were asked to rate each of the words based on a binary scale (0 = agree that the word is suitable to test, 1= not agree that the word is suitable to test).

Word Repetition Task

This task was used to test the articulatory performance of the subjects. The most frequently occurring words in Malayalam were chosen by the investigator based on the work by Ghatage (1984). The words in the list served to test eleven vowels, thirty three consonants,

one diphthong and four consonant clusters in Malayalam. The short vowels were tested in the initial, medial and final positions. Long vowels and diphthong were tested only in the initial and medial positions. Consonants and consonant clusters were tested in the initial and medial positions. The words were written in Malayalam on individual cards and were presented to the experimental and control subjects with the instruction to read each word. The words were randomized and presented one at a time. A gap of 40 s was given after the subjects' response, before the next card was presented. The verbal responses of the subjects were recorded using a digital tape recorder.

The speech samples of the experimental and normal control subjects were mixed and randomized based on a random table. The speech samples were then given to three judges for assessment of misarticulations. The experimenter was one among the judges and the other two judges were post graduate students in Speech - language pathology with clinical experience in transcription and analyzing errors based on SODA. International Phonetic Alphabet (Revised Edition, 1994) was used for phonetic transcription of recorded speech material. From the transcribed speech sample sound-by-sound analysis was done in the word-initial, word-medial and word-final positions. Errors in the subjects' response on the given target sound were described as substitutions, omissions, distortions or additions. All the errors identified were of distortion type and hence only a sound-by-sound analysis and error classification based on SODA was used in the study. The results were recorded in the following format as given in Table 1.

Table 1: Format for recording the analyzed speech sample

Target Sound (1)	Stimulus word (2)	Syllable structure of (2) (3)	Subjects' production (4)	Syllable structure of (4) (5)	Error type SODA (6)

The analysis of the transcribed speech sample was carried out as follows

- The syllable structure of the stimulus words and the subjects response was analyzed.
- Distortion errors were not considered for further analysis.

Percent agreement between the first and second judge, second and third judge and first and third judge was calculated using the formula:

$$\% \text{ agreement} = \frac{\text{Total number of sounds in agreement}}{\text{Total number of sounds}}$$

where Total number of sounds = Total number of agreements + total number of disagreements.

The same three judges re - analysed the samples of 5 experimental subjects which were randomly selected after 3 months and responses were recorded. The percent agreement between the first and second judge, second and third judge and first and third judge was calculated again. The findings were similar to that observed in the first analysis.

Results and Discussion

Word Repetition Task

A total of 86 stimuli words were used to test 11 vowels, 1 diphthong, 32 consonants and four consonant clusters. Details are provided in Method section and Appendix 3. Articulation analysis was done only for the experimental groups. Two judges transcribed the data of the subjects using IPA narrow transcription method and the errors were analysed in terms of substitution, omission, distortion and addition. Attempt was also made to analyse phonological processes as per Stoel-Gammon and Dunn (1985) and Lowe (1986, 1994). The processes that were looked into under Syllable-structure processes included:

- Unstressed – Syllable Deletion, Diminutization, Epenthesis, Final-Consonant Deletion, Initial-Consonant Deletion, Cluster reduction

The substitution processes were analysed in terms of:

- Stopping, Deaffrication, Velar Fronting, Backing, Depalatalization, Liquid gliding, Vocalization

Assimilation processes were looked into in terms of:

- Labial Assimilation, Velar Assimilation, Nasal Assimilation, Alveolar Assimilation, Prevocalic voicing

Postvocalic Devoicing

Percent agreement between the first and second judge, second and third judge and first and third judge was calculated using the formula:

$$\% \text{ agreement} = \frac{\text{Total number of sounds in agreement}}{\text{Total number of sounds}}$$

Where Total number of sounds = Total number of agreements + total number of disagreements.

Percent agreement for error analysis between the first and second judge was 95.34%, second and third judge was 89.53 % and between first and third judge was 94.18%. The same three judges re-analysed the samples of 5 experimental subjects after 3 months and responses were recorded and the percent agreement for error analysis between the first and second judge was 91.86%, second and third judge was 88.37% and first and third judge was 91.86%.

A seven-point severity rating scale was adopted for perceptual judgement of sample of narration. The scale was as follows: 1 = normal speech, 2 = mild, 3 = mild to moderate, 4 = moderate, 5 = moderate to severe 6 = severe, 7 = Profound

Ratings of the severity of dysarthria were done by three judges. Severity was rated as mild in all the experimental groups except subject ST (left antero-inferior lesion) and RN (right antero-superior lesion). Severity was rated as mild to moderate in subjects ST and RN.

1 (a) Vowel Error Patterns

Among subjects with left superior para-vermal lesion, no articulation errors were observed except for subject NB who showed breathiness for short vowel /ʌ/. Subjects with left antero-inferior lesions did not show any vowel errors. In subjects with superior vermis lesion, subject MK showed prolongation of /u/ and /o/ in the medial position [/u/ as /u:/ and /o/ as /o:/]. Subject BT, with lesion in the superior vermis showed breathiness associated with all vowels as well as diphthongs. Vowel errors were absent in right superior para-vermal, right postero-superior and right antero-superior subjects. Vowels /ʌ/ and /o/ were associated with breathiness for subject ST, with right superior para-vermal lesion. Less number of vowel

errors may be attributed to the mild severity of dysarthria in most of the experimental subjects.

1 (b) Consonant Error Patterns

With regard to consonants, the nasal sounds were not affected in any of the place of articulation (bilabial, velar, palatal, dental, alveolar, retroflex). Stops were not affected in any of the place of articulation (bilabial, velar, dental and retroflex), for any of the subjects in the experimental group.

Subject TJ, with left superior para-vermal lesion, showed derhotacization of alveolar flap /r/ and alveolar trill /R/ in the initial as well as medial position. Also, there is fronting of retroflex lateral approximant /ɻ/ for this subject. Subjects with left anteroinferior lesion did not show any errors for consonants. The alveolar flap /r/ is derhotacized for subject MK with lesion in the superior vermis. For subject BT with superior vermis lesion, there is derhotacization of /r/ and fronting of /ɻ/. Subject SP with right superior para-vermal lesion showed derhotacization of /r/ and /R/. Subject ST with right superior para-vermal lesion showed fronting of /ɻ/. Subject RN with right anter-osuperior lesions show fronting of retroflex fricative /ś/ and retroflex lateral approximant /ɻ/.

The spatial errors were observed in terms of substitution (S), omission (O), distortion (D) and addition (A) and phonological processes. The results show that substitution, omission and addition errors were not present in any of the dysarthric groups. Also, fronting was the only phonological process that could be identified in the analysis of the samples of experimental subjects. However, it is noticeable that it is seen only in few subjects (TJ, BT, MK, ST & RN) in the experimental group. These subjects had lesions in the left superior para-vermal, superior vermis, left antero-inferior and right antero-superior regions of the cerebellum, respectively. The few articulatory errors may be due to the mild degree of severity of dysarthria in most of the experimental subjects.

Although the errors associated with distortion were very less, based on the complexity of utterance, a pattern was evident from the data. Errors were minimal in all dysarthric groups. Also, there were very few vowel errors when compared to consonantal errors. The consonantal errors were mostly restricted to rhotacization of alveolar flap /r/ and alveolar trill /R/ and fronting of retroflex lateral approximant /ɻ/. The reason that errors were associated

with only these consonants may have to do with the difficulty in production of these sounds in Malayalam language (Syamalakumari, 1972). In the production of the voiced alveolar flap /r/, the tongue touches the alveolar ridge for a single tap. The rest of the tongue is low and during the tap it is laterally contracted. The soft palate is raised and the vocal cord vibrates. During the production of the alveolar trill /R/ in Malayalam, the tongue makes rapid vibrations against the alveolar ridge. The soft palate is raised to prevent the escape of air through the nasal cavity and there is vibration of the vocal cords. For the production of /ɻ/ in Malayalam, the tongue tip is curled back and it reaches towards the palate making a partial closure. The air is let out through the sides as well as over the tongue, with slight friction. The soft palate is raised and the vocal cords vibrate. Considering the fact that slow articulatory movements are a characteristic feature of ataxic dysarthria (Kent and Rosenbek, 1982), and the presumed difficulty in production of /r/, /R/ and /ɻ/ in Malayalam language could have contributed to increased frequency of errors on these consonants than others.

Subjects with ataxic dysarthria associated with diffuse or multifocal lesions demonstrated more errors in the non-initial position of words and substitution errors were more than distortion errors (Odell et al., 1991). In this study, there were very few errors observed in the dysarthric subjects and when present, they were mostly in the medial positions. Zyski and Weisiger (1987) and Zeplin and Kent (1996) observed vowel distortions and imprecise consonants in words of ataxic dysarthric subjects due to diffuse or multifocal lesions. It is noticeable that vowel distortions and consonantal errors were very few and only associated with few of the subjects with lesions restricted to the cerebellum. Out of twenty phonological processes that were looked for in the transcribed data, fronting is the only process that could be identified. The very few vowel and consonant errors in the experimental groups may be because of the mild severity of dysarthria of the experimental subjects. It would have been interesting to see if the trend remained the same with more severe forms of dysarthria. The results obtained for the word repetition task cannot be generalized due to the small sample size.

Conclusion

- Distorted vowels were not a predominant feature in any of the experimental groups.

- ‘Prolonged phonemes’ was present to a mild degree in subjects with right superior para-vermal (RSP), superior vermis (SV) and left superior para-vermal (LSP) lesions.
- Imprecise consonants were not a characteristic feature in subjects with right postero-superior (RPS) and left antero-inferior (LAI) lesions. This feature was rated as mild in all the other experimental groups.
- Irregular articulatory breakdown was not a characteristic feature in any of the experimental groups

Very few vowel and consonantal errors were observed in few subjects only of the experimental groups. Errors were mostly seen for the consonants /r/, /ʀ/, /ɻ/ and /ʤ/. No lesion specific trend could be observed based on the findings

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V. P. Vandana
Assistant Professor of Speech Pathology and Audiology
Department of Speech Pathology and Audiology
National Institute of Mental Health and Neurosciences
Bangalore - 560029
Karnataks
India
vpvandana@gmail.com

Dr. R. Manjula
Professor of Speech Pathology
Department of Speech Pathology
All India Institute of Speech and Hearing
Manasagangothri
Mysore - 570006
Karnataks
India
r_manjula@yahoo.com