DOI: 10.15415/jmrh.2015.12010

Spectral Measures of Loudness in Patients with Ataxic Dysarthria

VANDANA V. P

Assistant Professor of Speech Pathology and Audiology, Department of Speech Pathology and Audiology, National Institute for Mental Health and Neurosciences (NIMHANS), Bangalore, Karnataka

Email: vpvandana@gmail.com

Received: 25 November 2014| Revised: 9 January 2015| Accepted: 9 January 2015

Published online: April 06, 2015

Abstract Dysarthria refers to a group of speech disorders characterized by neuromuscular involvement. This may affect different subsystems of speech like respiration, phonation, articulation and prosody differentially. Ataxic dysarthria is caused due to damage to the cerebellum. Excessive fluctuation in loudness or monoloudness typically characterizes ataxic dysarthria. These characteristics may be different in ataxic dysarthria due to lesions in different cerebellar loci. There is a need to address the spectral measures related to loudness in patients with lesions in different cerebellar loci.Seventeen subjects with ataxic dysarthria due to lesions in different cerebellar loci and matched controls performed an alternating motion rate (AMR) task. The recorded and digitized speech samples were analysed for spectral measures of maximum and minimum intensity. Intensity range was reduced in subjects with left (left superior paravermal, left anteroinferior), superior vermis, right superior paravermal and right anterosuperior lesions compared to normal controls in AMR task. It was comparable to normal controls in subjects with right posterosuperior lesions. Reduced intensity range seems to be because of increase in energy minima and decrease in energy maxima or due to decrease in energy maxima only.

Keywords: Cerebellum, ataxic dysarthria, speech intensity measures

INTRODUCTION

'Dysarthria' refers to a group of speech disorders characterized by disturbance in muscular control due to damage to the central or peripheral nervous system leading to paralysis, paresis, weakness, slowness, incoordination and/or altered tone of speech musculature [1]. Ataxic dysarthria is caused due to damage to the cerebellum [2]. The interesting fact to a Speech - language Pathologist is that ataxic dysarthria is not always reported as a common feature in all subjects with cerebellar lesions. In other words, only certain areas of the cerebellum are speculated to be involved in speech motor control. Symptom clusters, including or excluding ataxic dysarthria are reported by some investigators, depending on the lesion site in the cerebellum [3].

Journal of Multidisciplinary Research in Healthcare
Vol. 1, No. 2
April 2015
pp. 137–142

CHITKARA UNIVERSITY

Vandana, VP

Very few speech tasks are reported as sensitive in identifying characteristics of ataxic dysarthria. The task of diadochokinesis (DDK) was reported to be sensitive in identifying the characteristics of ataxic dysarthria [4]. The clinical evidence in ataxic dysarthria proposed by [1] suggested that although prosodic deviations of excess and equal stress and explosive loudness are reported as cardinal features, they are not evident in all ataxic speakers. This study attempted to investigate the voice dimension, particularly loudness in Malayalam speaking ataxic dysarthric subjects with lesions in different cerebellar loci.

Aims of the study

- To analyse and differentiate spectral measures of loudness in alternating motion rate tasks in subjects with ataxic dysarthria due to lesions in various sites of the cerebellum using acoustic analysis
- To compare the results obtained in individuals with ataxic dysarthria against those of normal control group

Method

Only subjects with specified variety of lesions (tumour) were included. The experimental group included seventeen subjects with ataxic dysarthria. This group included subjects with lesions in left superior paravermal (LSP), left anteroinferior (LAI), superior vermis (SV), right superior paravermal (RSP), right posterosuperior (RPS) and right anterosuperior (RAS) regions of the cerebellum. The control group included thirty number of subjects matched for age and sex of the experimental subjects. A cross sectional standard group comparison research design was used for the study. The speech task (alternating motion rate-AMR) included in the study aimed to analyse the function of spectral measures of loudness.

Material and recording

The subjects in the experimental and control group were instructed to perform the AMR task. The speech samples of the subjects were audio recorded using a digital tape recorder Sony MZ-55.

Analysis

The recorded corpus of speech was subjected to acoustic analysis using energy contour modules in Computerized Speech Lab 4400 (CSL - 4400), Kay Elemetrics software. The experimental subjects were able to produce an average of fourteen syllables in one breath for AMR task. Ten syllables after three seconds from the beginning of repetition were chosen for analysis of speech sample for AMR task [5]. The speech samples of diadochokinetic repetitions of syllables (/p□/, /t□/ & /k□/) were digitized at a sampling rate of 16 KHz. Spectrographic analyses was done using wide band spectrogram using the spectrogram module of CSL - 4400 software.

The energy contour module in CSL - 4400 was used to analyse minimum and maximum intensity values for syllables /p□/, /t□/ & /k□/ in AMR task. The minimum and maximum intensity measures for the syllables /p□/, /t□/, /k□/ were obtained by placing the cursors on the trough of the energy contour for a syllable and then on the corresponding peak for that syllable [6]. These measures were obtained for 10 consecutive syllables for the AMR task. Energy minima (minimum intensity) and energy maxima (maximum intensity) were averaged for each speaker. All the measures were calculated for both the trial.

RESULTS AND DISCUSSION

A. Intensity measures

Reduced amplitude maxima in DDK tasks [4], and variability in amplitude maxima and amplitude minima across a syllable train is reported to be a characteristic feature of ataxic dysarthria [6],[4]. Intensity variations in DDK repetitions (AMR) have been examined less thoroughly than temporal characteristics of DDK in ataxic dysarthric subjects.

The measure of minimum and maximum intensity measures for the syllables /p□/, /t□/, /k□/ (AMR) were obtained by placing the cursors on the trough of the energy contour for a syllable (for minimum intensity) and then on the corresponding peak (for maximum intensity) for that syllable [6]. These measures were obtained for 10 consecutive syllables for the AMR task. Energy minima (minimum intensity) and energy maxima (maximum intensity) were averaged for each speaker.

a) Minimum and maximum intensity for AMR

The minimum intensity, maximum intensity and intensity range for AMR task in AMR task for normal control group (N) and experimental groups are given in Table 1 and Table 2 respectively.

Table 1: *Mean, SD and confidence interval (CI) for normal control subjects (N) for minimum and maximum intensity for /p□/, /t□/ and /k□/ for AMR*

		/p□/			/t□/			/k□/		
N		Mean (dB)	SD	CI	Mean (dB)	SD	CI	Mean (dB)	SD	CI
	Min I0	48.28	14.42	45.21 to 52.03	46.13	18.23	44.11 to 51.07	48.27	19.67	44.56 to 52.83
	Max I0	70.23	18.35	67.01 to 74.82	73.94	15.02	69.81 to 77.56	72.83	13.14	68.02 to 76.01
	I0 range	21.95	15.69	18.15 to 23.76	27.81	16.71	18.03 to 25.97	24.56	16.23	19.13 to 27.89

Table 2: *Mean and SD for minimum and maximum intensity (dB) and intensity range (I0 range) for the experimental groups for /p□/, /t□/ and /k□/ for AMR*

	/p□/		/t□/		/k□/	
Lesion	Mean (dB)	SD	Mean (dB)	SD	Mean (dB)	SD
Minimum intensity (dB)						
LSP	51.49	24.33	*54.95	26.04	*53.10	34.24
LAI	*53.15	22.12	*54.30	18.02	52.03	36.41
SV	*54.28	27.03	*53.28	24.24	*53.82	34.11
RSP	50.61	20.02	*52.28	18.41	51.63	22.33
RPS	48.99	21.52	50.55	24.44	49.05	18.03
RAS	49.03	18.01	48.25	16.33	51.87	21.53
Maximum intensity (dB)						
LSP	*62.93	15.22	*64.80	21.24	*60.31	20.13
LAI	*60.88	16.41	*62.22	14.32	*66.21	24.12
SV	*62.65	18.21	*64.36	21.03	*63.65	28.40
RSP	*66.28	21.12	*65.62	19.42	*66.22	24.44
RPS	69.75	18.13	*68.73	23.14	68.47	26.52
RAS	* 64.80	16.43	*67.93	15.33	*66.20	20.01
I0 range for AMR						
LSP	*11.44	24.33	*9.85	26.04	*7.21	34.24
LAI	*7.73	22.12	*7.92	18.02	*13.58	36.41
SV	*8.37	27.03	*11.08	24.24	*9.83	34.11
RSP	*15.67	20.02	*13.34	18.41	*14.59	22.33
RPS	20.76	21.52	18.18	24.44	19.42	18.03
RAS	*15.75	18.01	19.68	16.33	*14.33	21.53

Intensity range is reduced in subjects with left (left superior paravermal, left anteroinferior), superior vermis and right (right superior paravermal, right anterosuperior) cerebellar lesions. Io range in subjects with posterosuperior lesions is comparable to normal control subjects (Table 2). I0 range of /t□/ for subjects with right anterosuperior lesion is comparable to that of normal control subjects (Table 2). Reduced energy maxima and variable vocal intensity in DDK tasks is reported in individuals with dysarthria [7]. Reduced I0 range for /t□/ and /k□/ in subjects with left superior paravermal lesions, for /p□/ and /t□/ in left anteroinferior lesions, for /p□/, /t□/ and /k□/ in subjects with superior vermis lesions and for /t□/ in subjects

with right superior paravermal lesions is due to higher energy minima and lower energy maxima. The reduced range for /p□/ in subjects with left superior paravermal lesions, /k□/ in subjects with left anteroinferior lesions, /p□/ and /k□/ in subjects with right superior paravermal and right anterosuperior lesions are because of reduced energy maxima (Table 2).

Respiratory insufficiency or dysregulation are often reported in subjects with ataxic dysarthria due to nonfocal cerebellar lesions [4]. According to [4], variability in loudness in DDK task is considered a crucial feature in the diagnosis of ataxic dysarthria due to nonfocal lesions. The reduced Io range due to an increase in energy minima or a decrease in energy maxima or both in subjects with left superior paravermal, left anteroinferior, superior vermis, right superior paravermal and right anterosuperior lesions could be indicative of insufficient respiratory support for maintenance of steady AMR. It may be too early to presume an underlying respiratory cause for these findings as further studies are required in subjects with focal cerebellar lesions.

Variability is high for energy minima of syllable /p□/ in subjects with superior vermis lesion, for syllable /k□/ in subjects with left superior paravermal, left anteroinferior and superior vermis lesions, compared to normal control subjects. [4] opined that increased variability of energy minima could be due to poor coordination of voicing and articulation. It may be presumed that coordination of voicing and articulation is affected in subjects with left superior paravermal, left anteroinferior and superior vermis lesions. Increased variability of energy minima is a characteristic feature of ataxic dysarthria due to nonfocal lesions [4]. The results in Table 2 indicates that increased variability of energy minima is a characteristic feature of subjects with left superior paravermal, left anteroinferior and superior vermis lesions, only. Increased variability for energy maxima is associated only with syllable /k□/ and can be seen in all experimental groups (Table 2). Increased variability of energy maxima reflects respiratory instability or dyscoordination. Hence it may be inferred that respiratory dyscoordination is a characteristic feature of subjects with left (left superior paravermal, left anteroinferior), superior vermis and right cerebellar (right superior paravermal, right posterosuperior and right anterosuperior) lesions. The results in Table 2 indicate that tongue back sound (syllable /k□/) shows more variability than tongue blade or tongue tip sounds for energy maxima.

SUMMARY AND CONCLUSIONS

Intensity range is reduced in subjects with left (left superior paravermal, left anteroinferior), superior vermis, right superior paravermal and right anterosuperior lesions compared to normal controls in AMR task. It is comparable to normal controls in subjects with right posterosuperior lesions. Overall findings indicate that reduced

intensity range seems to be because of increase in energy minima and decrease in energy maxima or due to decrease in energy maxima only.

REFERENCES

[1] Darley, F. L., Aronson, A. E., & Brown, J. R. (1975). Motor Speech disorders. NewYork: W.B.Saunders, Philadelphia.

[2] Duffy, J. R. (1995). Motor Speech disorders. Substrates, differential diagnosis and management., St. Louis: Mosby Publications.

[3] Kent, R. D., Duffy, J. R., Slama , A., Kent, J. F., & Clift, A. (2001). Clinicoanatomic studies in dysarthria. Review, critique and directions for research.Journal of Speech, Language and Hearing Research, 44, 535 – 551. http://dx.doi.org/10.1044/1092-4388(2001/042)

[4] Kent, R. D., Kent, J. F., Duffy, J. R., Thomas, J. E., Weismer, G., and Stuntebeck , S. (2000). Ataxic dysarthria. *Journal of Speech, Language, and Hearing Research*, 43 (5), 1275 -1289. http://dx.doi.org/10.1044/jslhr.4305.1275

[5] Ozawa, Y., Shiromoto, O., Takeuchi, K., &Watamori, T. (1996). The influence of instruction differences on the performance of oral diadochokinesis in normal adults. *Hiroshima Prefectural College of Health Sciences*, Hiroshima, Japan.

[6] Kent, R. D., Duffy, J., Kent, J. F., Vorperian, H. K., & Thomas, J. E. (1999). Quantification of motor speech abilities in stroke: Time-energy Analyses of syllable and word repetiti*on. Journal of Medical-Speech Language Pathology*, **7** (2), 83-90.

[7] Murdoch,B.E.,Chenery,H.J.,Stokes,P.D.,&Hardcastle,W.J.(1991).Respiratorykinematics in speakers with cerebellar disease. *Journal of Speech and Hearing Research*, **34**, 768-778. http://dx.doi.org/10.1044/jshr.3404.768