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FORMANT CENTRALIZATION RATIO (FCR) - A MEASURE OF SPEECH INTELLIGIBILITY IN DYSARTHRIA?

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ABSTRACT

Acoustics analysis plays a prominent role in the measurement of speech intelligibility of dysarthric speech disturbances. Vowels produced by speakers exhibiting the dysarthria associated with Stroke are characterized by abnormalities

that can be detected at the perceptual, physiological, and acoustical levels of analysis.

Vowel space area (VSA) refers to the two-dimensional area bounded by lines connecting first and second formant frequency coordinates (F1/F2) of vowels. The present study aimed to determine the vowel space area functions VSA or the F1-F2 (Formant Centralization Ratio (FCR3) among the individuals with dysarthria and normal population. The main objective of the study was to document the formants (F1, F2, F3) among individuals with dysarthria (5 Males & 5 Females) and typical adults ((15 Males and 15 Females) between the ages 18 to 40 years.

The phonation samples of phonemes /a/,/i/,/u/ were obtained with a high quality condenser microphone at a distance of 12cm away from the mouth. The stimuli were further analyzed with Praat software. The frequencies of the first three formants were used to extract the function of Vowel Space area. The frequency values were used to create vowel quadrilateral plots, including F1-F2, F1-F3. FCR3 is the inverse of vowel articulation index (VAI3) deduced with the formula which was given by Sapir, Ramig, Spielman and Fox in 2010.

Formant Centralization Ratio (FCR3) = (F2u + F2a +F1i +F1u) ÷ (F2i + F1a).

Results suggested that there was significant difference of Formant values of phoneme /i/ between the groups. Formant frequencies (F1 & F2) of phoneme /i/

correlates with the height and advancement of the tongue in the production of the vowel. Other formant values were not significant.

1) INTRODUCTION

Acoustics analysis plays a prominent role in the assessment and treatment of dysarthric speech disturbances. As the acoustic signal provides the physical link between speech production and the perception of speech, many studies of dysarthria speech have focused on this aspect of the communication process in attempts to define speech production events (**Weismer,1984**). Vowels produced by speakers exhibiting the dysarthria associated with Stroke are characterized by abnormalities that can be detected at the perceptual, physiological, and acoustical levels of analysis. Perceptually, vowels are considered to be distorted, which is hypothesized to be the result of physiological deficits such as weakness in orofacial structures (i.e., especially the tongue) and/or reductions in the range and speed of articulatory movements **(Cha & Patten, 1989; Darley, Aronson, & Brown, 1975; DePaul & Brooks, 1994; Hirose, Kiritani, & Sawashima,** 1982). Vowel space area (VSA) refers to the two-dimensional area bounded by lines connecting first and second formant frequency coordinates (F1/F2) of vowels. Vowel space area (VSA) is an attractive metric for the study of speech production deficits and reductions in intelligibility. The mean F1/F2 value for each of the four

corner vowels is used to compute the area of the quadrilateral formed by the corner vowels. Since frequencies of the first and second formants roughly relate to the size and shape of the cavities created by jaw opening (F1) and tongue position (F2), the VSA is an acoustic proxy for the kinematic displacements of the articulators.

2) AIM

The present concern of the study is to determine the vowel space area functions VSA or the F1-F2 (Formant Centralization Ratio (FCR3) among the individuals with dysarthria and normal population.

3) OBJECTIVE

1) To document the formants (F1, F2, F3) among individuals with dysarthria and who doesn't have any speech language and hearing problems.

4) METHOD

Participants:

A total of 30 recordings were obtained from participants between the ages 18 to 40 years (15 Males and 15 Females) and 10 recordings were obtained from dysarthria population (5 males and 5 females).

DYSARTHRIA PARTICIPANTS	MEDICAL DIAGNOSIS
PARTICIPANT 1	Left basal Ganglia bleed
PARTICIPANT 2	Putamin bleed
PTICIPANT 3	Right MCA patchy infarct
PARTICIPANT 4	Left Basal Ganglia Bleed
PARTICIPANT 5	Left Pontaine acute infarct
PARTICIPANT 6	Acute infarct in posterior limb of right internal capsule
PARTICIPANT 7	
PARTICIPANT 8	Infarct involving right part of Pons
PARTICIPANT 9	Pontine Bleed
PARTICIPANT 10	Left corona radiate infarct

5) INCLUSIVE CRITERIA

- Control participants reported no history of neurological disease and passed a hearing screening or reported adequate hearing.
- Speakers with neurological diagnoses whose intelligibility or speech severity are being checked Frenchey dysarthria assessment (FDA) and passed a hearing screening or reported adequate hearing.
- Majority of the participants were spastic and much less of flaccid type.

6) EXCLUSIVE CRITERIA

- Patients in acute stage of recovery were excluded.
- None of the speakers wore hearing aids.

7) INSTRUMENT

The participants were instructed properly and the responses were recorded in a high quality condenser microphone with a distance of 5 cm away from the mouth. The recordings are further stored and analyzed in **praat6041_win64.zip** version.

8) PROCEDURE

The present study was carried out in a tertiary neuro-rehabilitation super speciality hospital and from the institution. Informed consent was taken from each participant/guardians. Upon the referral from neurologists for speech – language therapy, each participants were administered with patients were tested Frenchey Dysarthria assessment to check for the severity.The subjects phonated the vowels /a/,/i/,/u/ and recorded ina high quality condenser microphone with a distance of 5 cm away from the mouth.The stimuli were further analyzed with praat software. . The frequencies of the first 3 formants were used for the extraction of the Vowel Space area.

The frequency values were used to:

• Create vowel quadrilateral plots, including F1-F2, F1-F3.

- **Formant Centralization Ratio (FCR3) (Sapir, Ramig, Spielman & Fox, 2010).**

FCR3 = (F2u + F2a +F1i +F1u) ÷ (F2i + F1a)

Note: FCR3 is the inverse of vowel articulation index (VAI3).

The study mainly concerned on the extraction of one of the function of vowel space area which is **Formant Centralization Ratio (FCR3) (Sapir, Ramig, Spielman & Fox, 2010).**

The frequency values are of first 3 formants were measured in the **SPSS software and R software** for the statistical values.

9) RESULTS AND DISCUSSION

Results suggested that there was significant difference of Formant values of phoneme /i/ between the groups. Formant frequencies (F1 & F2) of phoneme /i/ correlates with the height and advancement of the tongue in the production of the vowel. Other formant values were not significant. Formant Centralization Ratio (FCR3) was significantly different with a statistical significance level of 0.11 between the groups in Independent samples Mann Whitney U test. It was a preliminary attempt in the study to correlate perceptual ratings of Speech Intelligibility with acoustic measurements. Perceptually, vowels are considered to be distorted, which is hypothesized to be the result of physiological deficits such as weakness in orofacial structures (i.e., especially the tongue) and/or reductions in the range and speed of articulatory movements and acoustically correlated with Formant Centralization Ratios.

10) Key words: Formant Analysis, Formant Centralization Ratios, Dysarthria, Stroke and Speech 2 & 3, Internee 4, Assistant Professor

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