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FORMANT PARAMETERS FOR TONGUE POSITION IN /R/ TRILL DYSARTHRIA THERAPY

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Abstract

This research aims to further research in determining the formant parameters for tongue position in pronouncing phoneme /r/ trill correctly for people with dysarthria. Observation method was used in collecting data in the form of consonant and vowel sounds from 4 dysarthria samples and 4 non-dysarthria samples. The data were analyzed by using equivalent intralingual method. The result showed that dysarthria samples were found to have tongue position lower and more back compared to non-dysarthria samples. This condition caused difficulty for the tip of the tongue of dysarthria samples to reach the alveolar—the place of which the phoneme /r/ trill is produced. Based on the condition, formant range needed as parameter for people with dysarthria to estimate whether they have placed their tip of the tongue correctly during the therapy. Further, the range of formants proposed was F1 (height of tongue) at an average of 480 Hz and F2-F1 (backness of tongue) at an average of 1.651 Hz.

Keywords: a*coustic features*; f*ormants*; Dysarthria; *therapy*; *phonemes /r/ trill*

1. Introduction

Personal performance is still an important aspect to complete one's insight and skills. This is proven by the global public's interest in improving their appearance, aesthetics and vocals in order to give a decent and professional impression. Starting from this phenomenon, dysarthria began to receive public attention. Based on an initial interview of people with dysarthria, it was found that they often obtain minor obstacles that interfere with the sufferers' performance. Some of the obstacles faced are lack of self-confidence when speaking in public (Kifriyani, 2020), difficulty of the interlocutor in understanding what the sufferers was saying, and immediate fatigue of the tongue when speaking loudly for a long time. Even though these obstacles do not significantly reduce the sufferers' performance, dysarthria causes sufferers to require more preparation before performing compared to people without dysarthria. Thus, it is important to find a therapy method based on acoustic analysis, since it could target the problems more accurately and shorten the healing duration.

Dysarthria is actually a disorder of the nervous system that could affect the performance of the articulator muscles. Therefore, dysarthria causes speech disorders. In Indonesia particularly, the inability to produce phoneme /r/ trill is considered a symptom of

dysarthria. The sufferers of /r/ trill dysarthria usually substituted the phoneme with other phonemes such as /l/ or /rkh/ (Matondang, 2019; Andriyana, 2020; Sundoro, 2020). In Indonesia, dysarthria is generally known as incorrect production of the phoneme /r/. In fact, dysarthria is not limited to the phoneme /r/, but could also occur in the production of other phonemes such as /t/, /l/, /s/, /d/, and many more. However, cases of phoneme /r/ dysarthria are most common in Indonesia. This is because the type of phoneme /r/ in Indonesian Language is the alveolar trill [r] which requires the most flexibility of the tongue to vibrate continuously for a long duration compared to other types of /r/ phonemes, such as tap [ɾ], approximant [ɹ], as well as non-rhotic [ʊ].

This research aims to further research in determining the difference of tongue ability in reaching alveolar between people with dysarthria and people without dysarthria before proposing the formant range needed to position tongue correctly during pronouncing phoneme /r/ trill. The initial research entitled Acoustic Features of Phonemes as Therapy Reference for Dysarthria Disorders: The Case of /r/ Alveolar Trill found that:

1. Factors that influence a person's inability to produce the phoneme /r/ alveolar trill could be detected by observing the acoustic features—formant—of other consonant phonemes that involve the same articulators as the phoneme /r/ alveolar trill production (Putri, 2021; Putri, 2023).
2. If the part of the articulator where a phoneme is produced has a problem, then the problem will also occur in all the phonemes produced in that articulator. Thus, therapy could be carried out by improving the pronunciation of the easiest phonemes (not involving much tongue movement) to the most difficult phonemes (involving complex tongue movements) produced at the articulator (Putri, 2021; Putri, 2023).
3. The flexibility of the tongue, the thickness of the tongue cord, and the distance between the tip of the tongue to the alveolar greatly influence the success in pronouncing the phoneme /r/ trill. So, the flexibility of the tongue must often be trained by pronouncing vowel phonemes such as /a/, /i/, /u/, /e/, /o/, /ə/ and bringing the tip of the tongue closer to the alveolar part (Putri, 2021).
4. The /e/ phoneme is the most neutral vowel phoneme that could be used to maintain the distance between the tip of the tongue and the alveolar when practicing the pronunciation of the /r/ trill phoneme. Practicing to pronounce /r/ trill by pronouncing /re/ and /ere/ will be easier compared to combining /r/ trill with other vowel phonemes (Putri, 2021).

With the discovery regarding the production of phoneme /r/ trill, the next part to be investigated is the formant parameters for tongue position to help the sufferers estimate the correct position of the tongue during the phoneme /r/ trill production.

The position of the tongue during the production of a phoneme could be determined by measuring the formant value. Formant is a broad peak in the spectrum of a sound wave that results from a resonance in the vocal tract. The value of formant 1 (F1) indicates the height of the tongue and the difference value between formant 2 and formant 1 (F2-F1) indicates the backness of the tongue (Ladefoged, 2011). The higher the value of the F1, the lower the tongue position. The higher the value of F2-F1, the more front the tongue position. Further, the intersection points between F1 and F2-F1 of a phoneme should be projected on formant table to find out the position of tongue when pronouncing the phoneme.

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Based on the method proposed by Ladefoged (2011), the differences of projections between people with dysarthria and people without dysarthria were observed to investigate the ability of the tongue to reach the alveolar (place of which phoneme /r/ trill is produced). After understanding the differences of tongue ability in reaching alveolar, the formant parameters to pronounce phoneme /r/ trill correctly was determined. Therefore, this research intended 2 problems, namely 1) How does the position of the tongue differ between people with dysarthria and people without dysarthria? 2) What range of formants is needed so that the tongue position of a dysarthria sufferer is more accurate when pronouncing the phoneme /r/ trill?

2. Literature Review

Dysarthria are closely related to language acquisition in childhood. Based on research by Miasari (2015) and Slamet (2017), it was stated that at the age of 6 years, children should have acquired and been able to produce the /r/ trill sound well. Miasari (2015) who analyzed phonemes and syllables in Indonesian language acquisition of toddlers aged 4-5 years, found that children aged 4-5 years still had a tendency to change the phoneme /r/ to /l/, /y/, and /ŋ/. However, Slamet (2017) that discussed the acquisition of Indonesian phonemes in children aged 4-6 years, it was found that children in the 4-6 years had mastered the vowels [a, i, I, ə, e, ɛ, o, O, u, U] and inhibitory consonants [p,b,t,d,k,g,ʔ], nasal [m,n,ŋ,ň] , fricative [s,h], affricative [c,j], lateral [l], trill [r], and semivocoid [w,y]. Hence, children who could not produce /r/ trill after the age of 6 years tend to experience /r/ trill dysarthria. Further, if children are not able to produce a sound well by the time they reach adulthood, then the children have a small chance of being able to master that sound throughout their life. The information was used to determine the age range of sample for the current study.

Leaving aside the types of dysarthria that are caused by abnormalities in the brain's nerves, humans' articulators consist of muscle tissues that have flexible and adaptable characteristics. The condition manages to consider therapy as one of solutions to minimize dysarthria. Therefore, efforts to minimize dysarthria are important things to develop, considering dysarthria itself could cause certain obstacles that affect the sufferers' performance.

Researches about the factors that influence the occurrence of dysarthria or the speech patterns of dysarthria sufferers have been widely discussed. One of those was research conducted by Matondang's (2019) that aims to investigate cases of children who experience dysarthria through psychological and neurological perspectives. In the research, it was stated that the speech disorder of a 27 years old young adult could be influenced by psychological factors derived from the environment and the innate factors when he was 2-3 years old. Besides, Matondang added that short tongue could also cause dysarthria. The samples of Matondang's research were mostly substituted phoneme /r/ into phoneme /l/, or simply omit it.

Other research by Sundoro (2019) stated that dysarthria is a phonetic language disorder that causes sufferers to experience a decrease in their level of self-confidence. The research aims to determine speech patterns and causes of dysarthria in adolescents. The results showed that head injury and short tongue were the causes of articulation failure in people with a dysarthria. By knowing phonemic speech patterns and the causes of dysarthria, it is possible to help the communication with dysarthria sufferers. Apart from

that, knowledge about dysarthria could increase insight for other people so that they do not give negative assumptions to people with dysarthria.

There also special case depicted by Andriyana (2020) that focused on the dysarthria experienced by informants, namely Aden Eka Pradana and Ilham Maulana Irsyad. The results showed that individual condition regarding tongue position during speech production might differentiate the pronunciation of phoneme /r/. The first participant produced an aspiration sound and the second participant produced a retroflex sound. Based on this information, the current research refused to measure the /e/ formant of syllable /re/ uttered by people with dysarthria, since the phoneme /r/ produced would not be the phoneme /r/ trill. Merely people without dysarthria would give the measurement of F1 and F2-F1 of /e/ from syllable /re/.

Putri (2021) who conducted Acoustic Features of Phonemes as Therapy Reference for Dysarthria Disorders: The Case of /r/ Alveolar Trill states that if the part of the articulator where a phoneme is produced has a problem, then the problem will also occur in all the phonemes produced in that articulator. Thus, therapy could be carried out by improving the pronunciation of the easiest phonemes (not involving much tongue movement) to the most difficult phonemes (involving complex tongue movements) produced at the articulator. Further, the /e/ phoneme is the most neutral vowel phoneme that could be used to maintain the distance between the tip of the tongue and the alveolar when practicing the pronunciation of the /r/ trill phoneme. Practicing to pronounce /r/ trill by pronouncing /re/ and /ere/ will be easier compared to combining /r/ trill with other vowel phonemes.

Based on the researches above, it could be said that the most cause of dysarthria was a condition in which the tip of the tongue could not reach the alveolar correctly (short tongue). Therefore, this research focuses on finding the difference of tongue position between dysarthria and non-dysarthria people in reaching alveolar before proposing formant parameters for tongue position in /r/ trill dysarthria therapy.

3. Research Method

This research was designed using a descriptive qualitative approach with field methods. A descriptive qualitative approach is used to provide as much space as possible for researchers to describe the correlation of each variable (Arikunto, 2006). The stages in this research include (1) sampling process, (2) data collection, and (3) data analysis. This research was conducted at the Language Laboratory of Warmadewa University using the observation method to collect data in the form of consonant and vowel phonemes. The observation method is a method used by researchers to collect data by observing the discourse spoken by informants or printed in the text (Sudaryanto, 2015). In this research, the observation method was carried out using listening and recording techniques by tapping the speech of 8 samples sequentially with recorder. The samples were selected by purposive sampling with the following criteria.

1. Four people who suffer from /r/ trill dysarthria and four people who do not suffer from /r/ trill dysarthria. The dysarthria samples consisted of two men and two women, as did the non-dysarthria samples.
2. The eight samples are in the age range of 20-30 years. In this age range, the samples have passed the golden period of language acquisition (Miasari, 2015; Slamet, 2017) and is considered mature to be cooperative during the data collection process. The samples

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must have complete speech organs and not be suffering from influenza, asthma or cough. This aims to maintain clarity of pronunciation and avoid bias caused by lung capacity.

3. Samples must live in lowland areas to avoid air pressure bias in the lung, considering that atmospheric air pressure where person live could affect the air pressure in their lungs (Putri, 2015). Areas with lower altitudes cause higher air pressure in human lungs, while areas with higher altitudes cause lower air pressure in human lungs (Putri, 2015).

These criteria were actually given by Ayatrohaedi (2002) with several modifications in terms of sample size, age range, and concepts related to the influence of atmospheric air pressure on air pressure in human lungs.

The data source for this research were syllables obtained from eight samples. The syllables then go through a segmentation stage to obtain data in the form of consonant and vowel phonemes. The segmentation process is carried out through PRAAT (Boersma, 2024) before going through the analysis stage.

In analyzing the differences of formant values produced by dysarthria and non-dysarthria samples, the intralingual equivalent method was used which was assisted by differential comparison techniques (Sudaryanto, 2015). Through these methods and techniques, different linguistic phenomena could be properly observed based on the formant differences.

4. Results and Discussion

4.1 Tongue Position Comparation between People with Dysarthria and People without Dysarthria

In comparing tongue position between people with dysarthria and people without dysarthria, this research used the phoneme /e/ as a companion to the consonant phonemes, since the phoneme /e/ is categorized as a middle front vowel phoneme. This means that the tongue position when producing the phoneme /e/ is in the middle of the oral cavity with the tip of the tongue positioned slightly forward. This position is considered neutral for comparing how front and high the tongue is when pronouncing the accompanied consonant sounds.

By knowing the tongue position when producing the phoneme /e/, the ability of tongue in reaching alveolar could be estimated. In this research, phoneme /e/ was measured along with some alveolar consonant phonemes, namely /d/, /t/, and /z/ since the consonants shared place of articulation with /r/ trill. The reason for not using phoneme /e/ with phoneme /r/ trill to compare the tongue position was people with dysarthria could not produce phoneme /r/ trill correctly. To get fair comparisons of tongue positions between people with dysarthria and people without dysarthria, the comparison used phonemes that shared the same place of articulation with phoneme /r/ trill. Below were the tabulations of the F1 value and F2-F1 value of the phoneme /e/ which came from the syllables /de/, /te/, and /ze/.

PHONEME /e/	FORMANT 1 (Hz)		FORMANT 2- FORMANT 1 (Hz)	
	DYSARTHRIA	NORMAL	DYSARTHRIA	NORMAL
SAMPLE 1	482	461	1.584	2.110
SAMPLE 2	386	401	1.689	1.969
SAMPLE 3	468	465	2.115	1.713
SAMPLE 4	385	360	1.810	1.801
AVERAGE	**430**	**422**	**1.800**	**1.898**

Table 1. Height and Backness of Tongue during the Production of Phoneme /e/ in Syllable /de/

Based on Table 1, it could be seen that the F1 average of the phoneme /e/ produced by dysarthria samples was found to be higher than that produced by non-dysarthria samples. It meant that the tongue position of the dysarthria samples when producing the phoneme /e/ in the syllable /de/ was lower than the tongue position of the non-dysarthria samples. Then, based on the F2-F1 average, it could be seen that the position of the tongue of the non-dysarthria samples was more front than that of the dysarthria samples since the F2-F1 average of the phoneme /e/ in the syllable /de/ by the non-dysarthria samples was found to be higher.

FONEM /e/	FORMANT 1 (Hz)		FORMANT 2- FORMANT 1 (Hz)	
	DYSARTHRIA	NORMAL	DYSARTHRIA	NORMAL
SAMPLE 1	544	481	1.783	1.881
SAMPLE 2	433	435	1.567	1.913
SAMPLE 3	467	460	1.815	1.822
SAMPLE 4	407	377	1.974	1.772
AVERAGE	**463**	**438**	**1.785**	**1.847**

Table 2. Height and Backness of Tongue during the Production of Phoneme /e/ in Syllable /te/

Based on Table 2, it could be seen that the F1 average of the phoneme /e/ produced by dysarthria samples was found to be higher than that produced by non-dysarthria samples. It meant that the tongue position of the dysarthria samples when producing the phoneme /e/ in the syllable /te/ was lower than the tongue position of the non-dysarthria samples. Then, based on the F2-F1 average, it could be seen that the position of the tongue of the non-dysarthria samples was more front than that of the dysarthria samples since the F2-F1 average of the phoneme /e/ in the syllable /te/ by the non-dysarthria samples was found to be higher. Therfore, People with dysarthria found to have tongue position lower and more back compared to sample without dysarthria.

PHONEME /z/	FORMANT 1 (Hz)		FORMANT 2- FORMANT 1 (Hz)	
	DYSARTHRIA	NORMAL	DYSARTHRIA	NORMAL
SAMPLE 1	432	425	1.729	1.805
SAMPLE 2	437	427	1.502	1.911
SAMPLE 3	442	453	2.034	1.543
SAMPLE 4	389	371	1.968	1.696
AVERAGE	**425**	**419**	**1.808**	**1.739**

Table 3. Height and Backness of Tongue during the Production of Phoneme /e/ in Syllable /ze/

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Based on Table 3, it could be seen that the F1 average of the phoneme /e/ produced by dysarthria samples was found to be higher than that produced by non-dysarthria samples. It meant that the tongue position of the dysarthria samples when producing the phoneme /e/ in the syllable /ze/ was lower than the tongue position of the non-dysarthria samples. Then, based on the F2-F1 average, it could be seen that the position of the tongue of the non-dysarthria samples was more back than that of the dysarthria samples since the F2-F1 average of the phoneme /e/ in the syllable /ze/ by the non-dysarthria samples was found to be lower.

After observing the comparison of formant data, it could be said that the dysarthria samples tended to have lower and more back tongue positions when producing the three syllables. Considering that the alveolar part is located in the front-upper part of the oral cavity, the position of the tongue which tends to be low and back during the pronunciation of the phoneme /e/ indeed would make it difficult to produce the phoneme /r/.

4.2 Ideal Formants Range

In finding the formant parameters of the phoneme /r/ trill production, the height and back of the tongue were measured merely from samples without dysarthria when they pronouncing the phoneme /r/ trill. The reason was dysarthria samples could not produced the phoneme /r/ trill correctly. The measurement results were listed in Table 4.

PHONEME /e/	FORMANT 1 (Hz)	FORMANT 2- FORMANT 1 (Hz)
	NORMAL	NORMAL
SAMPLE 1	528	1.519
SAMPLE 2	440	1.812
SAMPLE 3	544	1.657
SAMPLE 4	406	1.614
AVERAGE	**480**	**1.651**

Table 4. Height and Backness of Tongue during the Production of Phoneme /e/ in Syllable /re/

Based on Tabel 4, the range of formants needed to position the tongue more accurately when pronouncing the phoneme /r/ trill was F1 (height of tongue) in range of 406 Hz – 544 Hz or at an average of 480 Hz. Further, the F2-F1 (backness of tongue) was in range of 1.519 Hz – 1.812 Hz or at an average of 1.651 Hz. These indicated that people with dysarthria could produce better /r/ trill phoneme if they could achieve the formants' ranges. Achieving the ranges or averages meant placing the tongue more accurately.

5. Conclusion

The study found that individuals with dysarthria exhibited lower and more posterior tongue positions compared to those without dysarthria. To address these challenges in therapy, specific formant ranges were identified as targets for improving the pronunciation of the phoneme /r/ trill. The suggested parameters are F1 (tongue height) within the range of 406 Hz to 544 Hz, with an average of 480 Hz, and F2-F1 (tongue backness) within the range of 1.519 Hz to 1.812 Hz, with an average of 1.651 Hz. Therapeutic exercises could involve frequent practice of phonemes such as /re/ and /ere/ (Putri, 2021) to help

individuals with dysarthria achieve these formant values, thereby improving their ability to produce the /r/ trill phoneme accurately.

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