

Perceptual Perception Study of Fricative Consonants

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Abstract : Fricative Sounds have an important role in the perception of speech sounds. Besides its common articulatory characteristics the frequency of the fricative sounds at large, are dependent on certain other matters, such as affrication, voicing, palatalizing, fronting, etc. The central focus of the present study is to investigate the role of the fricatives in different frame structure of the vowels.

Keywords: Fricative sound, Speech sounds, palatalizing, affrication

1. Theoretical framework

On the basis of a number of studies of the American and European linguists, propose that fricative sounds have the following functions in the perception of speech:

- i. resonant frequency of the circuit is variable
- ii. bandwidth values are different
- iii. consistent pattern of responses is obtained with isolated stimuli.

The present study has some limitation with the previous works. It is reasonable to expect that the identification of a fricative consonant is dependent not only on the formant transitions of the adjacent vowel or vowels and on the intensity of the fricative relative to that of the vowel. In order to examine the role of these cues, a stimuli consisting of syllables has been prepared.

1.1 Review of the Literature

a. History of the present study

For the last fifty years in Europe and the United States, linguists have studied how the vowel sounds affect the cues of fricatives.

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Before all the research work started on fricatives, Fletcher in his monumental work "Speech and Hearing" (1965), studied in short the different aspects of fricative sounds. His study mainly based on the articulatory and acoustic aspects of fricatives. He mentioned about the cut-off frequency and the pitch levels of these consonants.

Heinz and Stevens (1961, p. 590) studied the properties of voiceless fricative sounds. They took the following voiceless fricatives: f s θ ð & r. They investigated mainly the acoustical properties of fricatives and tried to measure the frequency levels of these sounds and gave some hints on the synthetic and perception of fricatives.

Peter Strevens (1960, p. 34) of Edinburgh, dealt with the spectra of fricative noise in human speech. He also took the voiceless fricatives for the experiment and described the results of the spectrographic analysis. His article is different than Stevens and Heinz, and described in details the different acoustical properties of fricatives with charts and figures.

In 1956, Hughes and Halle carried out research on the spectral properties of fricative consonants.

In 1957 and 1958, K. Harris published two articles on "Some acoustic cues for the fricative consonants", and "Cues for the discrimination of American English Fricatives in spoken syllables."

b. Related Studies

Recently some of the linguists like Fischer-Jorgensen (1954), Halle-Hughes-Rodley (1957), Fujimura, Delattre, Ladefoged (1968), Fairbanks, etc. also studies the acoustical properties of the stops and nasals, with the same intention in mind, i.e. like the study of the different aspects of the fricatives.

The objective of the present study reported below is to investigate the perceptual side, the fricatives as pronounced by the native male, female, as well as foreign speakers in general, in contextual environment.

For the present purpose, the method which has been followed, may be described as below:

Firstly, the most common types of fricatives are taken. These are: f, v, s, z, θ, ð.

Secondly, the following context has been followed for the perceptual perception study (pl. see Appendix A (I)).

Thirdly, seven out of eight cardinal vowels are taken in the above contextual test.

First Method: Informants were chosen from the educated and moderately educated classes to compare their utterance and frequency of speech.

Second Method: Second method followed with the pronunciation of the fricatives in contextual by the native male and female speakers.

Third Method: Last method is based on the comparative study of the fricatives in isolation, as pronounced by both the native and foreign speakers.

1.2 Method

a. Subjects : A total of five speakers were selected for the study, four males and one female between the ages of 22 and 28 years.

b. Equipment: The experiment was conducted in one of the underground rooms in Totem Park residence and electrical engineering department. U.B.C. Among the apparatus was the tape recorder (Grundig TK...) and Sonograph, manufactured by the key Electric Company. The stimulus presentation was recorded by the tape and then is was transferred to the sonograph for result. It was marked by a stylus on the plain paper, which was designed for the sonographic use to get the time, intensity, etc. The paper was moved by a chart mover at 625 cm. per second.

c. Procedure : Prior to commencing the experiment, a pilot study was run in order to refine the procedure and work out any difficulties with the technical aspects of apparatus,

Before the recording started, a total view of the experiment was given to the speakers and at the same time they undergone for the short rehearsal. A small gap of duration of five seconds was maintained in between the two words and sounds.

d. Other : At the time of recording one speaker was allowed to stay in the recording room, with the belief that individual pronunciation may influence the other, which can make them conscious.

e. Recording Procedure: For the present purpose Grundig TK was used. Much care was taken about the voltage and frequency characteristics of the electric power.

Before the recording the magnetic head was checked for accurate result. The recording was done in the full track.

Speed: Much care was taken in speed for two reasons. First, it determines how much recording can be obtained on one track from the beginning to the end of the tape. Second, it determines the quality of the recording, the faster the speed, the higher the fidelity. For the above reasons we taped at 7 1/2 ips, and it is around 50-20,000 cycles per second.

Recording time: Voices of all the speakers were not recorded at the same time, with the intention that different frequencies may be obtained at different times. So, the recording took place in the morning, noon and the evening.

Magnetic tape: High-Fid. Magnetic tape was chosen for the present recording. The quality was determined by the material out of which the backing was made, the thickness of the backing, and the oxide coating. The most common thickness are 1.5 mils (0.0015 inch), 1 mil (extra or long play), and 0.5 mil (double play). Our safest choice was 1.5 mils. The description of the tape, which was used for the present recording, may be noted below:

Scotch, magnetic tape, 1/4 inch × 1200 feet, (6.35 mm × 360 m), silicone lubricated, 1.5 mil tenzar-backing.

Recording procedure: Good recording is dependable not only on the quality tape and tape recorder, but also on the recording procedure. So, much care was taken at the time of recording.

First choice came to control the volume. Precaution was taken to avoid echoes. For the purpose one of the underground rooms in Totem was chosen for recording. There was no internal noise, produced by the machine. External noise was avoided at the time of recording.

Microphone placement: The microphone was placed 8 inches from the speaker's mouth and about 4 to 6 inches down. It was possible to avoid strong aspiration as puffs or pops.

1.3 Results

Results perceived from the present experiment are shown with charts and figures in the next column and the rest at the end of the article in Appendix A and B. It may be mentioned here that though the experiment was made in a very short time, but the response was not so poor. Different charts and figures will prove it.

1.4 Discussion

Fricative consonants are produced by a narrowing of the air passage which produces a frictional or rubbing noise as the air passes through the tiny opening formed by the articulatory organ. These noise may be more or less audible according to the force of articulation and often almost disappears especially in the voiced types.

During the point of closure and /or opening the vocal folds may or may not vibrate. If it vibrates the resulting sound will be voiced; if they do not the sound will be voiceless fricative. Voiceless fricatives are all produced by turbulent air-flows caused by a constriction in the vocal tract at some point in or above the larynx the constriction, area of constriction, and shape of orifice. The sounds are those commonly referred to by the following symbols and articulatory labels:

Voiceless:	f	(Labio-dental);	θ	(dental);
	s	(alveolar);	ʃ	(palato-alveolar)
Voiced:	v	(bilabial);	z	(alveolar);
	ʒ	(alveopalatal);	ð	(dental).

It may be mentioned here that [s] and [z] consonants are sometimes referred to as sibilants – a terminology based on their acoustic impression which, in turn, is due to the difference in frequency which distinguishes them.

The resonator features are on the whole independent of the source features. The resonator features of the fricatives may be described as the level of speech production as follows:

Very narrow passage for the air stream at an obstructed region of the mouth or the pharynx.

Spectra of voiced fricatives can display the whole formant pattern. A fricative produced with a supra-glottal noise source is recognized by a

high-frequency noise area in the spectrum. Compared with an unvoiced vowel-like sound of a similar articulation, the fricative spectrum displays a larger high-frequency emphasis.

1.5 Introduction:

Already it has been mentioned that seven cardinal vowels have been taken for the present experiment. (i, e, æ, ə, o, u). It is known that all vowel colours are mainly characterized by the frequency of two formants. It is given here those two frequencies in cycles per second for an average male voice with a fundamental frequency of 120 cycles per second. However, the formants of a woman's voice may be 10 to 15 percent higher.

i	...	2500	ə	...	900
		300			550
e	...	2100	o	...	800
		400			400
a	...	1100	u	...	900
		750			300

The typical fricative is a noise sound, the spectral energy of which is largely contained in formants from cavities in front of the articulatory narrowing.

Second method: result

We followed the context of seven cardinal vowels and the common type of fricatives for the present work. Three subjects were taken from the English-speaking Canadians.

It has been noticed that the seven Cardinal vowels which are taken in the consonantal position, have important roles for the quality of fricatives. It is quite distinct that the (i) open vowels like æ ə a, and have more length than the close vowels; and the vowels have more length before the voiced fricatives than the unvoiced class.

The position of the constriction in the vocal tract is the chief reason of differences of sound quality in fricatives. The organs of articulation concerned in the production of the fricatives and their positions in the vocal tract at which the constriction occurs, are as follows:

- [f] : In the production of [f] the lower lip is against the upper teeth, that is, air continues to pass between the lower teeth and upper lip.
- [v] : In the production of [v] the lower lip is against the upper teeth.
- [θ] : In the production of [θ] the tip of the tongue is between the teeth.
- [ð] : In the production of [ð] the tip of the tongue is between the teeth.
- [s] : In the production of [s] the sides of the tongue are against the tooth ridge. The front of the tongue forms a small groove in order to focus the air stream against the tooth ridge and the upper teeth.
- [z] : The position of the tongue is the same as in [s].
- [ʃ] : In the production of [ʃ] the tip of the tongue is very close to the tooth ridge and the middle of the tongue is close to the palate; the tongue is grooved and the tips are pushed outward. The teeth are close together.
- [ʒ] : The position of the tongue is the same as in [z].

It is quite distinct from the articulatory points of view that the tongue and the lip are important for the production of fricatives. Where the differences of tongue and lip positions are great, the acoustic qualities of these sounds are easily obtainable. We can say about the formation of S, that there exist many varieties of S differing in the quality of the hiss or the degree of its penetrating power, which cause the acoustic quality of S due to the slight change in the adjustment of the tongue.

1.6 Formant frequency

We can quote Ladefoged to denote the meaning of formant, "The regions of the spectrum in which the frequency components are relatively large (i.e. the regions around the peaks) are known as formants (p.92). To measure the formant frequencies of the relative fricatives in our context, we have followed the rule proposed by Ilse Lehiste. It can be safely said that the formant frequencies depend on three factors: the position of the point of maximum constriction in the vocal tract; the size or cross-sectional area of the maximum constriction; and the position of the lips. In the case of the fricative sounds the constriction of the lips and tongue within the vocal tract is very important. In the first place due to lip rounding, there is formed a large resonating chamber in the front part of the mouth. So, the

measurement of the varying frequencies in the first two formants have given more importance than the measurement of the other formants.

FIV and VIF : In case of FIV and VIF the highest frequency is observed for FIV as the frequency of l is higher before the voiced fricatives. There is no difference in between the initial and final fricatives.

S æ z and S æ θ : The frequency of these words are almost the same, except in the dialectical variations of s and S.

θ θ δ and θ θ δ : In the first place the frequency of θ θ δ is smaller than θ θ δ. This may be due to the [θ] vowel, as it is very weak in the medial position.

VUF and FUV : The frequency range is variable in the above two contexts. Though both the words have the same vowel range, but the frequency varied due to the different constriction in the mouth cavity. VUF has more frequency than FUV.

zos and soz : The lip rounding is the same for [o], but the frequency varied due to the release of air for [z] in zos.

1.7 Comment

It can be said safely that though the three subjects pronounced the same words, but the result was different due to the following reasons:

- a. Frequency of words mainly dependable on the individual articulatory system, as the articulatory system plays a great role in the acoustic cues.
- b. The colour of frequency dependable at large on the pitch aspect, so if the speakers use the pitch in their own way, normally the frequency will not be the same. So, dialectical variation plays a discrete role in pitch.
- c. It is known that vowel burst plays a great role in the consonant, so when the subjects use different stimulus, there are different constriction in the mouth cavities, which causes the variations of frequency in the different formants.
- d. In case of vowel burst we can easily compare the English with Spanish vowels. There are only five vowels (i, e, a, o, u) in Spanish ... so for the Spanish Canadians, the range of the frequency of the vowels will be different in comparison with English speakers, whose vowels cover more area than the English-speaking Spanish Canadians.

So, we can say that the frequency of speech is dependable not only on the acoustic cues but also on the speaker's own articulatory system, which has a close link with pitch, quality, tempo, etc.

Third method result : This method followed to measure the frequency of the fricatives as pronounced in isolation by a native and a non-native speaker. It has been observed from their pronunciation that though the Canadian English is different that the British or American English, it has more tendency towards the American way of pronunciation. We can mention here about the fondness for /ə/ in Canadian and American English, as in the words like 'din ə r', 'mist ə r', 'wils ə n', 'ə n' (æ), etc.

The subjects for this experiment, pronounced the fricatives in their own way, without any prejudice. To show the basic differences, a chart of the frequency of occurrence of fricatives are given here.

Canadian		German
s	7.47	6.80
z	4.90	3.67
y	4.61	
h	3.26	1.90
v	3.17	3.88
f	2.86	3.94
θ	0.97	
ʃ	0.88	1.93
ʒ	0.16	

It is quite distinct here that personal way of pronouncing the sounds causes the variation in the frequency ranges due to the constriction in the vocal cavities. Both the Canadian and the German alveolar (s) has the maximum frequency, but in the case of lowest frequency they don't have any concordance. In German glottal (h), and in Canadian English alveopalatal (ʒ) has the minimum frequency. The difference of the frequency scale may be checked in the synthetic language, either of proper training in articulatory phonetics or changing the fundamental frequency.

It may be said that a consonant is not a stationary position, it is a movement (Fant et al, p.5). The outstanding contribution of acoustic

phonetic research in the last few years has been to show that consonants, unlike vowels, are largely perceived by rapid frequency changes in the shape and volume of the vocal tract cavities, which in turn are produced by articulatory movements of the tongue, lips, jaws, etc. The main difference in the frequencies of the English and German speakers are due to the tongue, lips and jaw movements, as they are different in the two languages. So, the frequency of the sounds in isolation is dependable on the physiological activities of vocal tracts. Of course, it is not possible here to show the movements of different articulators by pictures, as we don't have any facilities for motion picture x-rays (Fischer, P42).

1.8 Conclusion

In this work the perceptual perception study of the fricatives, both in isolation and contextual, is reviewed, and it is shown how the frequency of the spectra varies in different environment. The data presented here are almost the identical with the previous results except the present method which is slightly different.

1.9 Future research possibilities

Though some works are being made to recognize the acoustic elements of the fricative sounds, still there are enough scope for the perceptual perception study of these sounds from different angles. Different researchers can carry on some work on the affrication, palatalization, etc. that may cause the change of the frequency of the different fricatives. It is possible to think that sometime the allophonic distributions of different phonemes may cause the frequency change in the spectrograph for the parameters. There is another possibility to think about. Among the most productive articulators is the tongue tip, it is used at least for over half of all the consonants in English (ð, θ, s, z, ʃ, ʒ, ts, dz, t, d, n, l, r). The point of articulation of apical consonants are therefore very important in creating the characteristic auditory impression of a language. So, in the case of the production of some of the fricative sounds, the tip of tongue is very important. A research work can be carried out after showing the contribution of this articulator, what is known as 'frontal resonance', comparing the frequencies of the different formants.

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