EXPLORATION ON ACOUSTIC SOUND PATTERN

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ABSTRACT

The present paper proposed a methodology of acoustic sound pattern in the experimental analysis of tones, vowels, and consonants which include plosives, fricatives and nasalance analysis in human languages.

Keywords: acoustic sound pattern, tone pattern, vowel pattern, plosive pattern, fricative pattern, nasalance analysis

1. FRAME AND PATTERN

The speech sounds is different from sex, age, physique, disposition, mood, custom, status, stylistics as well as some other kinds of factors. However, so long as the people speak the same language, they can understand each other. What is the mystery? ‘The words stem from my mouth, enter your ear’. Although each syllable or tone is not so correct or standard, the sound can be understood through brain's synthesis processing of analysis, memory, comparison and so on, if the ‘frame’ of the sound is similar to each other. This ‘frame’ is called ‘pattern’. [17]

The sound pattern in the same language is relative stable. In this way it is able to exchange the information mutually between different speakers. Thus our task of sound analysis is to explore and discover the systematic relations between sounds in each language. Sound Pattern is the quantitative analysis and the statistical graphical representation of the relations among the sounds in a system by phonetic experiments. A pattern is a visible system.

Sound pattern generally includes vowel pattern, consonant pattern, intonation pattern and so on. Tone languages such as Chinese will also have tone pattern. The acoustic analysis of Chinese sound pattern started from tone pattern.

2. TONE PATTERN ANALYSIS

Tone pattern is the pattern constituted by all citation tones of a language or dialect. Generalized tone pattern should include the tone performance in bi-syllable and multi-syllable, which are dynamic analysis of tones. Sound pattern of single tone is a static analysis. It is the basic form of tone research. And it is the initial station inspecting each kind of tone change.

Obtaining the mean value of each measuring point of all citation tones by one speaker through phonetic experiment, 9 measuring points are taken for each tone for example. Then we can carry on the analysis of normalization with T value formula [8]:

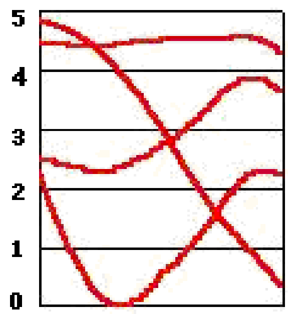
$$T = [(\lg x - \lg min) / (\lg max - \lg min)] \times 5 \quad (1)$$

Max is the maximum of mean values of all measuring points, making the top line of the tone register. Min is the minimum, the baseline of tone register. X refers to each mean value of the points. Common logarithm is used to make the hertz unit of pitch close to the features of human hearing. The result is multiplied by 5 to suit the five degrees of tone letters. Simplified formula may also be used: [11] p.114

$$T = [(x - min) / (max - min)] \times 5 \quad (2)$$

Figure 1 is the tone pattern chart of Beijing Mandarin based on T value. The systematic characteristics and relative relations of tones are visible in it. It enhances the comparability between different speakers and speakers in different places.

Figure 1: Tone pattern of Beijing Mandarin.

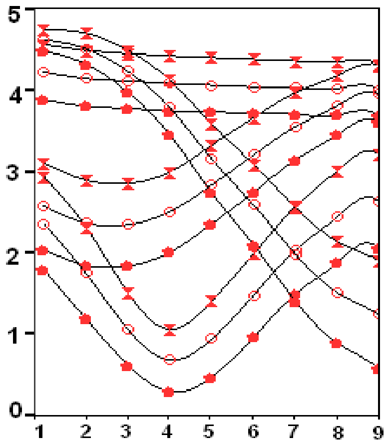


As for a statistical analysis of big sample, appropriate readjustment in the original T value formula is needed. T value formula suits the big sample is as follows:

$$T = \{[\lg x - \lg(min - SDmin)] / [\lg(max + SDmax) - \lg(min - SDmin)]\} \times 5 \quad (3)$$

Compared with the original T value formula, the new formula changes the minimum value (min) as (min-SDmin), namely the minimum value of mean values in various measuring points subtracts the standard deviation of all data of this spot; Maximum value (max) is changed as (max+SDmax) in the same way. The original formula suits single sample data processing. While the adjusted formula suits multiple sample data processing. The main distribution of the data by 52 speakers of Beijing Mandarin is shown in Figure 2. [16]

Figure 2: Main Distribution of tones in Beijing Mandarin.



3. VOWEL PATTERN ANALYSIS

Vowel pattern is the systematic performance of vowels. The nuclear vowels are of the most importance in vowel pattern. The nuclear vowels may have different kinds of relation in syllables. The vowels of first-level, or basic vowels, are in the monophthong syllables; those of second-level are the ones with onset; those of third-level are the ones with coda; the fourth-level vowels are those with both onset and coda. [9] The vowel pattern is based on the acoustic vowel chart. (Figure 3)

Figure 3: Formant chart of basic vowels in Mandarin.

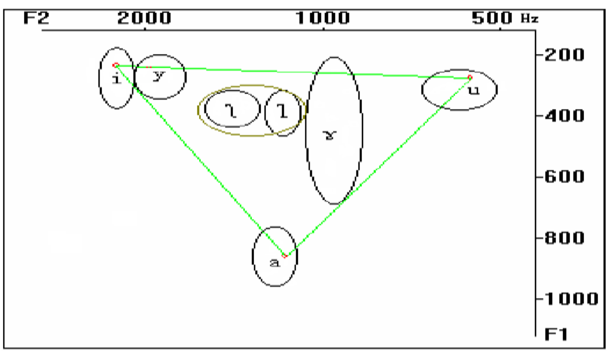
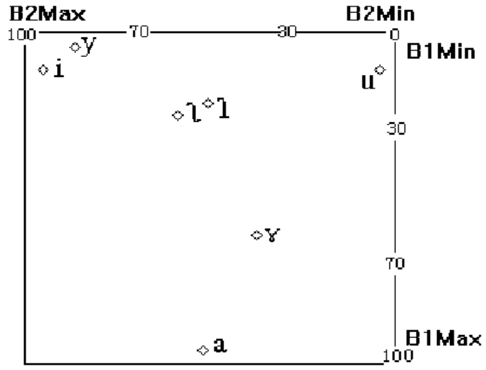


Figure 4: Vowel pattern of base vowels in Mandarin.



The formant frequency value are transformed into the Bark value first in the V value formula as follows [13]:

$$V1=\frac{B1x-B1min}{B1max-B1min}\times 100 \qquad V2=\frac{B2x-B2min}{B2max-B2min}\times 100 \qquad \text{(4) and (5)}$$

V1 is the relative value of F1, V2 is the relative value of F2. Like the T value formula in the above, B1 is refer to the Bark value of F1, and B2 to F2. The main idea of V value computation is consistent with T value of tone. In this way, the individuality of different person is downplays. The systematic features of the vowels are visible in the pattern chart as in Figure 4.

For the statistical analysis of vowels, being the same with the tonal statistical analysis, some appropriate readjustments of the original V value formula are needed as follows:

$$V1=\frac{B1x-(B1min-SD1min)}{(B1max+SD1max)-(B1min-SD1min)}$$

$$V2=\frac{B2x-(B2min-SD2min)}{(B2max+SD2max)-(B2min-SD2min)} \qquad \text{(6) and (7)}$$

Figure 5 shows the basic vowels in 26 kinds of languages in the world. The distribution of vowel /i/ is the smallest, making the basic point of vowel articulation. The vowel /a/ increases in the height; while vowel /u/ in the front-back dimension. [14]

Figure 5: The pattern of basic vowels in 26 languages.

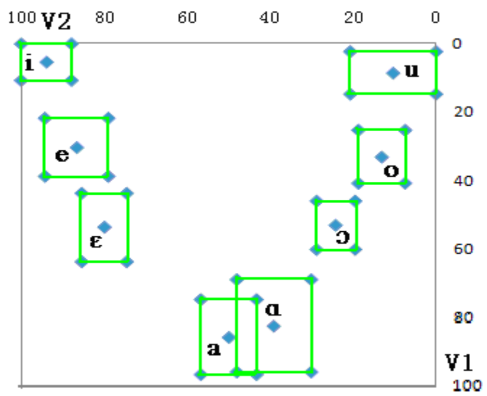
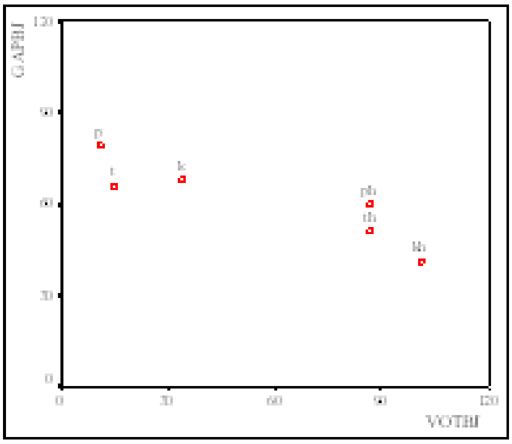


Figure 6: Plosive initial pattern chart of Beijing Mandarin.



4. CONSONANT PATTERN ANALYSIS

The pronunciation of vowels and tones are continuous, while consonants are in divergent. According to different series and categories in consonant research, different sub-patterns for each kind of consonant series are needed. For example, the plosive pattern, the fricative pattern, as well as the contrast between nasals and approximants, etc. The analysis of consonant pattern began from the plosives.

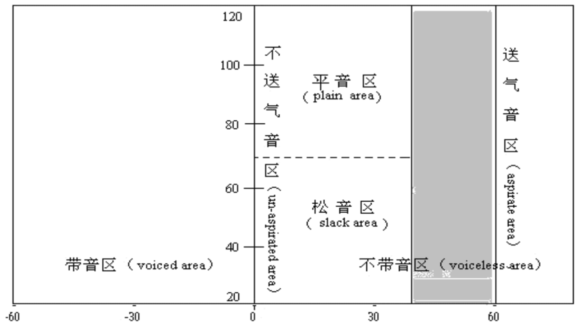
4.1. Plosive pattern

The closure duration (GAP) is the important acoustic feature of plosive. The voice onset time (VOT) refers to the relative time relations between the eruption of plosive and vibrating of the vocal cord, which is an effective parameter to discriminate categories of plosive. It is a simple and convenient method to construct a plosive acoustic space with VOT and GAP as coordinates. Figure 6 is a pattern of the plosive initials in Beijing Mandarin.

On plosive pattern chart, the ordinate axis (GAP) expresses the degree of muscle tense and the characteristics of elasticizing of pronunciation. The abscissa axis (VOT) expresses the attribute of the way of plosive pronunciation, such as voicing and aspiration. Different categories of plosive can be discriminated in the chart.

We can observe the distribution characteristics of each kind of plosive in different languages in the plosive pattern. Based on analysis of various languages, we can get the reference chart of plosive distribution region as Figure 7. Each kind of plosive distributes respectively in certain area theoretically in this chart. [12]

Figure 7: Distribution chart of categories in plosive space.



4.2. Fricative pattern

Fricative is a common category of consonant. It has 12 kinds of articulation position in Chinese dialects [6]. [15] used two parameters of center of gravity and dispersion to construct the fricative acoustic space.

The following formula is used in the process of normalization of frequency gravity center:

$$G = (Gx-Gmin) / (Gmax-Gmin) * 100 \qquad (8)$$

The form and method of the normalization of dispersion degree is the same as the above formula. We can see from the fricative pattern chart of Beijing Mandarin (Figure 8) that the dispersion degree of /h/[x] is the biggest, and its frequency gravity is the lowest.

Figure 8: Fricative pattern of Beijing Mandarin.

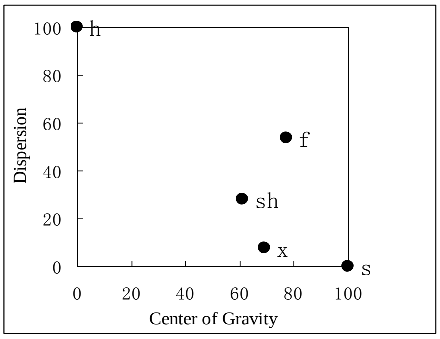
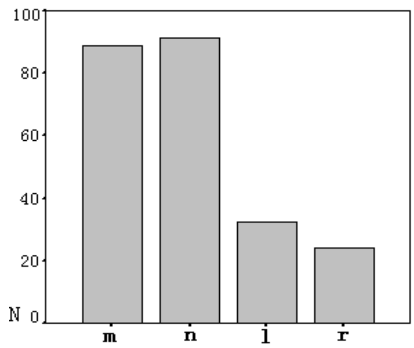


Figure 9: Nasalance of approximant initials in Mandarin.



The dispersion degree of /s/ is the smallest, and the frequency gravity center is the highest. The two sounds occupy the two apex position of the pattern chart, which determine the scope of the fricative pattern chart. Other plosives are within this scope. The fricative pattern has promulgated the acoustic characteristics and contrast relations of different fricatives respectively. [7]

4.3. Nasalance analysis

Nasalance with Nasometer is the nasalization degree when pronunciation. It is the proportion the nasal energy occupies in the entire oral and nasal acoustic energy. The formula is as below:

$$N = 100 \times n / (n + o) \quad (9)$$

The letter 'n' refers to the nasal acoustic energy, and 'o' the oral acoustic energy.

Nasalance analysis is not only for nasal sounds. There is different degree of nasalization in vowel and approximants. The bigger the nasalization contrast is, the more obvious the difference between the nasals and the non-nasals is. Approximant initials in Beijing Mandarin have a high degree of nasalization contrast according to the experiment. (refer to Figure 9). Evolution of nasals is an important issue in the historical study of Chinese sounds. The confusion of nasals and laterals in some dialects is because of the increasing nasalance of the laterals.

5. CONCLUSION

More and more linguistic conclusions are drawn from the strict experimental process and statistical analysis. The systematic and social characteristics of language may be manifest and confirmed in the statistical analysis. Modern linguistics is the study of data. The data is the quantification of materials. The analysis of sound pattern has provided the theoretical method and foundation for how to obtain and process the data. We should enhance the ability in understanding and processing linguistic data.

6. REFERENCES

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