The Airflow and Air Pressure Model of [Pa] In Mandarin

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Abstract: On basis of MATLAB programming language, this paper adopts the method of experimental phonetics, in mandarin Chinese plosive (pa) as the research object, with 20 pronunciation (10 male female) corpus as experimental basis, designs and implements the breathing air flow signal and pressure signal analysis program, through the same gender painted the same signal is fold, including air flow signals mainly focus on left side, about air pressure signal is divided into two parts, further draw a picture of each type of signal average chart.The average graph of each part was used to find 20 points to match the curve. The least square fitting of the line (polynomial fifth-order fitting) and sin function were used to fit the curve respectively, to establish the flow and pressure model of stop [pa]. Through analysis and comparison, the polynomial fifth-order fitting model was selected as the optimal fitting model.

1. Introduction

"The study of phonological physiology has always been an important aspect of linguistic research, because the study of phonological physiological mechanism is the theoretical basis of phonetics [1]."The production of speech is a complicatedly physiological process: The instructions from the language center are expressed as nerve impulses, which direct the muscles of the vocal organs to produce movement, and finally produce the language that we can understand through the changes of air pressure, the adjustment of glottis and acoustic resonance system [2]. In the pronunciation process of mandarin Chinese, air flow and air pressure have a crucial influence on the production of pronunciation. In mandarin Chinese, consonant analysis is a foundation, and understanding the characteristics of consonants in mandarin can provide reference and reference for the phonetic acoustic analysis of a large number of Chinese dialects [3]. From the perspective of application, the results of in-depth experimental analysis of mandarin consonants can provide data for phonetic teaching, phonetic engineering, and application of phonetic technology, as support and reference for these studies. Secondly, the experimental analysis of Chinese blocking consonants is also based on the analysis of other types of consonants. Understanding the characteristics of blocking consonants will be more beneficial to the analysis of other consonants. Finally, speech aerodynamics research began in the 1950s, air flow, air pressure were opened to consonant research and discussion, in terms of basic theory and application study in foreign countries are system and in-depth, Draper (1959) first studied the speech event and breathing, the lung volume changes in voice and domestic air dynamics research later, Yonghong Li (2015) writed a paper of An aerodynamic study on articulation of Mandarin initials, Journal of Chinese linguistics.In this paper [4], MATLAB is used to analyze and match the parameters extracted from the air flow signal and air pressure signal, so as to better master the pronunciation process of stop sound, and lay a foundation for the study of other consonants, which is of great significance for the promotion of mandarin Chinese.

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2. Collection and processing of corpus signals

The collected corpus is obtained by a physiological phonetics instrument, the airflow barometer, which can independently collect airflow signal and pressure signal and display the overlapping drawing of four channels, namely, speech signal, airflow signal, pressure signal and three signals, as shown in figure 1.The air pressure signals collected by this instrument are stored by default in the format of. NSP.

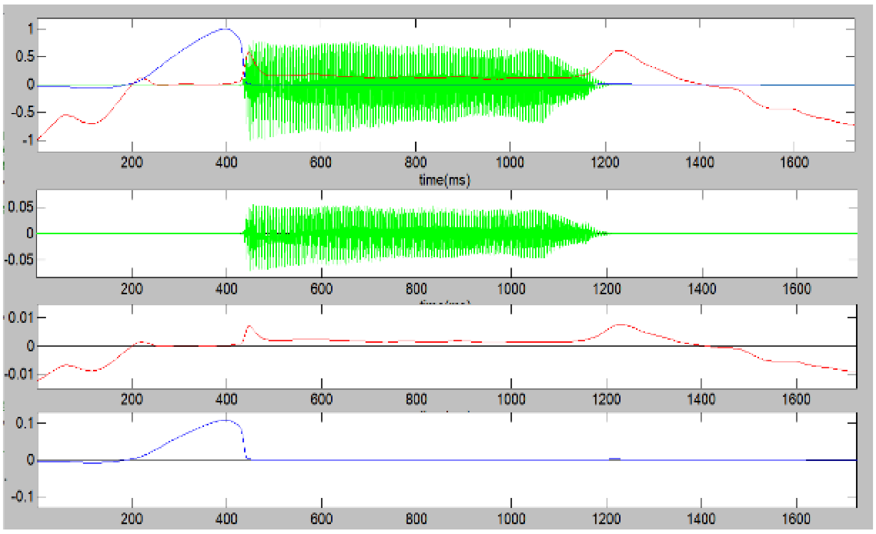

Figure 1. Respiratory signal analysis system diagram

3. Airflow signal modeling

Based on MATLAB platform design and implementation of airflow signal analysis procedures. All signals can be divided into two groups of men and women, because men and women in a vocal cord vibration frequency is different, the girl the high frequency range of 220-1.1 kHz, bass frequency range of 200-700 kHz, male, the high frequency range is 160-523 kHz bass is 80-358 Hz frequency range, and there are differences between the male and female within the oral cavity, too, so will vary in gas flow [5].

3.1 Cutting phonetic

Collected each corpus for plosive [pa] repeat five times the signal (10 men, each list five corpora, male corpus, a total of 50, ditto female corpora, a total of 50), will be after corpus, each flow signals are extracted, airflow after is the key cut signal the beginning and end position, the position in the pressure signal is coming to an end, ended in air flow leveling off signal, this paper concerns as the airflow signal peaks as the boundary of the left hemisphere, the signal more representative, is advantageous for the experimental observation, extract the key features.

3.2 Calculation of curve mean of airflow Signal

MATLAB is used to program the corpus after sound cutting to realize the overlay of airflow signals. Based on the fold after the draw air signal, delete the stack of drawing up and down around 3% each signal [6], in order to ensure the accuracy of the subsequent fitting curve, the same abscissa ordinate points and the mean, to find out the curve of flow signal average figure, as well as the signal flow curve and the average graph, figure 2 shows male and mean flow curve graph and figure 3 shows the mean flow curve and curve, women from figure easy to obtain in the process of voice signal, the female voice volume flow of gas is greater than the male voice.

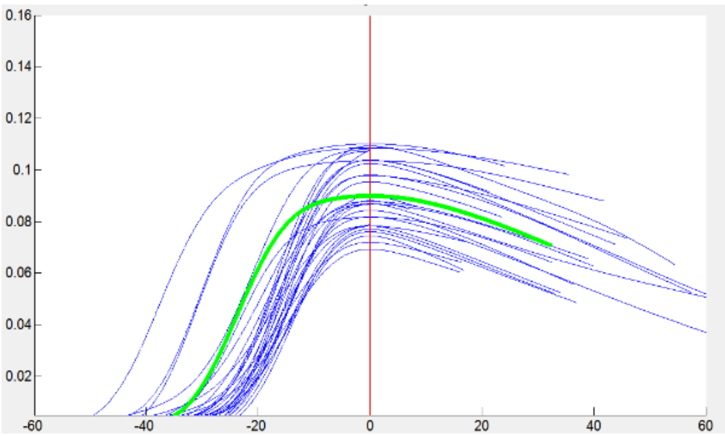

Figure 2. Airflow curve and mean curve (male)

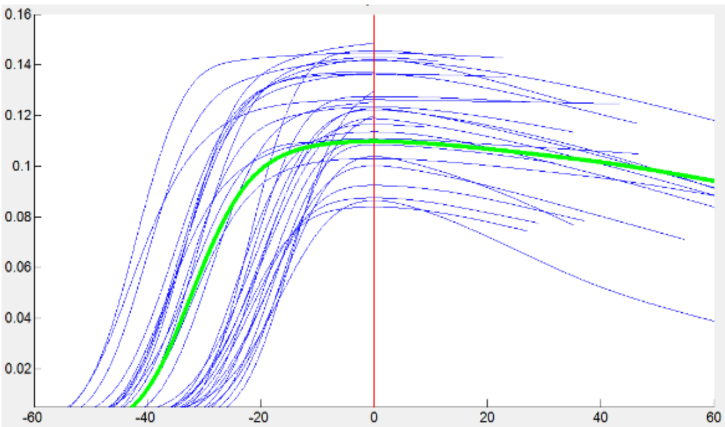

Figure 3. Flow curve and mean curve (female)

3.3 Air flow signal fitting modeling

The left hemisphere of the airflow signal more representative and the characteristic, based on the average curve, left side of the data signals are extracted, and average 20 points, the air flow signal fitting, respectively using the linear least squares fitting (5 order polynomial fitting) and sine function fitting, as shown in figure 4 left said male airflow signal polynomial fitting curve, the right girl said air flow signal polynomial fitting curve, figure 5 left said male airflow signal sine fitting curve, the right girl said air flow signal sine fitting curve, and establish the fitting the equation (1),(2),(3),(4).

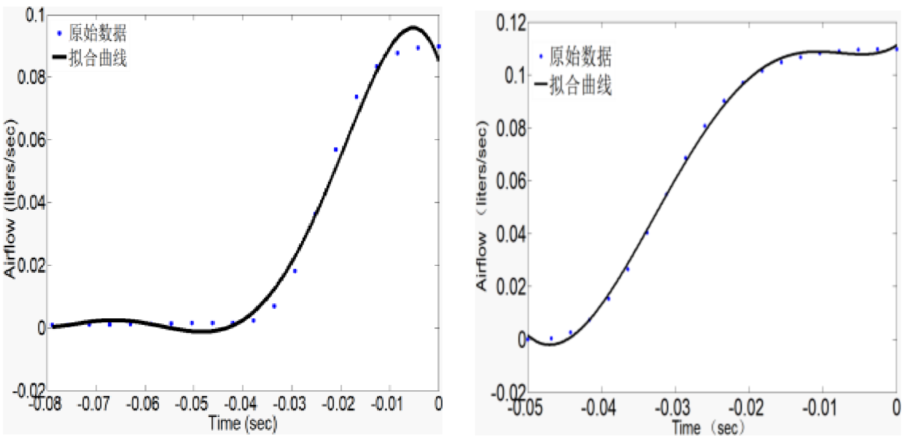

Figure 4. Polynomial fitting (left: male, right: female)

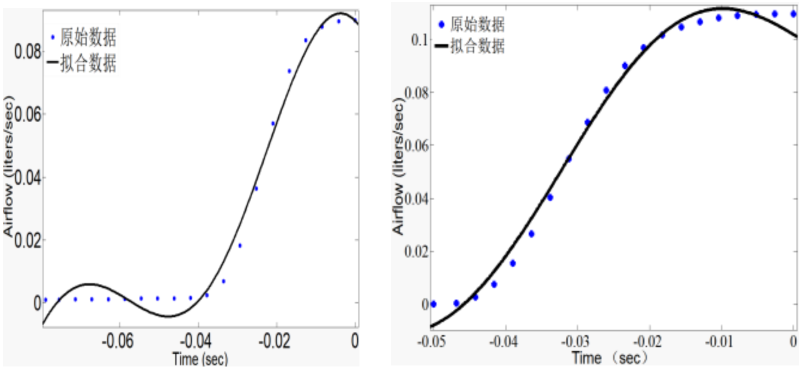

Figure 5. Sum of sin function (left: male, right: female)

Ym1=656220*10.^5-163920*x.^4-14644*x.^3-526.17*x.^2-4.36*x+0.09 (1)

Yw1=1054200*x.^5+267150*x.^4+16737*x.^3+291.57*x.^2+1.73*x+0.11 (2)

Ym2=0.0737*sin(44.35*x+2.579)+0.0539*sin(75.07*x+1.202) (3)

Yw2=0.1007*sin(10.38*x+1.347)+0.0011*sin(45.98*x+1.107) (4)

4. Air pressure signal modeling

4.1 Plotting air pressure signal

MATLAB based design and implementation of the pressure signal overlay program, each signal peak point as zero coordinates, the pressure signal overlay.

4.2 Calculation of curve mean of Air Pressure

Based on the fold after drawing pressure signal, delete the stack of drawing up and down around 3% of the signal, in order to ensure the accuracy of the fitting curve in the future, will be the same all the vertical curve of abscissa point and average, it is concluded that the curve of pressure signal average figure, and the signal of the pressure curve, and average graph, as shown in figure 6, 7, respectively male and female pressure signal curve graph and mean.

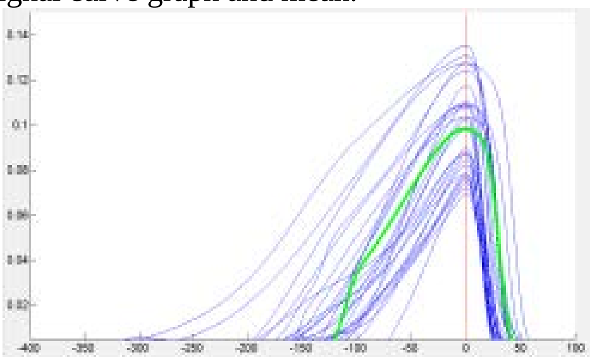

Figure 6. Airflow curve and mean curve (male)

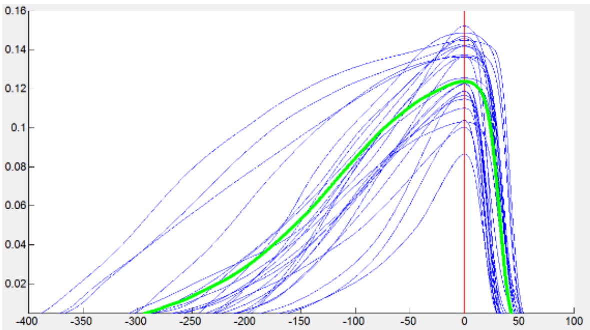

Figure 7. Airflow curve and mean curve (female)

4.3 Air pressure signal fitting modeling

Pressure signal of the left and the right has a strong representative, therefore to zero as the dividing line, analyze the signal and the fitting equation, based on the average curve, data signals are extracted respectively in the left side and the right half of the average 20 points, the pressure signal, respectively, using the linear least squares fitting (5 order polynomial fitting) and sine function fitting method to fit the data, as shown in figure 8 left said male voice signal left part of the polynomial fitting curve, right said male right part of the polynomial fitting curve, pressure signal in figure 9 left said male pressure signal left part of sine fitting curve. The right side represents the sine fitting curve of the right part of pressure signal of male voice. FIG. 10 and FIG. 11 are the same as above (female voice), and the fitting equations are established, such as equation (5), (6), (7), (8), (9), (10), (11), (12).

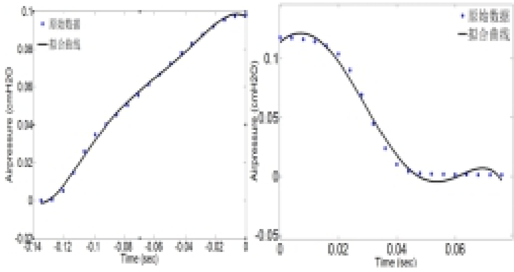

Figure 8. Polynomial fitting (left: male, right: female)

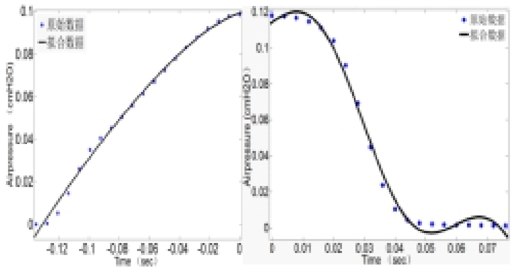

Figure 9. Sum of sin function (left: male, right: female)

Ylm1=-25231*x.^5-8451.7*x.^4-100.65*x.^3-53.26*x.^2-0.53*x+0.097 (5)

Yrm1=-792530*x.^5+109100*x.^4-2604.2*x.^3-132.5*x.^2+2.11*x+0.11 (6)

Ylm2=0.1007*sin(10.38*x+1.347)+0.001128*sin(45.98*x+1.107) (7)

Yrm2=0.1953*sin(10.08*x+2.533)+0.02724sin(103.9*x+0.09482) (8)

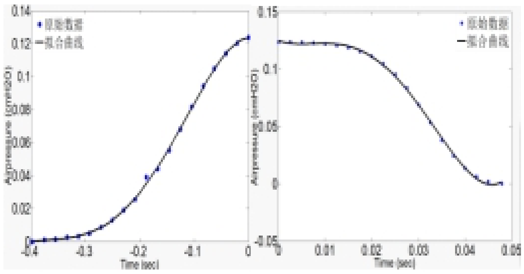

Figure 10. Polynomial fitting (left: male, right: female)

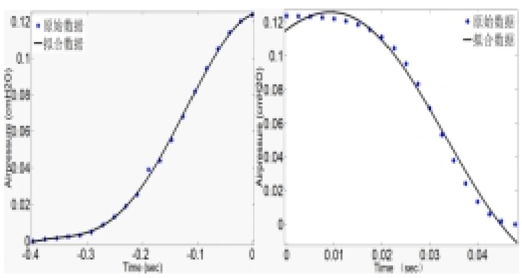

Figure 11. Sum of sin function (left: male, right: female)

$$Ylw1=-18.44*x.^5-39.28*x.^4-26.04*x.^3-6.05*x.^2+0.0144*x+0.1234 \quad (9)$$

$$Yrw1=488720*x.^5+117530*x.^4-11897*x.^3+221.77*x.^2-1.39*x+0.12 \quad (10)$$

$$Ylw2=0.1407*sin(6.896*x+2.462)+0.09416*sin(9.93*x+0.3849) \quad (11)$$

$$Yrw2=0.1198*sin(14.3*x+2.204)+0.04225*sin(81.23*x+0.4668) \quad (12)$$

5. Modeling analysis

By using the least square fitting method (polynomial 5th order fitting) and sin function fitting method to fit and compare the data, as shown in table 1, it is easy to find that the least square fitting method (5th order) and sin function fitting method of the line have different modeling effects for different parts of the data. The optimal fitting model of air flow signal selects the model established by polynomial fitting function. In the four groups of data, the two fitting effects account for 50% respectively, but the fitting error of polynomial is relatively small. In the end, the optimal fitting model of the pressure signal is the model established by polynomial fitting function.

Table.1. The fitting error analysis of two modeling methods: airflow and air pressure model of plosive [pa]

	Air pressure				**Airflow**	
Gender	*Male*		*Female*		*Male*	*Female*
Attribute	Left	Right	Left	Right	Left	Left
Polynomial fitting (1)	0.0392	0.0916	0.0127	0.0242	0.0489	0.0262
Sum of sin function (2)	1.051	0.0664	0.0123	0.0753	0.0676	0.0599
The best fitting method	(1)	(2)	(2)	(1)	(1)	(1)

6. Conclusion

In the process of speech pronunciation, the study of aerodynamics theory is of great significance to the related research and promotion of mandarin. In this paper, the air pressure acoustic mechanism of mandarin consonants of male and female is compared by taking the stop sound [pa] as an example, and the aerodynamic parameters are analyzed in detail. This paper designs and realizes the extraction of air pressure signals by MATLAB software, calculates the average value and fits it, and then USES two methods to model air pressure signals of different genders. Experimental results show that the optimal fitting models of air flow and air pressure signals are established by polynomial fitting functions. This experimental study on signals exert a great impact on further understanding the air pressure of respiratory signals, and provides learning methods for other consonants. However, there are still some shortcomings in the experiment. The collected signals are not enough, and the calculated results have some errors. The efficiency of the program needs to be improved significantly.

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