Aerodynamic Measurements: Normative Data of Voiced Consonant for Children Ages 15-17 Years

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Abstract: In this paper, three 15-17 year olds were selected as subjects to study the various parameters of airflow and pressure during the obstruction and deblocking stages of the voiced consonants in this age group. The main collection of the voiced consonant into the obstruction and deblocking section of the resistance period, peak pressure, peak airflow, air flow four parameters for comparison. The results show that the duration, peak gas flow and peak pressure of the obstruction section or the deblocking section [ʐ] are larger than [m], [n], [l].The nasal sounds [m], [n] and the side sounds [l] have little difference in the pronunciation duration, peak pressure, peak airflow, and airflow in the obstruction and deblocking sections.

1. Introduction

Speech aerodynamics mainly studies the size of vital capacity, the level of subglottic pressure, and the change of airflow rate during human pronunciation. The Rothenburg mask, designed by Rothenberg, M. in 1971, is of great significance for the use of airflow barometers for speech physiology research, and also allows humans to redefine the invisible airflow and air pressure during vocalization.

There are many researches on consonants at home and abroad. Ohala (1974) explored the nasal pattern from a physiological and physical perspective. Zhu (2007) used experimental phonetics to discuss various situations of nasal sounds. It is believed that the external features of nasal sounds are obvious. When nasal sounds and vocal or oral sounds are produced or combined at the same time, complex speech phenomena are generated. Fu (2018) analyzed the acoustic characteristics of voiced consonants. To study the acoustic characteristics of male and female in the process of voiced consonants, such as formant, duration, energy and so on, to compare the differences between male and female in voicing consonants, and to provide methods for improving voiceprint identification.

This paper mainly studies the voiced consonants [m], [n], [l], [ʐ] in the 21 consonants of Mandarin Chinese. The 15-17 year olds are in the period of changing voices, and the physiological structure of their throats changes. The boys and girls in the vocal cords of adolescence are also slightly different. The boys' vocal cords will grow 5-10mm after puberty, and the girls' vocal cords will grow 4-8mm after puberty, so the boys' voices are thicker and the girls' voices are clearer. And the adolescent period is the most energetic stage, and the vocal cords are also better.

2. Experimental explanation

2.1 Experimental Materials

This paper selects the Chinese consonant voiced consonants [m], [n], [l], [ʐ]. In order to make it clearer that the stop sound is blocked and the block is removed, the above voiced consonants are matched with the vowel [a]. In order to avoid the influence of different tones on the experimental data,

all the syllables are 55 tone.

2.2 Participants

The main speakers are two men and one woman, standard Mandarin, without any throat disease, and good vocal cord conditions. All the speakers were trained in pronunciation before the experiment, and they were asked to read each tone five times according to the pronunciation table. At the same time, the mask should be placed close to the face as much as possible. The mouthpiece is used to hold the air pressure tube and adjust the position of the air pressure tube according to the difference of the sounding resistance. Otherwise, the air pressure and airflow data will be affected, because the data collection of the air pressure is easy to deviate.

2.3 Instruments

This experiment used the Phonatory Aerodynamic System 6600 of the American KAY company.

The aerodynamic parameters selected in this paper are mainly.

(1) Expiratory Airflow Duration (EAD): Expiratory Airflow Duration refers to the time length of the whole articulating process, from the airflow starting point to the end of articulation.

(2) Peak Air-pressure (PAP): Refers to the maximum pressure in the oral air pressure before the deblocking.

(3) Expiratory Volume (EV): Expiratory Volume is the amount of airflow exhaled during the consonant articulation.

(4) Peak Expiratory Airflow (PEA): The airflow signal is the volumetric velocity of the airflow as a function of time. The peak velocity of the airflow is the maximum value of the airflow signal during the consonant pronunciation.

3. Experimental results

3.1 Aerodynamic characteristics of voiced consonants

Consonants are classified into voiced consonants and clear consonants depending on whether the vocal cords vibrate during pronunciation. During the pronunciation, the airflow generated from the lungs vibrates the vocal cords as it passes through the glottis, and after the obstacle is broken, the sound is resonated in the resonance chamber. This paper selects four voiced consonants [m], [n], [l], [ʐ] in Mandarin Chinese. Among them, [m] and [n] are nasal sounds, the vocal organs are occluded during pronunciation, and the soft palate droops to form two resonance chambers, one is the mouth and the pharyngeal cavity, and the other is the nasal cavity. The airflow vibrates through the vocal cords and then flows out through the nasal cavity. [l] is the lateral sound. Its pronunciation length is similar to that of the nasal consonant, but the intensity is weaker than the general voice consonant. Its pronunciation is in the tip of the tongue. When the resistance is removed, the airflow flows out from both sides of the tongue. Its acoustic characteristics are similar to the resonance peak of [n], indicating that their tuning parts are roughly the same. In Chinese Mandarin, [ʐ] is a squeaky sound with both voiced and unvoiced. Its language map has a turbid bar with the characteristics of formants. Its pronunciation is located behind the tip of the tongue, and the airflow vibrating the vocal cords breaks through the obstacles.

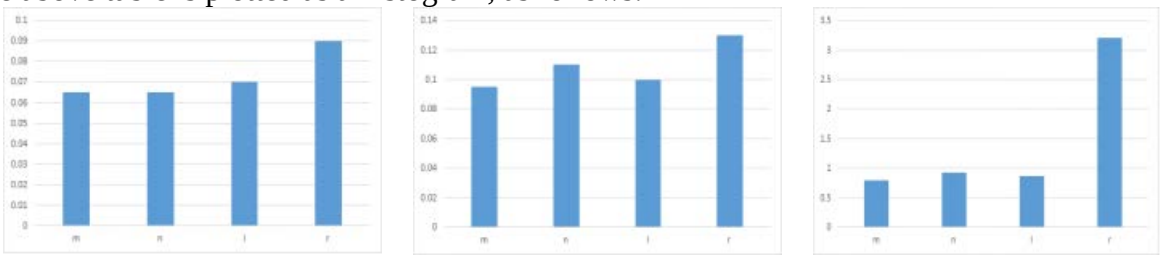
3.2 Analysis of the obstruction segment

It mainly analyzes four sets of data of voice consonants in Chinese Mandarin: expiratory airflow duration, expiratory volume, peak expiratory airflow, peak air pressure. The collected three speakers will average the four sets of data of the voice consonants, and the average results are as follows:

Table 1 Resistance segment parameter

Parameter	[m]	[n]	[l]	[ʐ]
Expiratory Airflow Duration (Sec)	0.065	0.065	0.07	0.12
Peak Expiratory Airflow (Lit/Sec)	0.095	0.11	0.12	0.13
Peak Air Pressure(cm H_2O)	0.8	0.92	2.8	3.2

Since the oral airflow in the obstructing section is not blasted, the airflow barometer does not detect the airflow, so the data in the expiratory volume is displayed as 0.The airflow and pressure data of the above table is plotted as a histogram, as follows:



Expiratory Airflow Duration Peak Expiratory Airflow Peak Air Pressure

Fig. 1 Resistance segment parameter histogram.

According to Figure 1, we can analyze:

From the point of view of expiratory airflow duration of blocking sound, the resistance time of [ʐ] is longer than that of the nasal sound [m], [n] and lateral sound [l].

From the point of view of the peak air flow of blocking sound, the peak airflow of [ʐ] is larger than the nasal sounds [m], [n] and lateral sounds [l].

From the point of view of the peak air pressure of blocking sound, the peak pressure at the time of [ʐ] is significantly higher than [m], [n], [l].

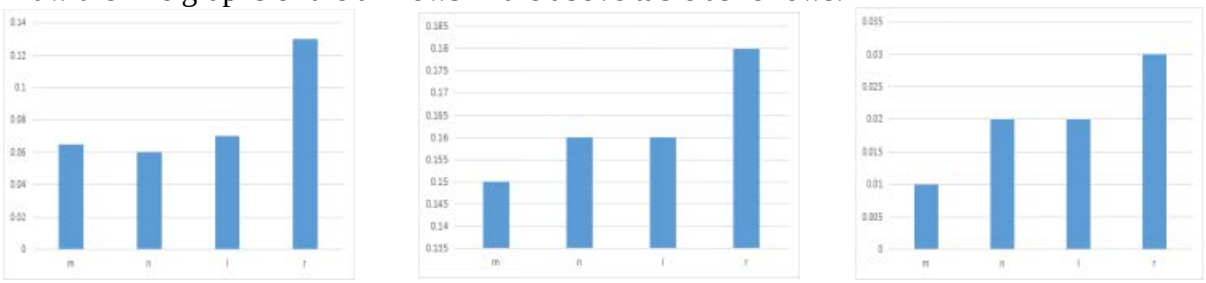
3.3 Analysis of the destruction segment

Since the peak pressure is reached at the end of the resistance, the peak pressure is not used as a research parameter in the deblocking phase. The three sets of data collected by the three speakers are averaged by the three groups of the voiced consonants, and the average results are as follows:

Table 2 Destruction segment parameter

Parameter	[m]	[n]	[l]	[ʐ]
Expiratory Airflow Duration (Sec)	0.065	0.07	0.07	0.13
Peak Expiratory Airflow (Lit/Sec)	0.15	0.16	0.16	0.18
Expiratory Volume（Lit ）	0.01	0.02	0.02	0.03

Draw the line graphs of the airflows in the above table as follows:



Expiratory Airflow Duration Peak Expiratory Airflow Expiratory Volume

Fig. 2 Destruction segment parameter histogram

According to Figure 2, we can analyze:

From the expiratory airflow duration of deblocking sound, the average length of the deblocking

section of [ʐ] is longer than [m], [n], [l].

From the peak airflow of deblocking sound, the peak gas flow rate of [ʐ] is larger than the peak gas flow rate when [m], [n], and [l] are removed.

From the point of view of expiratory volume, the air flow rate at the time of removing the resistance of [ʐ] is larger than the air flow rate of [m], [n], and [l].

4. Conclusion

In summary, this paper studies the airflow and pressure parameters of the voiced consonants [m], [n], [l], [ʐ] of the 15-17-year-old Chinese Mandarin. It is found that the formation resistance time, peak gas flow rate and peak pressure of the obstruction section [ʐ] are larger than [m], [n], [l]; [m], [n], [l] have a small difference in the duration of formation, peak airflow, and peak pressure. The obstruction duration, peak airflow, and peak air pressure of the obstruction section [ʐ] are greater than [m], [n], and [l].Airflow volume is the product of peak airflow and duration. Therefore, [ʐ] is greater than the airflow pressure of the nasal and side sounds, both in the obstruction section and the de-blocking section.[m], [n] are nasal sounds, and most of the airflow from the nasal cavity during the pronunciation, so the nasal airflow detected by the nasal sound is particularly small.

In this paper, the airflow barometer is used to measure the size of the airflow and air pressure parameters in the oral cavity when the voiced consonant is detected. Analyze the principle of speech vocalization, which provides evidence for theoretical linguistics from the perspective of speech aerodynamics. However, this article only selects three teenagers. It is only a brief look at the difference in airflow pressure data. It is not possible to give the standard of airflow pressure parameters for adolescents with voiced consonants. This requires further research in the future.

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