

Research on Children's Mandarin Chinese Voiceless Consonant Airflow

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Keywords: child, voiceless consonant, airflow, Mandarin Chinese

Abstract: This paper studies the airflow changes of children's Chinese-speaking voiceless consonants. The selected data has the pronunciation of airflow duration, average airflow velocity, airflow volume, and peak airflow velocity. It was found that the airflow velocity of the stop is greater than the affricative and fricative. Fricative has the longest pronunciation duration. The change of the voiceless consonant pronunciation airflow data has a great relationship with the pronunciation place and the pronunciation method. These results can be visually seen through experimental means.

1. Introduction

Pronunciation is a dynamic process, so studying phonemes is not only about studying the phoneme itself, but also by studying it in syllables and streams, so that you can more fully understand the research object. Therefore, speech aerodynamic has been the focus of phonetics research since the 1950s. It has been determined through research that adults produce airflow during the process of consonants, and the most important factor affecting consonant pronunciation is the pronunciation part and pronunciation method of consonants. The study by Stathopoulos (1980) and Warren (1982) found that the difference in the pronunciation of the consonant sound is affected by the pronunciation part and the pronunciation method, and the above viewpoint is experimentally demonstrated again.

In the syllable or continuous stream, not only the pronunciation part and the pronunciation method will affect the airflow of the consonant pronunciation, but its pronunciation environment is also the main factor affecting it. The specific expression is that the consonant airflow in the continuous speech is superimposed on the adjacent vowel. The difference between the vowel airflow is the result of the consonant context (Warren, 1982) [1]. In addition, researchers have found that the difference in airflow between men and women is less than that of consonant consonants in voicing consonants, as well as in adults and children (Stathopoulos and Weismer, 1984) [2].

Gender and age also have effect on airflow size, and males have a higher airflow value than women (mean/female average = 1.42) (Emanuel and Counihan, 1970) [3]. Other researchers have found significant airflow differences between male and female adults and between adults and children (4-13 years) in the study of English syllable airflow (Stathopoulos and Weismer, 1984) [4]. Further studies by Trullinger and Emanuel (1983) found significant differences in airflow between the 10-year-old children and the 8-9-year-old children group [5].

The research on speech aerodynamics has been deeply studied in foreign countries. In the 1980s, the research technology was introduced into China. The research on speech aerodynamics in China mainly focuses on the study of Mandarin Chinese and dialect pronunciation in adults. Yonghong Li collected the speech, airflow and air pressure signals of the Mandarin stop, studied the aerodynamic mechanism of the stop and gave a reference range for each parameter [6]. Axu Hu conducted an aerodynamic study on the Mongolian tight vowel. It was found that the airflow rate of the pine vowel was greater than that of the tight vowel, and the glottal resistance was less than the tight vowel [7].

However, there is still a big gap in the field of aerodynamic research on children's pronunciation in China. This paper chooses children as the pronunciation object, mainly to explore the data changes of children's pronunciation and the correspondence with the acoustic law.

2. Experimental explanation

2.1 Experimental Materials

This article is to study the consonants of Mandarin Chinese as the research object. The linguistic definition of the voiceless consonant is the consonant that the vocal cords do not vibrate when pronounced. Mandarin Chinese is mainly composed of voiceless consonants, and 17 of the 22 consonants are voiceless consonants, including stop sounds, squeaks, and squeaking (except [r]).

In order to better conform to the spelling rules of Mandarin Chinese, and to avoid the different tones of the pronunciation, the syllables are matched with [a] and both are 55. The pronunciation materials selected in this paper are as follows:

Table.1. Voiceless consonants

Articulatory place	Plosive		Affricative		Fricative voiceless
	unaspirated	aspirated	unaspirated	aspirated	
Bilabial	b[p]	p[ph]			
Labiodental					f[f]
Dental			z[ts]	c[tsh]	s[s]
Alveolar	d[t]	t[th]			
Post-alveolar			zh[tʂ]	ch[tʂh]	sh[ʃ]
Palatal			j[tɕ]	q[tɕʰ]	x[ç]
Glottal	g[k]	k[kh]			h[x]

2.2 Participants

The main speaker is a 7-year-old first-year boy, standard Mandarin, without any laryngeal disease, good vocal fold conditions, normal hearing ability and normal sound characteristics. All the pronunciation people were trained in pronunciation before the experiment, and they were asked to read each sound five times according to the pronunciation table. This experiment was conducted with the consent of the guardian.

2.3 Instruments

The aerodynamic data acquisition device of this experiment consisted of a circular ventilatory breathometer mask connected to a narrowband pressure sensor (PTL-1) and a separate broadband pressureflow sensor (PTW-1) (Glottal Enterprises MS 110). The calibration gas flow volume was 1.4 L and the flow rate was 0.5 L/s. The data collection work was carried out in the professional studio of Northwest University for Nationalities. The following figure shows the original airflow pattern collected by the MS110.

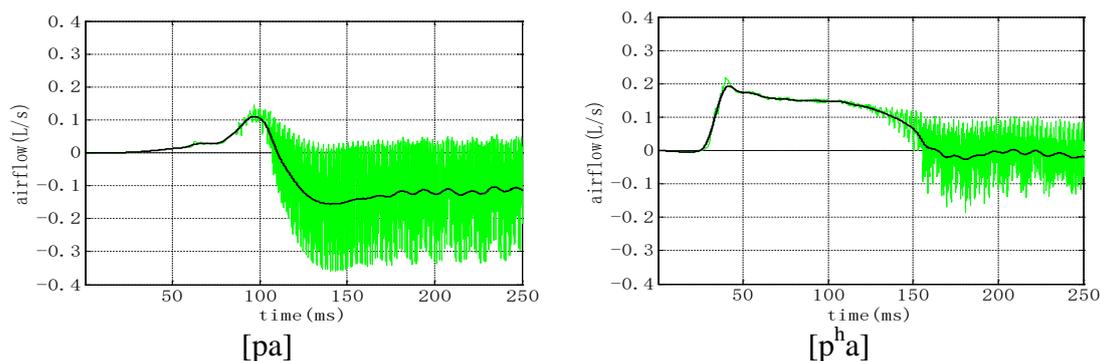


Figure 1. [pa] and [p^ha]

The parameters collected during airflow data analysis are:

Expiratory airflow duration (ms): refers to the length of time that the voiceless consonant is pronounced in the syllable.

Average airflow speed (ml/s): refers to the change of the velocity of the airflow over time in a relative time.

Airflow volume (ml): refers to the total amount of airflow exhaled during the process of pronunciation. The size of the airflow depends on the speed of the airflow and the length of the pronunciation.

Peak Expiratory Airflow (l/s): The airflow signal is the volumetric flow 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 pronunciation of the voiceless consonant.

3. Experimental results

3.1 Aerodynamic characteristics of voiceless consonants

3.1.1 Acoustic and aerodynamic characteristics of the stop

The acoustic characteristics of the stop sound are mainly represented by spike on the spectrograms. When the stop sound is removed, the spectrograms has a strong energy from low frequency to high frequency. This energy is displayed on the spectrograms as color. The deep line is called the “spike”. Although the sound is the same, but the pronunciation part is different, there will be difference in the spike. For example, when the behind of tongue is blocked, the double-spike phenomenon may occur due to the large resistance area. The aspiration stop will appear aerated and chaotic after the spike, so the VOT duration of the aspiration stop will be longer than the unaspiration stop.

The voiceless stop sound has the function of aspirating and unaspirating. When the pronunciation is pronounced, the sound is tightly closed. The air generated by the lungs passes through the respiratory tract to increase the pressure in the oral cavity. When the pressure reaches a peak, the airflow breaks through the obstruction and resonates in the resonance chamber. [p][t][k] does not give air when removing the resistance, [ph][th][kh] gives up when removing the resistance.

3.1.2 Acoustic and aerodynamic characteristics of the Affricative

The acoustic characteristics of the affricative are more special on the spectrograms. Instead of direct blasting when removing the resistance, a gap is first opened to allow the airflow to pass through. It has both a spike of stop and a chaotic of affricative, so the VOT duration of the affricative sound is longer than the stop.

The affricative sound has the function of aspirating and unaspirating. When the vocalization is in contact with the upper gingival in the vocalization, the obstruction part opens a narrow slit, and the airflow flows out from the narrow slit and rubs into sound. [ts] [tʂ] [tɕ] does not give air when removing the resistance, [tsh] [tʂh] [tɕh] gives up when removing the resistance.

3.1.3 Acoustic and aerodynamic characteristics of the fricative

The acoustic features of the fricative appear as chaotic lines on the language map. Due to the difference in position of pronunciation, it is possible to distinguish which kind of fricative is based on the difference in energy. The fricative is blocked at the blocking position when the sound is pronounced. When the resistance is removed, the resisting portion opens a narrow slit, and the airflow is frictionally flowed out from the narrow slit. From the perspective of the duration of the VOT, the VOT of the fricative is longer than the stop and the affricative.

3.2 Analysis of airflow data

All recorded children's stop, affricative, fricative's pronunciation duration, average airflow velocity, airflow volume, and peak airflow velocity data were extracted and averaged to obtain an average value for analysis.

3.2.1 Analysis of the duration of Voiceless Consonant pronunciation

The following is a comparison of the duration of the voiceless consonant pronunciation.

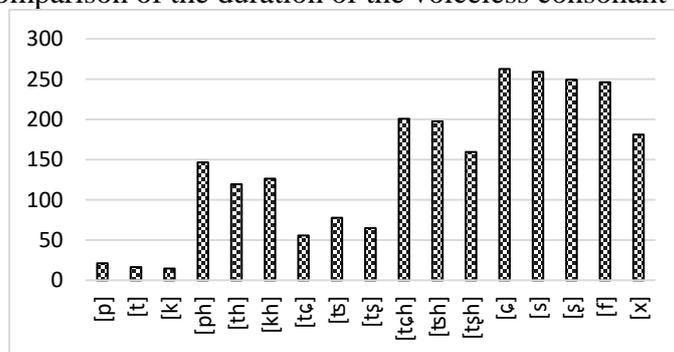


Figure 2. Comparison of the duration of voiceless consonant histogram (ms)

From the perspective of the duration of the pronunciation of the consonants, the following conclusions can be drawn:

a) The duration of the sound of the aspirating stop sound and the affricative sound is longer than that of the unaspirating stop sound and the affricative sound. The duration of the pronunciation of the unaspirating stop is about 14ms-21ms. The duration of the pronunciation of the aspirating stop is about 119ms-146ms. The duration of the pronunciation of the unaspirating affricative is about 55ms-77ms. The duration of the pronunciation of the aspirating affricative is about 159ms-200ms.

b) The duration of the pronunciation of the affricative is longer than that of the stop.

c) The fricative has the longest duration. The duration of the fricative sound is approximately 181ms-262ms.

d) The order of duration of the pronunciation from big to small is: fricative, aspirating affricative, aspirating stop, unaspirating affricative, and unaspirating stop. This is basically consistent with the results of the acoustic analysis.

3.2.2 Analysis of the average airflow velocity of Voiceless Consonant pronunciation

The following is a comparison of the average airflow velocity of the voiceless consonant pronunciation.

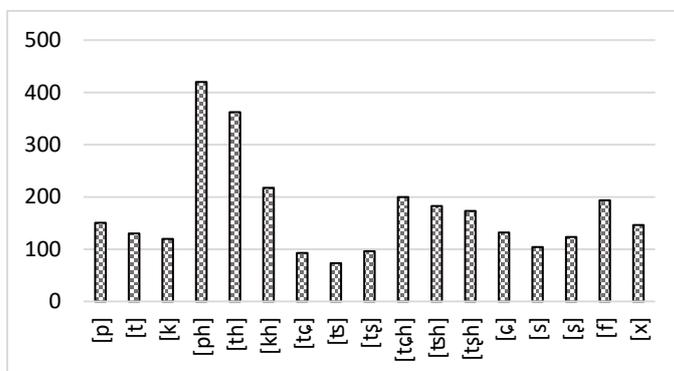


Figure 3. Comparison of the average airflow velocity of voiceless consonant histogram (ml/s)

From the perspective of the airflow velocity of the useless consonant, the following conclusions can be drawn:

a) The average airflow velocity of the aspirating stop is greater than the unaspirating stop. The average airflow velocity of the aspirating stop is approximately 217 ml/s -435 ml/s. The average airflow velocity of the unaspirating stop is approximately 119ml/s-150ml/s.

b) The average airflow velocity of the aspirating affricative is higher than the unaspirating affricative. The average airflow velocity of the aspirating affricative is approximately 173 ml/s -199 ml/s. The average airflow velocity of the unaspirating affricative is approximately 73ml/s-96ml/s.

c) The average airflow velocity of the stop is greater than the affricative. The main reason is that the stop blasting removes and the airflow is instantaneously opened when the glottis is opened, resulting in a large average airflow velocity.

d) The average airflow speed of the fricative is small relative to the aspirating stop and the affricative. The average airflow rate of the fricative is approximately 104 ml/s -193 ml/s.

e) The average airflow velocity of the pronunciation is in descending order: aspirating stop, aspirating affricative, unaspirating stop, fricative, unaspirating affricative.

3.2.3 Analysis of the airflow volume of Voiceless Consonant pronunciation

The following is a comparison of the airflow volume of the voiceless consonant pronunciation.

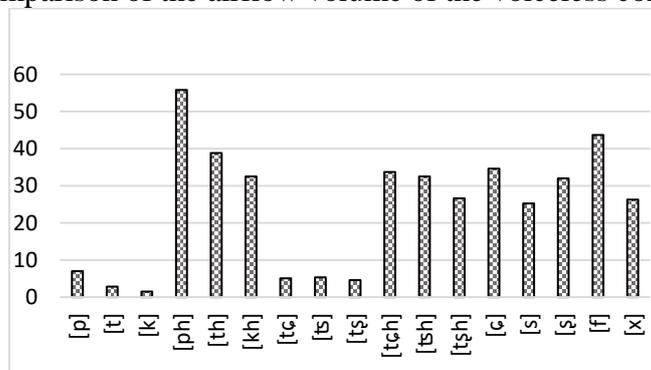


Figure 4. Comparison of the airflow volume of voiceless consonant histogram (ml)

From the perspective of the voiceless consonant sound airflow volume, the following conclusions can be drawn:

a) The airflow volume of the aspirating stop is larger than the unaspirating stop. The airflow volume of the aspirating stop is about 32ml-55ml; the airflow volume of the unaspirating stop is about 1ml -7ml.

b) The airflow volume of the aspirating affricative is larger than the unaspirating affricative. The airflow volume of the aspirating affricative is about 26ml-34ml; the airflow volume of the unaspirating affricative is about 4ml-6ml.

c) The airflow volume of the fricative is small with respect to the aspirating stop and the aspirating affricative, and the airflow volume of the fricative is larger than the unaspirating stop and the unaspirating affricative. The air flow of the fricative is about 25ml-43ml.

d) The pronunciation of the airflow volume from the largest to the smallest in order: aspirating stop, aspirating affricative, fricative, unaspirating stop, aspirating affricative.

3.2.4 Analysis of the peak airflow velocity of Voiceless Consonant pronunciation

The following is a comparison of the peak airflow velocity of the voiceless consonant pronunciation.

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