The Influence of Different Finals Ending on the Pronunciation Airflow of Syllables Based on Cooperative Pronunciation Theory

Jing Wang*, Yonghong Li and Zeguo Liu

Key Laboratory of China's Ethnic Languages and Information Technology of Ministry of Education, Northwest Minzu University, Lanzhou, Gansu, China

*Corresponding author: y200740030@stu.xbmu.edu.cn

Abstract. Based on the theory of coarticulation, this paper studies whether different endings of stops and affricate vowels in syllable structure affect the pronunciation airflow. Through the analysis of the data, we can see that the stop initial syllable at the back of the pronunciation part is longer than the stop initial syllable with the same vowel in the same position. No matter whether the stop or affricate is the initial, the average air velocity of the syllable with the ending of the front nasal is higher than that of the syllable with the opening syllable and the last nasal sound.

Keywords: Speech aerodynamics, coarticulation, stops.

1. Introduction

The ability of speech pronunciation depends on the stability of the exhaled air flow during vocal cord vibration, which is regulated by the resonance organ after vocal cord vibration. In speech production, the lung must provide sufficient power and ventilation for the laryngeal organs. At this time, the inspiratory time is short and the expiratory time is long. Inspiration accounted for 10% of the whole respiratory cycle, while exhalation accounted for 90% of the whole respiratory cycle, that is, the time ratio of inspiratory to expiratory was 1:9 [1]. In the flow of syllabic articulation, what we measure is the size of the air flow and the average air velocity produced in the process of exhalation. The pronunciation of stops and affricates in Putonghua can be divided into three stages: forming resistance, retaining resistance and removing resistance. In the first two stages, the air flow barometer can not collect any data, so the data used in this paper are the air flow generated by the stop and affricate initials and the subsequent vowels. According to the theory of co-articulation, this paper studies whether there is a final or not and whether different endings affect the whole syllable, and whether different endings affect the average air velocity of syllable pronunciation.

Coarticulation theory is a new phenomenon which is different from the traditional phonetics gradually discovered after the 1960s. It means that in the language flow, the segment is not a static and separated sound, and the segment will affect the adjacent segment [2]. Zharkova Natalia (2018) reduced coarticulation in the youngest age group may be due to insufficient tongue differentiation. Immature patterns for lingual consonants in 5- to 11-year-olds are explained by the goal of producing the consonant target overriding the goal of coarticulating the consonant with the following vowel [3]. Elina Rubertus, Aude Noiray (2020) study indicate that the degree of vocalic carryover coarticulation...
decreases with age. Vocalic prominence within an utterance as well as its change across childhood depended on the postvocalic consonant’s articulatory demands for the tongue dorsum (i.e., its coarticulatory resistance): Low resistant /b/ and /g/ allowed for more vocalic perseveration and a continuous decrease, while the highly resistant /d/ displayed lower coarticulation degrees and discontinuous effects [4]. There are many scholars in China who study the collaborative pronunciation of Mandarin Chinese and dialect. Wang Maolin (2011) investigated the phenomenon of coordinated pronunciation between two vowels in the Chinese syllable two-syllables “vowel-stop-vowel” sequence by means of acoustic analysis. It is found that when the vowels are aerated between the two vowels, the synergistic effect of the vowels is relatively small due to the longer value of the aspirating sound, and the aspiration is an important factor to suppress the synergistic effect; When the post vowel is /I/, the cross lip sound has a greater synergistic effect, while the cross tongue sharp sound has a smaller synergistic effect. However, the interaction between the post vowel and the post vowel is greater than the unilateral effect of the post vowel [5]. Li Yonghong (2015) findings on the aerodynamic features of Mandarin initial consonants on different articulatory places and manners. Signals of speech, airflow, and air-pressure. Got aspirated consonants have higher sound pressure level (SPL), expiratory airflow duration (EAD), peak air-pressure (PAP), peak expiratory airflow (PEA) and EV than their unaspirated counterparts. Therefore all these parameters can be regarded as criteria for distinguishing aspirated and unaspirated consonants [6].

2. Experimental explanation

2.1. Experimental Materials
In this paper, the stops and affricates in Mandarin Chinese are selected as the syllables with initial consonants followed by Kai Yuan, front nasal and back nasal. In order to avoid the influence of different tones on the experimental data, all syllables are 55 tones. The main pronunciation lists are as follows:

| [pa] | [pʰa] | [ta] | [tʰa] | [ka] | [kʰa] |
|------|-------|------|-------|------|-------|
| [pan] | [pʰan] | [tan] | [tʰan] | [kan] | [kʰan] |
| [pan] | [pʰan] | [tan] | [tʰan] | [kan] | [kʰan] |
| [tɕia] | [tɕʰia] | [tɕa] | [tʰa] | [tɕa] | [tʰa] |
| [tɕian] | [tɕʰian] | [tɕan] | [tʰan] | [tɕan] | [tʰan] |
| [tɕian] | [tɕʰian] | [tɕan] | [tʰan] | [tɕan] | [tʰan] |

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 pressure 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.

The aerodynamic parameters selected in this paper are mainly:
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.

3. Experimental results

3.1. *The comparison of the air flow parameters of stop initials*

According to the collected data of the parameters of the initial stop syllable, and according to whether it is aspirated or not, the following histogram is drawn.

![Figure 1. Histogram of duration of Stop initial syllable](image1)

![Figure 2. Histogram of average airflow velocity of stop initial syllable](image2)

![Figure 3. Histogram of air flow of stop initial syllable](image3)

According to the comparison of the duration of stop initial syllable, it can be concluded that whether aspirated or not, the pronasal final syllable has the longest duration, the duration of the
opening syllable is slightly longer than that of the nasal ending. The final stop initial syllable in the pronunciation back part is longer than that in the same part. The duration of aspirated stops is slightly longer than that of unaspirated stops.

According to the comparison of the average air velocity of stop initial syllable, it can be concluded that the average air velocity of front nasal final syllable is the longest, whether it is aspirated or not. The results showed that the initial consonant syllables of labial stops > root stops > tip middle stops. The average air velocity of aspirated stops is longer than that of unaspirated stops.

Because the air flow rate is determined by the duration of articulation and the average air velocity, the last syllable of the front nasal has the longest air flow rate, whether it is aspirated or not.

3.2. **Comparison of the average air velocity of affricate vowels**

According to the collected data of the air flow parameters of affricate vowels, and according to whether they are aspirated or not, the following histogram is drawn.
Because the front of the tongue [tɕ] [tɕh] in affricate can not be directly combined with the opening call vowel, in this paper, in order to ensure the consistency of the ventral and final, we choose the combination of [tɕ] [tɕh] and Qichi Hu. However, there is no special rule in the duration of pronunciation because the initial syllable of the affricate on the tip of the tongue has a preposition.

According to the comparison of the average air velocity of affricate vowels, it can be concluded that whether aspirated or not, the front nasal final syllable has the longest average air velocity.

Because the air flow is determined by the duration of articulation and the average air velocity, the air flow of the final syllables of the front nasal sound is longer, but the air flow of [tɕia] is greater than that of [tɕian] because of the longer duration of [tɕia], which has a great relationship with personal pronunciation habits.

4. Conclusions
This paper mainly studies the influence of different finals after the vowels of stops and affricates on the pronunciation airflow. According to the data comparison, we can get that the final stop initial syllable in the pronunciation part is longer than the stop initial syllable with the same vowel in the same position. No matter whether the stop or affricate is the initial, the average air velocity of the syllable with the ending of the front nasal is higher than that of the syllable with the opening syllable and the last nasal sound. The results showed that the order of the air velocity of stops was double lip stops > tongue base stops > tip of tongue middle stops. Due to the limitation of speaker and parameters, the data obtained in this paper are less, and further research is needed in the future.

Acknowledgments
This work was financially supported by Fok Ying Tung Education Foundation fund (Grant No. 151110) and Northest minzu university Yxm (2019010).

References
[1] Wan Qin. Fundamentals of speech science [D]. East China Normal University, 2016
[2] Zhang Lei. Acoustic study of consonant in Mandarin syllables [D]. East China Normal University, 2012
[3] Wang Maolin. Chinese two syllable word VCV sequence co pronunciation [a]. Speech information professional committee of Chinese information society, speech, hearing and music acoustics branch of Chinese acoustics society, speech science branch of Chinese phonetics society. Proceedings of the 11th National Human Machine speech communication Academic Conference (2) [C]. Speech information Professional Committee of Chinese information society, speech of Chinese acoustics Society Hearing and music acoustics branch, phonetics branch of Chinese phonetics Society: Chinese information society, 2011: 5
[4] Zharkova Natalia. An Ultrasound Study of the Development of Lingual Coarticulation during Childhood. [J] Phonetica, 2018.
[5] Elina Rubertus, Aude Noiray. Vocalic activation width decreases across childhood: Evidence from carryover coarticulation [J]. Laboratory Phonology: Journal of the Association for Laboratory Phonology, 2020, 11 (1).
[6] Li Yonghong, Fang Huaping, Hu Axu, Lv ShiLiang. An aerodynamic study on articulation of Mandarin initials, Journal of Chinese linguistics, 2015.1, 43 (1), 411-433