The Research on the Consonants Constraint Degree of Tibetan Xiahe Dialect by Means of EPG

Yonghong Li[a], Pengcuo Dawa[b]

Key Lab of China's National Linguistic Information Technology, Northwest University for Nationalities, Lanzhou, Gansu 730000, China

[a]lyhweiwei@126.com, [b]dawapengcuo@163.com

Abstract. This paper aims at analyzing the contact between tongue and hard palate during production of Tibetan plosives, fricatives and affricates in Xiahe dialect by means of Electropalatograph (EPG). Their tongue characteristics of onset during speech production are obtained: under the same manner of articulation, the more anterior articulation place is, the higher constraint degree and the more stable articulation onset it has and the more posterior articulation place is, the lower constraint degree and the less stable articulation onset it has, forming a proportional relationship between articulation places and constraint degree correspondingly.

Keywords: Consonants; Manners and Places of Articulation; Tibetan; Electropalatograph.

1. Introduction

Traditional linguistics mainly conducts static description of speech organs and manner so far as consonants are concerned. It is hard to conduct a dynamic analysis for the articulation of consonants. The invention of electropalatography made possible the dynamic research of consonants articulation. In 1936, Morse E. R first conducted electropalatographic analysis, and put forward the importance of electropalatographic study for linguistic research. Ever since 1990s, many countries around the world has established their own electropalatographic corpus, including English (Hardcastle, 1989), German (Kohler K, 1976), French (Corneau C, 1999). In China, Mr. Zhou Dianfu first used static palatal camera to record tongue-palate contact of speech segments and also used X ray technology to record the articulation process [1]. Bao Huaiqiao and Zheng Yulin has established first electropalatographic corpus for standard Chinese and Mongolian language[2][3][4].Using acoustic methods and electropalatography, professor Hu He has studied Mongolian plosives, fricatives, affricatives and /r/[5]. Using EPG, Ping YueLing has studied articulation physiology of consonants[6].Li Yinghao has used EPG to study intra-syllable co-articulation of standard Chinese at different articulation speed[7].

Consonants are speech sounds that are articulated with complete or partial closure of the vocal tract, form which the production can be divided into three physiological processes: approach, onset and offset. Approach is the process of closure forming; Onset is the process of closure keeping; offset is the process of closure eclipsing. During the first and last process, linguopalatal contact shifts from on position to a target position, making these two processes unstable. However, the onset process is relatively stable by holding the closure without shifting to another target position. Zhen Yuling has found that initial consonants of Chinese syllables range slightly in the stability during onset process. In her research, ‘j’ /tɕ/,‘q’ /tɕ‘/ and ‘x’ /ɕ/ are the highest in constraint degree, which is the above mentioned ‘stability’, during coarticulation, and ‘l’/l/ and ‘ng’/ŋ/ are the lowest in constraint degree. The relationship of these seventeen initial consonants in constraint degree can be described from high to low as the following: ‘j’ /tɕ/,‘q’ /tɕh/, ‘x’ /ɕ/, ‘d’ /t/, ‘t’ /t‘/, ‘z’ /ts/, ‘c’ /tsh/, ‘s’ /s/, ‘zh’ /tʂ/, ‘ch’ /tʂh/, ‘sh’ /ʂ/, ‘r’ /ʐ/ , ’g’ /k/, ‘k’ /kh/, ‘n’ /n/, ‘l’ /l/, ‘ng’ /ŋ/[8]. This paper will discuss constraint degree in Tibetan plosives, fricatives and affricates of Xiahe dialect during onset process.

2. Experimental grogram

2.1. Word list design

The word list is made up of all monosyllables, which consists of 'consonant + vowel'. For the sake of convenience of discussion, this paper makes some new definitions: Consonant is defined as C, vowel is defined as V.

Most consonants are articulated with complete or partial closure of the vocal tract. Because of acquiring limitation of EPG, the consonant list is excluding bilabial, labiodental, and glottal. In Xiahe dialect, there seldom exist "Voiced consonant + vowel" syllables at the beginning of a word, so voiced consonants are also excluded from the consonant list. Except the above, consonants list consists of all the other consonants: /t/, /th/, /k/, /kh/, /s/, /sh/, /z/, /ʂ/, /ʐ/, /ɕ/, /ʦ/, /ʦh/, /ʈʂ/, /ʈʂh/, /ʨ/, /ʨh/.

The vowel list consists of extreme three vowels in the tongue: /a/- the highest,/i/-the lowest,/u/-the most posterior.

All each consonant from consonant list combine every vowel from vowel list to form a syllable as possible as they can. Despite that some consonants can't combine with some vowels in a syllable, there are 88 words in the word list.

2.2. Signals acquisition

The experimental signals are acquired from a native speaker of Xiahe dialect, who has been living in Xiahe since he was born and now is a teacher in Northwest University for Nationalities. Before the signal acquisition, the speaker had been trained about some acquiring skills and read the word list ahead of the signal acquisition, so he would offer the most valid signal samples to this project without any potential obstacles.

This project uses Palatometer6300 to acquire the dynamic palatography by the sampling rate of 100Hz, recording the audio at the same time by the sampling rate of 16000Hz.

2.3. Parameters settings

Refrring to contacting parameters invented by Fontdevila in 1994, this paper use CA, CC and CD to analyze the dynamic palatography: CA represents Contact Anteriority, which reflects the foremost electrode of Electropalatograph of all the contacted electrodes; CC represents the Contact Centrality; CD represents Constraint Degree, which reflects the stability in the onset process of speech production.

In the following formulas, R(n) means the contacted electrodes in row n; C(n) means the contacted electrodes in column n; CAstd and CCstd are standard deviation of CA and CC respectively. R(n), C(n) are calculated by the self-designed Elctropalatal Processing Platform. The following is their formula.

$$CA=(\log(1*(R(8)/8)+9*(R(7)/8)+81*(R(6)/8)+729*(R(5)/8)+6567*(R(4)/8)+59049*(R(3)/8)+531441*(R(2)/8)+3587227*(R(1)/6)+1))/(\log(4185105)) \quad (1)$$

$$CC=(\log(1*((C(1)+C(8))/14)+17*((C(2)+C(7))/16)+289*((C(3)+C(6))/16)+4913*((C(4)+C(5))/16)+1))/(\log(5220+1)) \quad (2)$$

$$CD=1/(CAstd+CCstd)\ . \quad (3)$$

From the CD formula, it can be known that Constraint degree is depended on the standard deviation of CA and CC. so if CA or CD changes is unstable in a certain period, CD must be affected: the least stable CA or CC is, the higher CAstd or CCstd, which means the lower constraint degree the consonant has; the most stable CA or CC is, the lower CAstd or CCstd, which means the higher constraint degree the consonant has. In short, the higher stability, the higher constraint degree, and vice versa.

2.4 Parameters extraction

All the following processes are based on Elctropalatal Processing Platform. First, load epg and speech sigals in to platform; second, make physical process marks for each epg signal by referring relative speech sigal; third, cut out three physical process for each epg signal; fourth, calculate R(n) and C(n); last, put R(n) and C(n) into formulas to calculate CA, CC, and CD.

3. Constraint degree of Tibetan plosives, fricatives and affricates

This paper mainly discusses the consonant stability of onset during speech by involving CD from the perspective of articulation manner. The articulation manners can divided into Plosives, Fricatives, Affricates, nasals, laterals, lateral fricatives, thrills and semi-vowels. The sympathetic chord cavity of nasals is totally different from other consonants from EPG perspective, resulting impropriety of research on nasals from EPG. In Xiahe Tibetan, there is only one consonant for laterals, lateral fricatives and thrills, and they are /l/, /ɬ/and /r/ respectively. Semi-vowels are the most special consonants, which convey too much vowel characteristics. Except that, this paper only discusses the stability of Tibetan plosives, fricatives and affricates during their onset process of speech production.

3.1 Plosives

Due to the total block in vocal tract, all airflow of plosives ceases during speech production. There are only four plosives in the word list: /t/, /th/, /k/, /kh/, and they both can combine with /a/, /i/, /u/. Table 1 shows the combined syllables and the constraint degree of their plosives.

Table 1 Plosives in a syllable and their constraint degree

alveolar				velar			
unaspirated		aspirated		unaspirated		aspirated	
ta	8.5	tha	24.3	ka	7.6	kha	6.1
ti	16.8	thi	10.2	ki	6.6	khi	5.5
tu	10.5	thu	10.2	ku	7.4	khu	5.2

From the perspective of articulation places, the CD of alveolar is higher than that of velar. It can be concluded that the more anterior the articulation place is, the higher constraint degree the plosive has, and vice versa. That means the more anterior the articulation place is, the more stable the plosive is.

3.2 Fricatives

The air in the vocal tract is forced through a narrow channel between two articulators, forming fricatives. There are six fricatives in the word list: /z/, /s/, /sh/, /ʂ/, /ʐ/, and /ɕ/, and not all of them can combine with /a/, /i/, /u/. Table 2 shows the combined syllables and the constraint degree of their fricatives.

Table 2 Fricatives in a syllable and their constraint degree

alveolar				retroflex		palatal	
unaspirated		aspirated		aspirated		aspirated	
za	12.7	shu	13.9	ʂa	4.2	ʐa	4
zi	9.7	shi	15.1	ʂi	4.2	ʐi	6.8
sa	14.9	sha	17.9			ɕa	4.1
si	18.9					ɕi	6.7
						ɕu	6.8

From the perspective of articulation places, the CD of alveolar is higher than that of retroflex and palatal; what's more, the CD of retroflex is higher than that of palatal. It can be concluded that the more anterior the articulation place is, the higher constraint degree the fricative has, and vice versa. That means the more anterior the articulation place is, the more stable the fricative is.

3.3 Affricates

Beginning as plosives but releasing as a fricative, Affricates get some plosive characteristics and some fricative characteristics. As figure 1 shows, there exits total block in vocal tract from frame 61 to frame 65, which seems like plosive; and there exits narrow channel in the vocal tract from frame 66 to frame 82, which seems like a fricative.

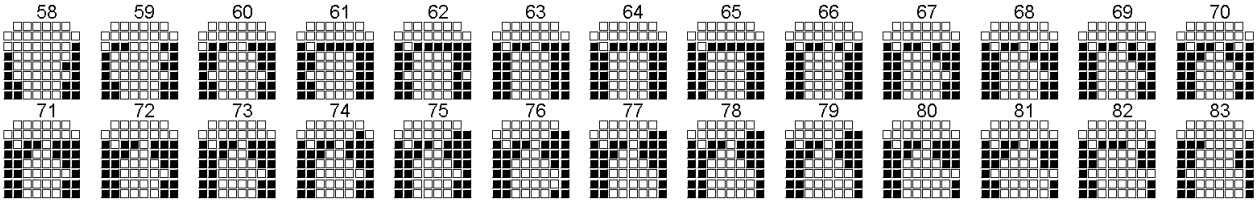

Fig. 1 Affricate /tʂha/ on EPG

There are six affricates in the word list: /ʦ/, /ʦh/, /tʂ/, /tʂh/, /tɕ/ and /tɕh/, and all of them can combine with /a/, /i/, /u/. Table 3 shows the combined syllables and the constraint degree of their affricates.

Table 3 Affricates in a syllable and their constraint degree

alveolar				retroflex				Palatal			
unaspirated		aspirated		unaspirated		aspirated		unaspirated		aspirated	
tsa	52.1	tsha	22.3	tʂa	7.6	tʂha	12.2	tɕa	8.1	tɕha	6.7
tsi	36.9	tshi	17.8	tʂi	18.2	tʂhi	13.2	tɕi	5.5	tɕhi	10.8
tsu	32.8	tshu	11.3	tʂu	7.9	tʂhu	8.2	tɕu	5.8	tɕhu	8

From the perspective of articulation places, the CD of alveolar is higher than that of retroflex and palatal; what's more, the CD of retroflex is higher than that of palatal. It can be concluded that the more anterior the articulation place is, the higher constraint degree the affricates has, and vice versa. That means the more anterior the articulation place is, the more stable the affricate is.

To sum up, there exists a corresponding relationship between the articulation place and constraint degree for Tibetan plosives, fricatives and affricates: the more anterior the articulation place is, the higher constraint degree the consonant has, and vice versa. That means the more anterior the articulation place is, the more stable the consonant is.

4. Conclusion

Constraint degree reflects the stability of the consonant, which is a kind of the ability to keep on itself against coarticulation. Because of different kind of artificial palatal and different outline of oral cavity, constraint degree varies among people; however, articulation manners and places affect constraint degree in a same trend for different artificial palatal and oral cavity. This paper, by means of EPG, conducts a research of constraint degree by involving Tibetan plosives, fricatives and affricates, resulting the correspond relationship between articulation place and constraint degree. What's more, the experimental results provide a reference for the further research on the articulating mechanism of Tibetan and the theory of speech production.

Acknowledgements

This article is subsidized by The National Natural Science Foundation of China (Grant No. 61262052).

References

[1] D.F. Zhou, Z.J. Wu: Mandarin Pronunciation Patterns (The Commercial Press Chinese 1963), p.10.

[2] H.Q. Bao, Y.L. Zheng: Electropalatography Studies on Articulation of Standard Chinese, Journal of School of Chinese Language and Culture Nanjing Normal University, (2011) No.3, p.1.

[3] Hascimeg, Y.L. Zheng: The Database on EPG phonetics of Mongolian, The Sixth National Conference on modern phonetics (Tian Jin, 2003.10), p.527.

[4] Huhe Harnud: Research on the stops by dynamic palatogram in Mongolian, Journal of Inner Mongolia University, (2005) No.3, p.17.

[5] G.L. Bao, Hascimeg and K ke, An EPG-Based Study on the Place of Articulation of Mongolian Consonants, Minority Languages of China,(2011) No.3, p.57.

[6] Y,L. Ping: A study of Monosyllabic plosive and affricate palate of Shanghai dialect, The Sixth National Conference on modern phonetics (Tian Jin, 2003. 10), p.39-44.

[7] Y.H Li, J.P. Kong, Anticipatory coarticulation in V1n#C2V2 sequences in Standard Chinese, Journal of Tsinghua University (Science and Technology), Vol.53 (2013) No.6, p.818.

[8] Y.L. Zhen, J. Liu: the reacher of Articulation places of consonants and their constrain: based on EPG, Journal of China Phonetics, The Commercial Press, (2008), No.1, p.171.