

# Analysis of Acoustic Parameters of Amdo Tibetan monophthong Based on Signal Processing Technology

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**Abstract.** This paper sorts out the phoneme distribution of Amdo Tibetan vowels, and uses acoustic experimental methods to analyze the pitch, duration, tone intensity and formants of Tibetan Amdo vowels. The study found that the fundamental frequency of the unit tone is about 190Hz-280Hz. When the voiced consonant /r/ is an adjacent consonant, the fundamental frequency usually decreases. In terms of duration, the position of the vowel in the syllable structure and the difference in the pronunciation of the consonants before and after will affect the duration of the vowel. In addition, subsequent consonants have a greater impact on vowels than preceding consonants. In terms of sound intensity, the sound intensity of the back and high round vowels /o, u/ is relatively high, while the front low and second-low vowels are relatively small, which is a special phenomenon. In addition, from the perspective of the vowel pattern, the position of /e/ is higher than /i/ is a special phenomenon discovered in this study.

**Key words:** Tibetan Amdo; Vowel; Phoneme; Acoustics.

## 1. Foreword

The Amdo dialect in Tibetan is widely distributed, covering seven Tibetan autonomous prefectures and one autonomous county, and spanning three provinces. Although some scholars divide Amdo dialect into pastoral dialect, agricultural dialect and semi-agricultural semi-pastoral dialect according to the characteristics of language style [1]. Due to the good internal consistency of the dialect, the communication between people in different places is not affected. Amdo dialect is one of the representative dialects of Tibetan, and it is also the teaching language in Tibetan areas. The study of Amdo dialect will be beneficial to the correct pronunciation of Tibetan language teaching. The traditional Amdo speech research is mostly based on the auditory perception of field surveys, lacking the description and verification of relevant objective data. With the popularization of speech experimental methods in domestic speech research, it is necessary to apply relevant methods to Amdo speech. research for a more detailed and accurate description. Previously, Xiaoying Chen et al. (2010) analyzed the vocal characteristics of monophonic sounds in different environments through EGG signals, and pointed out that the three parameters of fundamental frequency, opening quotient and velocity quotient are strongly correlated in Amdo Tibetan monophonic sounds [2]. However, the article does not examine the vowel intensity, duration, formant and vowel pattern of Tibetan Amdo dialect. Ladefoged has pointed out that the traditional vowel tongue map is actually based on the perceptual results of vowel acoustic properties [3]. Therefore, the acoustic research in this paper can provide an acoustic reference for the traditional notation results.

## 2. Experimental method

We first selected 2,121 Tibetan Amdo words from three authoritative dictionaries, "Tibetan-Chinese-English Verification of Amdo Tibetan Spoken Dictionary" [4], "Tibetan Standard Syllable Frequency" [5] and "Amdo Tibetan Spoken Dictionary" [6]. The results of the phonological induction in "Amdo Dialect Vocabulary [7]" and "Tibetan Brief History [8]", 141 initials and 31 finals were sorted out. The finals include 6 unitary finals, namely /i, e, a, o, u, ə/, and each vowel has its own

combination requirements. This paper will analyze the phonological distribution characteristics of these six unit tones, and analyze their acoustic characteristics at the same time. A total of 4 subjects participated in this experiment, 2 males and 2 females, whose native language is Tibetan Amdo. Aged between 25-35 years old, no physical defects or dysphonia, clear articulation, and a good foundation of Tibetan language and writing. The audio is captured by a professional sound card (Innovative Blaster X-Fi Surround5.1pro) and a microphone (Sony MLCROPHONE ECM-44B), the sampling rate is set to 16000Hz, the sampling precision is 16-bit, monophonic. In the later stage, Praat software is used to perform voice annotation and data extraction on the recording files. The extracted acoustic parameters include fundamental frequency, duration, sound intensity and resonance peak.

### 3. Experimental data

We can directly measure the intrinsic fundamental frequency of vowels for comparison. By comparing the average fundamental frequencies of the vowels of Amdo, we get the following order: /i/ > /u/ > /ə/ > /o/ > /e/ > /a/.

**Table 1.** Voice average fundamental frequency data (Hz)

match	i	e	a	o	u	ə
V	258	222	207	229	256	251
CV	197	220	198	262	258	204
VC	/	228	203	276	252	198
CVC	/	283	261	279	251	271

The overall order of vowel duration is /a/ > /u/ > /o/ > /ə/ > /i/ > /e/. Under the four different combinations, the vowels are ranked as follows: vowel /i/ is V > CV; vowel /e/ is VC > V > CVC > CV; vowel /a/ is V > VC > CV > CVC; vowel /o/ is V > CVC > VC / CV; vowel /u/ is VC > V > CVC > CV; vowel /ə/ is V > CV > VC > CVC.

**Table 2.** Vowel duration data (ms)

match	i	e	a	o	u	ə
V	240	210	420	390	290	240
CV	130	120	400	180	140	230
VC	/	250	410	180	410	180
CVC	/	150	170	190	200	160

Table 3 gives the sound intensity data of each vowel. It can be seen that the sound intensity values of vowels in the four structures are similar, and the basic trend is roughly VC > CV > CVC > V.

**Table 3.** Vowel intensity data (dB)

match	i	e	a	o	u	ə
V	58	65	75	81	78	76
CV	81	79	79	85	80	80
VC	/	80	80	85	85	80
CVC	/	79	78	83	84	79

We extracted the first three formants of 6 vowels in the V, CV, VC, and CVC structures of Amdo (Table 4). In general, the F1 of /a/ is relatively the highest, and the other vowels F1 are ranked in the order of /e/ > /ə/ > /o/ > /i/ > /u/; F2 is usually the highest of /e/, and /u/ has the smallest second resonance peak. Observing F3, the third formant of /i/ is the highest, and the third formant of /a/ is the smallest, and the overall order is /e/ > /i/ > /ə/ > /e/ > /o/ > /u/ > /a/.

**Table 4.** Vowel formant data (Hz)

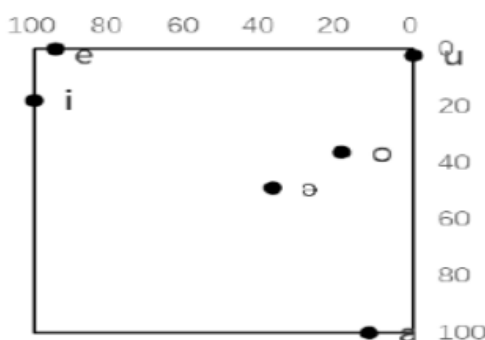
	match	F1	F2	F3		match	F1	F2	F3
<b>i</b>	V	613	1832	2931	<b>u</b>	V	200	752	2393
	CV	322	1604	3084		CV	541	829	2741
	VC	/	/	/		VC	225	1294	2467
	CVC	/	/	/		CVC	667	1860	3140
<b>e</b>	V	463	1934	2714	<b>o</b>	V	577	1547	2737
	CV	281	1596	2490		CV	528	1268	2562
	VC	295	1491	2507		VC	562	1097	2685
	CVC	558	1715	2571		CVC	495	1177	2764
<b>ə</b>	V	530	1383	2840	<b>a</b>	V	894	1353	2599
	CV	635	1491	3050		CV	837	1010	1935
	VC	579	1309	2037		VC	843	1526	3083
	CVC	624	1270	2237		CVC	743	1061	2099

#### 4. Discussion and analysis of experimental results

It should be pointed out that except /u/ in CV and CVC and /e/ in VC structure are matched with unvoiced consonants, the rest are the combination of voiced consonants and vowels.

1). Fundamental frequency analysis. We further investigate the fundamental frequency differences of each vowel in four different combinations, and compare the fundamental frequency values of vowels in the four structures. Except for /u/ and /i/, the fundamental frequencies of the other four vowels are in Significantly higher in CVC. When the voiced consonant /r/ is adjacent to the consonant, the fundamental frequency value is usually lower. For example, the fundamental frequency of /a, i/ in the CV structure and /ə/ in the VC structure are all low, and all are below 200Hz. The fundamental frequency value of the vowel /u/ is not much different in the four structures. It seems that the unvoiced consonants appearing before the vowel in the combination of CV and CVC have little effect on the fundamental frequency value of the vowel. For /o, e, ə/, the front and rear nasal sounds seem to increase the vowel fundamental frequency to some extent. The specific impact trend remains to be explained by later large-sample acoustic studies.

2). Time analysis. The V structure is actually the case when the vowel is pronounced alone. Since there is no restriction on the front and back segments, the duration is usually the longest. In addition, it is also found that the duration of /e and u/ in the VC structure is longer than when V is issued. Relatively speaking, the vowel durations in the CVC and CV structures are generally small, and we believe that the front consonants have a greater restriction on the vowel duration. In addition, we also found that the vowel duration of nasals when they are only pre-consonants is quite different from that when they are only post-consonants. For example, the change of the duration of vowels /o/ and /ə/ in the VC structure is opposite to that of other vowels in the VC structure, which means that nasal sounds have a greater impact than non-nasal sounds in the post-consonant position.



**Figure 1.** The vowel pattern of Tibetan Amdo dialect

3). Sound intensity analysis. Sound intensity is usually the main acoustic counterpart of auditory loudness, and the loudness sequence of vowels tends to be low vowel > middle vowel > high vowel.

In this experiment, we found that from the overall trend, the so-called back and high rounded vowels /o and u/ have high sound intensity, but the front low and second low vowels have low sound intensity. a special phenomenon. This may reflect, to a certain extent, the inherent differences in the pronunciation of Amdo Tibetan vowels.

4). Vowel formant and pattern analysis. It can be seen from the vowel pattern that the position of /e/ in Amdo is higher and higher, even higher than /i/, which seems to be different from the general situation. The /e/ in the traditional notation shows particularity in acoustics, which may be the characteristic of the Amdo Tibetan unit sounds. However, due to the small sample of speakers in this study, it remains to be seen whether this special situation is universal. Pending verification.

## 5. Epilogue

In this paper, the acoustic parameters such as fundamental frequency, duration, tone intensity and formant of unit tones in Tibetan Amdo dialect are measured and analyzed. The study found that the fundamental frequencies of the six unit tones are all distributed between 190Hz and 280Hz, and the intrinsic fundamental frequencies of each vowel are /i/ > /u/ > /ə/ > /o/ > /e/ > /a/. When a voiced consonant /r/ is an adjacent consonant, the fundamental frequency usually decreases. At the same time, the variation of vowels in the CVC structure is larger than that in the other structures. The above shows that the voiced consonants in the position before and after the vowel in the Tibetan Amdo dialect will affect the fundamental frequency of the vowel. From the perspective of duration, the position of vowels in the syllable structure and the difference in pronunciation of consonants before and after will affect the duration of vowels. In addition, following consonants have a greater impact on vowels than preceding consonants. In terms of sound intensity, the sound intensity of the back and high rounded vowels /o and u/ is high, but the sound intensity of the front low and second low vowels is small, which is a special phenomenon. In addition, from the perspective of vowel pattern, the position of /e/ higher than /i/ is a special phenomenon found in this study, but it needs to be further proved. This paper is only a preliminary study of the differences in the unitary sounds of Tibetan Amdo dialect in different environments. As for the gender differences of speech and the acoustic characteristics of vowels in polysyllables, more work is needed to explain.

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