International Journal of Database Theory and Application
Vol.9, No.3 (2016), pp.113-122
http://dx.doi.org/10.14257/ijdta.2016.9.3.13

The Patterns of Vowels in Monosyllabic Words of Uyghur Language

Seyyare Imam[1], Aynur Nurtay[2], Akbar Pattar[2] and Askar Hamdulla[3]

[1]*School of Politics and Public Administration, Xinjiang University, China*
[2]*Institute of Information Science and Engineering, Xinjiang University, China*
[3]*Schools of Software, Xinjiang University, Urumqi, China*
askarhamdulla@sina.com

Abstract

In this paper, on the basis of traditional phonetics, by using the methods of experimental phonetics and voice pattern theory, Analyzed and summarized the vowel pattern of the monosyllables in Uyghur language. The statistical analysis is carried upon the vowel formant frequency values in monosyllables, and discussed by using Joos method in more details. For the first time, with the actual experimental data proves the accordance of tongue location features of Uyghur vowel with the traditional knowledge from hearsay. The research results of this paper will have a high reference value for the study and application development of both Uyghur language and the other languages are belongs Altaic language family.

Keywords*: Uyghur; Formant; monosyllabic word; Vowel pattern; Formant pattern*

1. Introduction

Uyghur language is the main communication tool for Uygur community, and also is a common language among many other ethnics in Xinjiang Uyghur Autonomous Region located in the west part of China [1]. In Uyghur language, each syllable must be composed of a vowel phones in every inherent Uyghur words, so the study of Uyghur vowel patterns plays very important role in improving the naturalness of speech synthesis and speech recognition research area. Due to a single vowel can form a single syllabic word, so there is always have a need to take acoustical measurements for vowels in speech recognition technologies [2]. In Uyghur language there are eight vowel phones (ئا (a), ئە(e), ئې (é), ئى (i), ئو (o), ئۇ (u), ئۆ (ö), ئۈ (ü)). Due to Uyghur is a toneless language, so the Uyghur speech pattern analysis issues just include the patterns of consonants and vowels. This article mainly studies Uyghur vowel pattern in mono-syllabic words. Vowel pattern is the systemic representation of a vowel, it include vowel positioning, internal variations, overall distribution relations. Each vowel phonemes in a language and dialect could form a pattern, and can be seen directly from the vowel's tongue position charts, and can be described by acoustical vowel chart by acoustical experiments values [3]. In experimental phonetics, the vowel's voiced quality mainly depends on the first formant (F1) and the second formant (F2) values. By extracting the vowel's formant frequency values, the acoustic vowel diagram can be drawn correspondingly. Acoustical vowel diagram is the result of the vocal resonance characteristics, and compared with a traditional tongue position charts are much more accurate.

This paper adopted the Joos type of acoustic vowel diagram to study the vowel patterns in monosyllabic words in Uyghur language. Joos (1948) proposed an acoustic vowel diagram that taking F1 and F2 as longitudinal and horizontal coordinates respectively, Joos associate F1 and F2 with the high-low and front-back of tongue positions respectively, and revealed the contrastive relations between the different two acoustic

ISSN: 2005-4270 IJDTA

vowel diagram [4]. Generally, each vowel has five formants, the first three formants plays critical role to vowel's timbre. And the first two formants F1 and F2 are particularly sensitive to the change of tongue position and lip forms. So, in phonetics, take the F1 and F2 numerical value as description for vowel timbre. In which, the tongue's high-low positions are closely related with F1, a high tongue position is corresponding to a low F1 value, and a low position is corresponding to a high F1 value. Also, the tongue's front-back positions are closely related with F2 values, the frontier of the tongue position is corresponding to a higher F2 value, and vise versa [2]. Therefore, the use of acoustic vowel diagram in study vowel system is very convenient.

The research work of vowel's acoustic field has begun in the 19th century, it mainly from the perspective of physiological phonetics explore the relations between tongue positions and vowel generation [5]. From the beginning of the 20th century, the exploration method gradually developed from physiological to acoustical, and the aim is to find the relations between vowel's tongue positions and the formants, in which, the task of draw tongue position charts is turned into drawing acoustical diagram according to formants values [6]. In China, the research on vowel's acoustic space began in the 60s in last century, Wu Zongqi, Cao Jianfen and Shifeng, on the basis of the framework of two dimensional space, they are analyzed the vowel's acoustic space from different angles. Among them, Shifeng who puts forward the concept of "vowel pattern", then broke the previously prevailed divided and ruled separately situations between phonetics and phonology, and combined those of two fields. In paper [7], Yu Jue, Li Aijun and Wang Xia used the method of acoustical diagram and modeling of vowel's formants comparatively studied the Shanghai mandarin and standard mandarin retroflex vowel's acoustic features. In paper [8], Yinxuekan analyzed front vowel's formant mode. In paper [9], Bao Huaiqiao and Axim used only 232 polysyllabic words have got the preliminary results of eight Uyghur vowel's pattern. In paper [10], Zilkam Kasim *etc.* have analyzed the acoustical patterns of the vowels occurred in the first syllable of the given words.

So far, most researchers in vowel pattern field are all based on the language of Chinese, Mongolian and others. But, there are almost no research work conducted on Uyghur language from the view of acoustical vowel diagram, and no work was done in research area of Uyghur formant mode analysis. Although, there are a few studies in Uyghur vowel pattern, but their corpus is very small. In this paper, the experiments carried out with 515 monosyllabic words, thereby have improved the accuracy of formant frequency values .This paper, comprehensively analyze and summarize the vowel patterns in Uyghur monosyllabic words by making statistics separately on the first formant frequency and second formant frequency, at the same time, we proposed Uyghur vowel formant arrangement modes for the first time. With actual experimental data verified that the Uyghur vowel tongue position characteristics are conform to the traditional "hearsay knowledge" conclusions. In this paper, the research work will reveal some phonetic phenomena can't be observed in the past.

2. Experimental Methods

2.1. Source of Corpus

In order to study the Uyghur mono-syllabic word's vowel pattern, this paper collected mono-syllabic vowel's formant frequency from the "Uyghur speech acoustic parameter database" which was built by the National Ministry of Education and the National Language Commission's National language standards construction and Informationization project on the speech acoustic parameter database of Tibet, Uyghur, Yi, and carried out the statistics and analysis. According to statistics, we know that in the "Uyghur speech acoustics parameters Database" There are 515 (male, female) monosyllabic words, consisting of the vowel (a) is 134 words, the vowel (e) is 131 words, the vowel (é) there is

5 words, the vowel (i) there is 65 words, the vowel (o) there is 77 words, the vowel (u) there is 42 words, the vowel (ö) there is 39 words, and there is 22 words consisting of the vowel (ü). The corresponding proportions are shown in Figure1 below.

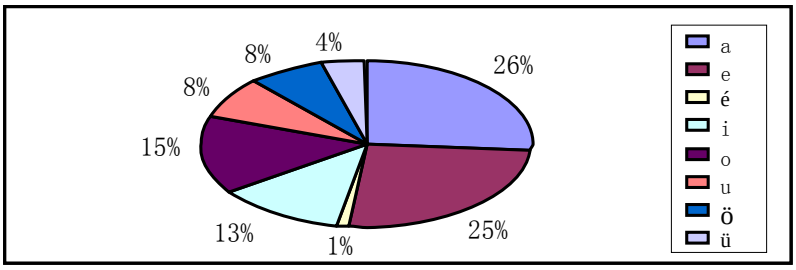

Figure 1. Vowel Distributions in Database

2.2. Recordings and Data Acquisition

We carried out the recording task in the standard studio of the Ethnology and Anthropology Institute of the Chinese Academy of Social Sciences by using IBM R51 laptop and the external sound card. The pronunciation collaborators are male, female, at the age of 30 to 40, are professional announcers of China National Radio. Each word individually read twice. Acoustic parameters extracted by using the Praat Speech Analysis Software. Such as: Vowel duration (Unit: ms) (vowel duration corresponding to the duration of second formant); Collected the vowel sound intensity curve peak values, and took them as the sound intensity target value (Unit: DB); Vowel's first formant F1 (Unit: Hz); Vowel's second formant F2 (Unit: Hz); Vowel's third formant F3 (Unit: Hz); Vowel's fourth formant F4 (Unit: Hz). In a specific speech environment, vowel's formants values were varied at different degrees due to the effect of its front-rear consonants [9], so the vowel formants measured in relatively stable segments of speech data.

2.3. Experimental Methods

Vowel's formants are the most critical acoustic parameters of vowel sound quality. It is generated by taking the vibration of the vocal cords as excitation source, and it is just the vocal tract resonances. Different vowels have different vocal tracts, and each has their own formants. Generally, in acoustical study, the first two formants play the major role in the vowel sound quality. This paper took the first, second, third and fourth formant frequency values of eight vowels in the monosyllabic words includes in the "Uyghur speech acoustic parameter database", and the average values are calculated respectively, and draw out the acoustical vowel diagram by using the first two formant's average values, and formant pattern charts of the vowels in the Uyghur monosyllable words by using the average values of all four formants values.

3. Statistics and Analysis on the Data

3.1 Statistics on the Vowel's Formant Values

According to the different pronunciations, we have extracted the different acoustic parameters for each vowel phonemes in one-syllabic words separately, namely the first vowel formant F1, second vowel formant F2, vowel formant 3 F3 and vowel formant F4. And take the average values for those four different statistical values respectively. As shown in Table 1, (M for male pronunciation, F pronunciation women).

Table 1. Statistics on the Vowel Formant Frequenc

Vowel	sex	F1	F2	F3	F4
a	M	692	1256	2664	3561
	F	741	1406	3195	4542
e	M	657	1724	2594	3750
	F	685	2014	3178	4648
é	M	450	2108	2715	3655
	F	512	2352	3248	4561
i	M	435	1881	2768	3744
	F	505	2218	3325	4359
o	M	514	944	2801	3475
	F	506	1139	3075	4095
ö	M	462	1728	2547	3458
	F	489	1856	2929	4164
u	M	427	1001	2777	3480
	F	466	1195	3062	4086
ü	M	360	1848	2553	3481
	F	444	1918	2864	4176

3.2. Acoustical Distribution of the Vowels and Discussions

This paper used the Joo's type of acoustic mapping method, and used the SMA4WIN drawing software. According to the Table 1, we can draw the Uyghur vowel's acoustical distribution diagram using the first and the second formant values, in which taking the vowel's second formant frequency values as the x axis, and taking the first formant frequency values as the y axis, by using logarithmic scale for x and linear scale for y, and setting the zero point at right upper corner, and then each vowel can be mapped a corresponding point in that plane. SMA4WIN is the Japanese data processing software, and the Gaussian fitting procedure can be accomplished on the given data. Pronunciations made by male and female speaker were shown in Figure 2, the vowel) ۇۆ□ö) is represented by 2 (the solid circles represent the female speakers, blank circles represent the male speaker) in Figure 2.

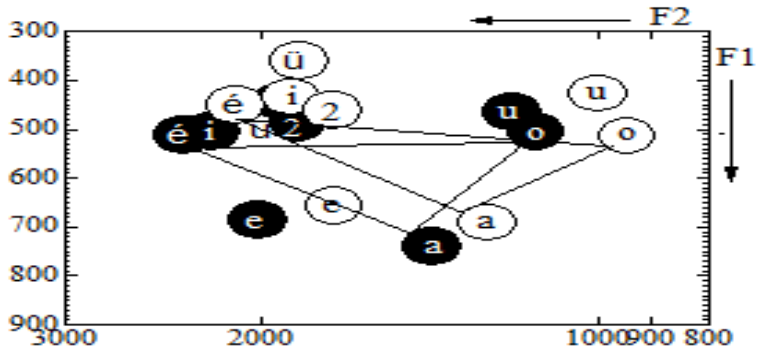

Figure 2. The Acoustical Distributions of the Vowels in Monosyllabic Words

But for convenience of analysis, in this paper the three vowels interconnected by lines according to the status of tongue positions such as most forwarded, most rearward, and the lowest.

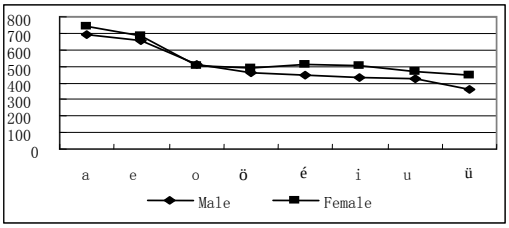

Figure 3. The First Formants of Vowels in Uyghur Monosyllabic Words

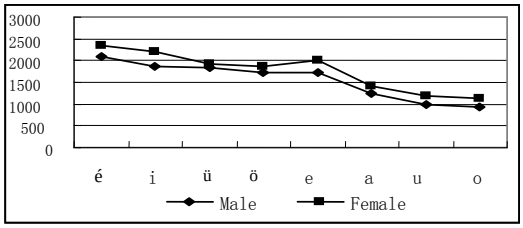

Figure 4. The Second Formants of Vowels in Uyghur Monosyllabic Words

We analyze the patterns of each vowel in mono-syllabic words of Uyghur as follows:

ئا(a): from the Figure 2 it can be seen that vowel ئا(a) is located in the lowest position in the diagram. Also it can be seen from the Table 1 that vowel ئا(a) has the maximum first formant frequency (male: 692 Hz, female: 741 Hz), and have a lowest tongue position. from the view of front or back tongue position, it is can be seen from the Figure 4 that vowel ئا(a) is located before vowel ئۇ (u) , and it's second formant frequency values is male: 1256 Hz, female: 1406 Hz, and the tongue location is backward positioned. So, vowel ئ ا (a) is a backward vowel with lowest tongue position.

ئە(e): From the Table 1 and Figure 2 ~ 4 can be seen that the vowel ئە(e) is the second low vowel just after the vowels ئا (a). The second formant frequency value of vowel ئە(e) is 1724 Hz (male) and 1724 Hz (female), and the tongue is front positioned. So, the vowel ئە(e) is a front vowel with lowest tongue position.

ئې(é) : the vowel ئې(é) is front positioned whatever it is uttered by male or female speaker. From the Figure 2~4 and Table 1, it is can seen that é is the most front tongue positioned vowel and has a maximum second formant frequency value. From the Figure 3, vowel ئ ي (é) has the first formant frequency of 450Hz for male, and ranked by fifth order, and the tongue position is higher, while the first formant frequency of 512 Hz for female, ranked by third order, and the tongue position is relatively lower. So, ئ ي (é) is a front vowel with higher tongue position.

ئى(i): From Table 1 and Figure 2~3 can be seen that the vowels i has the formant frequency (435Hz) for male and ordered at sixth position, and tongue positioned just after vowel ئې(é) and its tongue position is slightly higher than that. While, vowels i has the formant frequency (505Hz) for female and ordered at fifth position, and the tongue position is higher. From the view of front or back tongue position, it is can be seen from the Figure 3~4 that the ئى(i) is the front vowel just after the vowel ئ ي (é). It is also can be seen Figure 4 that the second formant frequency value just behind the vowel ئ ي (é).

ئو(o): it is can be drawn from table 1 and Figure 3~4 that the vowel ئو(o) is the backward vowel with lower tongue position. The first formant frequency value for male is 514 Hz, for female is 506Hz, and both pronunciations are located in the fourth order, and

just after the vowel é, the tongue position is relatively lower, but it has a minimum second formant frequency value with lowest tongue position.

ۇ(u): From Table 1, Figure 2 and 4 can be seen that the vowel ۇ(u) has second formant frequency values of 1001Hz for male, 1195 Hz for female, and its tongue position just after the vowel ئو(o). From Figure 3 it is concluded that the ۇ(u) has first formant frequency value of 427 Hz for male, 466Hz for female, and its tongue position lower than vowel ۈ(ü). So, the vowel ۇ(u) is the backward vowel with high tongue position.

ۆ (Ö): From Table 1, it is concluded that the vowels ö has first formant frequency value of 462 Hz for male, of 489Hz for female, and it is located before the vowel ئو(o) and after the vowel ئې (é). From the view of tongue height, it belongs to semi high vowel. From the Figure 4, it has the second formant frequency values of 1728Hz and 1856Hz for male and female separately, and ranked by fifth and fourth order for female speaker and male speaker correspondingly, from the view of tongue position, it is also belongs to semi front vowel.

ۈ(ü): From Figure 3 can be seen that the first formant value of vowel ۈ(ü) for whatever the speaker is male or female are the minimum, and from Table 1, it has a highest tongue position. From Figure 4, it is can be seen that the second formant frequency (male:1848 Hz, female:1918Hz) ranked third and fourth order separately. So, the vowel ۈ(ü) is a semi front vowel with frontier tongue position.

3.3. Vowel Formant Pattern

Each vowel's several formants have its own particular arrangements on the frequency axis, and form their own unique style. If all vowels' formants arranged together, then they will construct a graph that well-proportioned and orderly arranged that it is called a formant pattern. If the vowel's tongue shapes changed, the formant pattern will also be changed. This paper is trying to identify each Uyghur vowel through the corresponding formant patterns. According to the four formant frequency values (given in Table 1) of vowels in the monosyllabic Uyghur words, we could get the vowel formant patterns for corresponding male and female speaker as in Figure 5 (a) and (b).

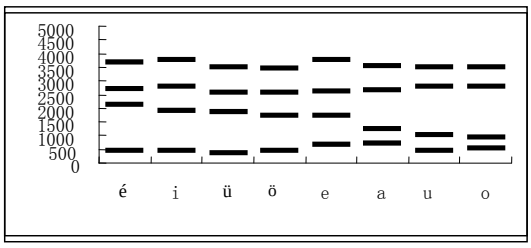

Figure 5. Vowel Formant Pattern for Male Speaker

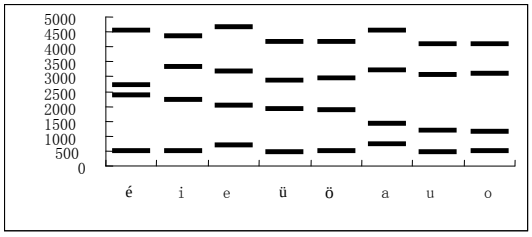

Figure 6. Vowel Formant Pattern for Female Speaker

From the Figure 5. and Figure 6., it is clear to see that the female speaker's overall formant frequencies in Uyghur one-syllabic words are higher than male speakers. The

vowel positions and relationships are all different, so we mainly discuss them in following few aspects:

1. F1 values are much related to the height of tongue. The higher the tongue positions, higher the F1 values, and vice versa. This phenomenon can be clearly seen From Figure 5 and Figure 6. The tongue position of vowel ئۈ(ü) is the highest, so its F1 value is the lowest one, and the tongue position of vowels ئا(a) is the lowest, so its F1 is the highest one. The tongue position of vowels ئە(e) is lower, so its F1 value is the higher one. the tongue positions of vowels ئې(é), ئى(i), ئو(o), ئۆ(ö) are similar level, so their F1 values are no different at all.

2. F2 values are associated with the anteroposterior position of tongue. The frontier the tongue, the F2 values are higher, and vice versa. The second formant frequency of three rear vowels of ئا (a), ئو(o), ئۇ(u) are more lower than other vowels. The formant value of vowel ئى (é) is the highest one.

3. F2 has something to do with roundness of lip shapes, and it will decrease the frequency values of F2. Although the tongue positions of three rear vowels of ئا(a), ئو(o), ئۇ(u) are same, but the vowel of ئو(o)、ئۇ(u) is rounded vowels, so their F2 frequency values lower than ئا(a), and the frequency values of vowels ئۆ(ö), ئۈ(ü) are lower than vowel ئې(é), ئى(i).

In addition, whether it is pronounced by men or female speaker, the distances between each resonance peak (formant values) are roughly stable. You can see from Figure 5 and Figure 6, with the backward-shift of tongue, the differences between the first and the second formant values are gradually become smaller. Except the vowelئى(i) , the difference between the second and third formant values are increased gradually.

4. Conclusions

In the field of vowel pattern research, this paper conduct the comprehensive analysis and summarization about the vowel patterns of one-syllabic Uyghur words, and for the first time, put forward the vowel formant model for monosyllabic Uyghur words. In the standard Uyghur phoneme system there are eight vowel phonemes such as a, e, é, i, o, ö, u, ü.

1) The front or rear tongue position distribution characteristics of the eight Uyghur vowels are as follows: the é, i, ü, ö, e are belong to front vowels, and the a, o and u belong to rear vowels, their front-rear orders are é→i→ü→ö→e→a→u→o (for male) and é→i→e→ü→ö→a→u→o (for female).

2) The low or high tongue position distribution characteristics of the eight Uyghur vowels are as follows: the é, i, o, ö, u and ü are belong to high vowels, and the a and e belong to low vowels, their high-low orders are ü→u→i→é→ö→o→e→a (for male) and ü→u→ö→i→o→é→e→a (for female).

3) The female's formant mode little higher than the men and the arrangements are disordered slightly relative to the men. The more the shifted rear of tongue position, the more closer the distance between vowels' first and second formant values, the more far the distance between the vowels' second and third formant values.

The vowel patterns and formants distribution analysis of two, three and multi-syllabic Uyghur words will be the further study issues in the following papers.

Acknowledgments

This work was supported by the National Social Science Foundation of China (13BYY062) and Natural Science Foundation of China (61063023).

References

[1] X. Zhao and Z. Zhu, "An Overview of Uyghur Language", the National Press, March, **(1985)**.
[2] W. Kunlun, Z. G. Zhang and T. Abdukirim, "Analysis of Acoustic Frequency Feature of Uyghur Vowels and Their Identification", Journal of Chinese Information Processing, March, vol. 24, no. 2, **(2010)**, pp. 122-125.
[3] F. Shi, "Exploration of Experimental Phonology", Beijing: Beijing University Press, **(2009)**.
[4] Z. Wu and M. Lin, "Summary of Experimental Phonetics", Beijing: Higher Education Press, **(1989)**.
[5] P. Wang, X. Bei and F. Shi, "Vowels of three-dimensional space", Beijing: contemporary linguistics, vol. 12, no. 3, **(2010)**, pp.241-251.
[6] E. Zee, "The phonetic value of the vowels, diphthongs, and triphthongs in Beijing Mandarins", Editor of LianHong Cai, TongChun Zhou, JianHua Tao, "The 5th international symposium on modern phonetics", Beijing: Beijing Qinghua University Press, **(2001)**, pp.54-60.
[7] J. Yu, A. J. Li and X. Wang, "Shanghai mandarin and standard mandarin retroflex vowels acoustic characteristics of the study", Contemporary linguistics, Beijing, vol. 10, no. 3, **(2000)**, pp.211-219.
[8] Y. Xuekan, "Analysis of Formant Mode of Incorrect Front Vowel pronunciation", Journal of Qiongzhou University, December, vol. 15, no. 6, **(2008)**, pp.123-125.
[9] B. Huaiqiao and Haxim, "A Preliminary Analysis on Uyghur Vowels Acoustics", Minority Languages of China, vol. 5, **(1988)**, pp.4-13.
[10] Z. Kasim, N. Tursun and W. Silamu, "Acoustic Analysis of the Initial Syllabic Vowels in Uyghur Language", Journal of Chinese Information Processing, vol. 23, no.5, **(2009)**, pp. 114-118.
[11] Z. Xuewen, H. He, W. R. G. X. L. Tu, H. S. Q. M. Ge and Z. Yuling, "Acoustic Feature and Variance of Uyghur Vowels", International Conference on Speech Database and Assessments (Oriental COCOSDA), 2011, 26-28 Oct. Hsinchu, **(2011)**, pp. 180-184.

Authors

Seyyare Imam, she received her B.E. and M.S. degree in politics and philosophy, from Xinjiang University and Xinjiang Normal University of China, in 1995 and 2008, respectively. Since 1996, she has been working as a teacher in school of politics and public administration, Xinjiang University. Her research interests include Social Language, Uyghur Phonetics and Linguistics, and related issues about Uyghur ontology construction *etc.*

Aynur Nurtay, she received her B.E. and M.S. degree in Information Science and Communication Engineering from Xinjiang University, China, in 2009 and 2012, respectively. She is working as research assistant at the Key Laboratory of Intelligent Information Processing, Xinjiang University, China. Her research interests include Uyghur Phonetics and Linguistics.

Akbar Pattar, he received his B.E. degree in radio electronics from Xinjiang University, China, in 1983. He has been working as a teacher in School of Information Science and Engineering, Xinjiang University since 1983. His research interests include experimental phonetics and natural language processing.

Askar Hamdulla, he received the B.E. in 1996, M.E. in 1999, and Ph.D. in 2003, all in Information Science and Engineering, from University of Electronic Science and Technology of China. In 2010, he was a visiting scholar at Center for Signal and Image Processing, Georgia Institute of Technology, GA, USA. Currently, he is a professor in the School of Software Engineering, Xinjiang University. He has published more than 160 technical papers on speech synthesis, natural language processing and image processing. He is a senior member of CCF and an affiliate member of IEEE.