

EGG Model of Ditoneme in Mandarin*

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ABSTRACT

This paper concerns with the study of EGG (electroglottogram by laryngograph) model of ditoneme in Mandarin. The parameters for establishing models are fundamental frequency (F0), which is regarded as reference, speed quotient and open quotient, which are all extracted from the EGG signal by using the software EGG.exe, an option of CSL, Model 4300B, KAY. The result shows that speed quotient and open quotient have close relationships with the F0 in different ditonemes. In general, speed quotient and open quotient will decrease, when F0 increases in sustained vowels. But in the ditonemes, speed quotient and open quotient show different natures according to the position and environment. The conclusion is that EGG models of ditonemes are composed of the patterns of F0, speed quotient and open quotient in Mandarin.

1. INTRODUCTION

Chinese is a typical tonic language, in which tones, mainly based on the F0 acoustically, are very important in distinguishing meanings. In the phonetic study of Chinese tones, almost all the researchers focused their attention on F0, and many contributions have been achieved (Liu Fu, 1924; Wu Zhongji, 1980).

Along with the development of speech science and technology, the knowledge of phonetics becomes more and more important with co-related sciences and is examined in applicant speech system. For instant, in the formant parameter synthesis, the tone parameters, F0, can be exactly given, but the synthesized speech tones in some cases, especially in the tone with lower pitch, seem unnatural. In the aspect of perception, people will always find that the pitch is not lower enough. That shows that there is something unknown about the pitch, though we know the main acoustic parameter is F0.

In the phonetic study of the minority languages in China, which, as Chinese, all belong to Sino-Tibetan family, many different phonation types have been found and studied. We find that different phonation types, to some extent, always have relations with pitch or exactly, we may say, with F0. In these minority languages, different phonation types distinguish meanings and their acoustic and physiological features can also be used to explain the changes and relations in both synchronous and historical aspects. Although phonation types in Mandarin are not significantly important as those in the minority languages, they really appear in different parts or levels of pitch, and are often used by singers and oral artists. In addition, different phonation types, which are significant in phonemes, have been found in Chinese dialects. From this point of view, F0 always has close relation with different phonations. In the aspect of phonation study, many methods have been developed, which provide effective tools (Fourcin, A. J., 1981).

In Mandarin, the relationships among the speed quotient, open quotient and F0, which are extracted from EGG signal of sustained vowels, have been studied. (Kong Jiangping 1998; Chen Jiayou and Kong Jiangping, 1998). See Figures 1. 2. 3. The sustained vowel is [a], each of which is pronounced by 15 males and 15 females twice at 5 levels. The figures show the average parameters of them.

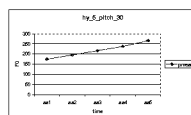


Figure 1.

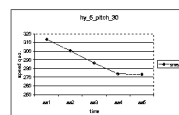


Figure 2.

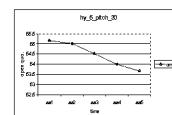


Figure 3.

Figure 1: This figure shows F0 of 30 persons in 5 different levels from low to high.

Figure 2: This figure shows the 5 speed quotients correspondent to the 5 F0. From the figure, we can see speed quotient decreases, when F0 increases.

Figure 3: This figure shows the relation of open quotient to correspondent F0. When F0 increases, open quotient decreases.

This paper concerns the study of EGG model of ditonemes of Mandarin, by which relationship of EGG parameters have been described and modeled.

2. METHOD

In this section, the method of parameter extraction and treatment, materials' sampling and some of the basic knowledge about Mandarin tones have been introduced.

2.1 Basic Knowledge of Tones in Mandarin

There are 4 basic tones in Mandarin, which are described as 55 (high level or tone 1), 35 (rising or tone 2), 214 (dim or tone 3) and 51 (falling or tone 4) by 5 letter system (Zhao Yuanren, 1930). There are 15 ditones (Wu Zongji, 1980; Kong Jiangping and Lu Shinan, 1998) composed by 4 * 4, among which tone 3 + tone 3 -> tone 2 + tone 3. The tone value of 214 in ditone are changed into 211 (low falling or low level).

2.2 Materials and Sampling Methods

In this study, 16 disyllable words are chosen. For each disyllable words, 15 males and 15 females pronounce two times. The speech sound and EGG signals are recorded by Sony DAT tape recorder in 16 bit and 50 kHz sampling frequency through two channels simultaneously. So each word has 60 samples. There are 960 samples of disyllable words altogether.

After these two kinds of signals recorded, they are transferred into computer through an DAT interface installed in Kay Speech Work Station model 4300B. There are 960 data files, each of which has two channels data in the *.NSP format.

2.3 Parameter Extracting

The parameters are extracted by EGG.exe software, which is an option of model 3400B for EGG signal analysis, and CSL.exe, which is another option of this instrument for speech spectrum analysis. The main parameters are F0, speed quotient and open quotient, which are extracted from EGG signal. The other parameters are amplitudes. One is extracted from the speech sound and the other is extracted from the EGG signal. These two kinds of amplitudes are only used as the references for determining the effective period of EGG signal.

2.4 Parameter Treatment

The parameters are treated by 1. interpolation, 2. time normalization, and 3. effective parameter's determination. The concrete steps are as follows:

- * Each of the 960 data files is first interpolated two times.
- * The duration of one signal is normalized by extracting 24 parameters from each data file.
- * The 24 parameters of 60 data files for each disyllable word are averaged.
- * According to the values of F0, speed quotient, open quotient and the two amplitudes which are used as references, the useless parameters of F0, speed quotient and open quotient are deleted at the beginning and ending of signals of ditoneme words.
- * Finally, there are 16 data files and each of them contains 24 parameters of F0, speed quotient and open quotient respectively. Then 32 figures are drawn by these parameters, through which EGG models are shown.

3. RESULT

The parameters and patterns are described and shown in the 4 following subsections respectively. The first subsection presents parameters and models of single syllable tones. The subsections of 2, 3 and 4 described the relationships of F0, speed quotient and open quotients. Finally they are defined as distinctive features in subsection 5. See table 1 to 3. The EGG models of ditonemes are described by the 3 groups of distinctive features phonetically and the models in form of mathematics are not discussed here, since the space is limited. The parameters of F0 and open quotient of tone 3 + tone 3 is same to tone 2 + tone 3, but the parameters of speed quotient have a little difference. There are 15 ditones are discussed here, but 16 * 2 figures are presented in this paper. In this research, the patterns of F0, speed quotient and open quotient have been described by distinctive features, such as H (high level) and F (falling), but the values are quite different. The parameters of speed quotient and F0 are shown in one figure and the parameters of open quotient are shown in another figure.

3.1 Pattern of Single Syllable Tones

Before the models of ditones are discussed, the parameters and patterns of single syllable tone of the 30 persons are introduced, which can be taken as conferences to compare with those appeared in the ditones and from which pattern changes can be found and seen. See figures 4 to 11. These figures show the patterns of F0, speed quotient and open quotient.

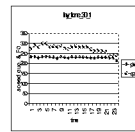


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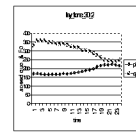


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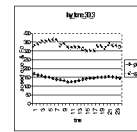


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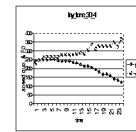


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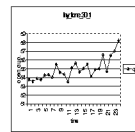


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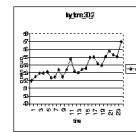


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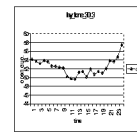


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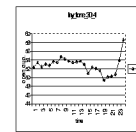


Figure 11.

Figure 4: This figure shows parameters of F0 and speed quotient of tone 1. The contours are all high level.

Figure 5: This figure shows parameters of F0 and speed quotient of tone 2. The contour of F0 is rising and the contour of speed quotient is falling.

Figure 6: This figure shows parameters of F0 and speed quotient of tone 3. The contour of F0 is low level and the contour of speed quotient is high level.

Figure 7: This figure shows the parameters of F0 and speed quotient of tone 4. The contour of F0 is falling and the contour of speed quotient is rising.

Figure 8: This figure shows the parameters of open quotient of tone 1. The contour of open quotient is rising.

Figure 9: This figure shows the parameters of open quotient of tone 2. The contour of open quotient is rising.

Figure 10: This figure shows the parameters of open quotient of tone 3. The contour is first falling and then rising.

Figure 11: This figure shows the parameters of open quotient of tone 4. The contour is a little bit rising, then falling and finally rising quickly.

To compare with the features of sustained vowel and the 4 tones in Mandarin, we can see the relationships between F0 and speed quotient are same. But the relationships between F0 and open quotient are not same. The contours of open quotients of tone 1 and tone 2 are all shown as rising, though the contours of F0 of them are different. The relationship between F0 and open of tone 3 is not as same as that of sustained vowel. The contour of open quotient is as same as that of F0. The relationship between F0 and open quotient is more complicated. From the relationships, talked above, we can see that the phonation feature changes in the different tone of real speech.

3.2 Patterns of F0

The figures and parameters show that the 8 tones of tone 1 in both first syllable and second syllable are all high level. The 8 tones of tone 2 are all rising in both first syllable and second syllable. The 3 tones of tone 3 are dim (or low falling) in first syllable and the 3 tones of tone 3 in the second syllable are low level. In this research, they are described as D (dim) and L (low) respectively. The 8 tones of tone 4 are all falling tones in both first syllable and second syllable. So there are 15 patterns of F0 of ditones.

3.3 Patterns of Speed Quotient

The 8 speed quotient contours of tone 1 in both the first syllable and second syllable are high level, which is about 270. The 8 speed quotients contours of tone 2 are all falling, which means

that the speed quotient decreases in value, when correspondent F0 increase. The 3 speed quotient contours of tone 3 in first syllable go up a little and then go down. The pattern of this kind of contours is described as HF(high level and falling). The 4 speed quotient contours of tone 3 in second are L (low). The 4 speed quotient contours of tone 3 in the second syllable are all rising (R). The 3 speed quotient contours of tone 4 in the first syllable go up first and fall at the end, which are described as RF(rising and falling). The speed quotient contour of tone 4 in the first syllable of ditone 4 + 3 is R (rising). There are 3 speed quotient contours of tone 4 in the second are R (rising) and the one in ditone 4 + 4 is RF.

3.4 Patterns of Open Quotient

The 8 open quotient contours of tone 1 and tone 2 in first syllable are H (high level), which is about 54. The 7 open quotient contours of tone 3 and tone 4 in the first are all F (falling). The 4 open quotient contours of tone 1, 2, 3 and 4 are all rising (R) in the second syllable of ditones of 1 + 1, 1 + 2, 1 + 3 and 1 + 4. The 4 open quotient contours of tone 1, 2, 3 and 4 are all rising (R) in the second syllable of ditones of 4 + 1, 4 + 2, 4 + 3 and 4 + 4. The 4 open quotient contours of tone 1 and 4 are all high level (H) in the second syllable of ditones of 2 + 1, 2 + 4, 3 + 1 and 3 + 4. The 4 open quotient contours of tone 2 and 3 are all rising (R) in the second syllable of ditones of 2 + 2, 2 + 3, 3 + 2 and 3 + 3.

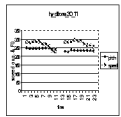


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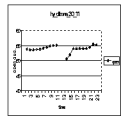


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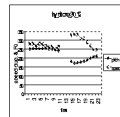


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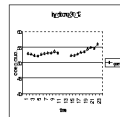


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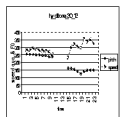


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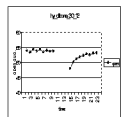


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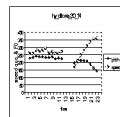


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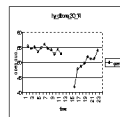


Figure 19.

Figure 12: This figure shows the parameters of F0 and speed quotient of ditone 11.

Figure 13: This figure shows the parameters of open quotient of ditone 11.

Figure 14: This figure shows the parameters of F0 and speed quotient of ditone 12.

Figure 15: This figure shows the parameters of open quotient of ditone 12.

Figure 16: This figure shows the parameters of F0 and speed quotient of ditone 13.

Figure 17: This figure shows the parameters of open quotient of ditone 13.

Figure 18: This figure shows the parameters of F0 and speed quotient of ditone 14.

Figure 19: This figure shows the parameters of open quotient of ditone 14.

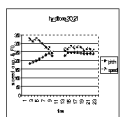


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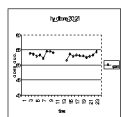


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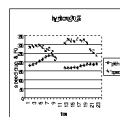


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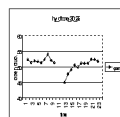


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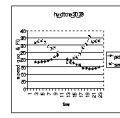


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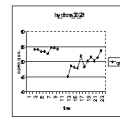


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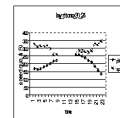


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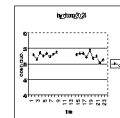


Figure 27.

Figure 20: This figure shows the parameters of F0 and speed quotient of ditone 21.

Figure 21: This figure shows the parameters of open quotient of ditone 21.

Figure 22: This figure shows the parameters of F0 and speed quotient of ditone 22.

Figure 23: This figure shows the parameters of open quotient of ditone 22.

Figure 24: This figure shows the parameters of F0 and speed quotient of ditone 23.

Figure 25: This figure shows the parameters of open quotient of ditone 23.

Figure 26: This figure shows the parameters of F0 and speed quotient of ditone 24.

Figure 27: This figure shows the parameters of open quotient of ditone 24.

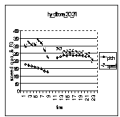


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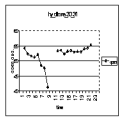


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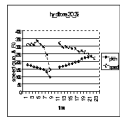


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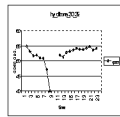


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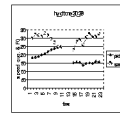


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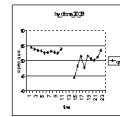


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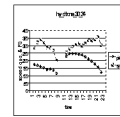


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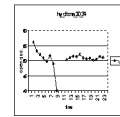


Figure 35.

Figure 28: This figure shows the parameters of F0 and speed quotient of ditone 31.

Figure 29: This figure shows the parameters of open quotient of ditone 31.

Figure 30: This figure shows the parameters of F0 and speed quotient of ditone 32.

Figure 31: This figure shows the parameters of open quotient of ditone 32.

Figure 32: This figure shows the parameters of F0 and speed quotient of ditone 33.

Figure 33: This figure shows the parameters of open quotient of ditone 33.

Figure 34: This figure shows the parameters of F0 and speed quotient of ditone 34.

Figure 35: This figure shows the parameters of open quotient of ditone 34.

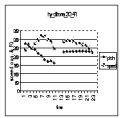


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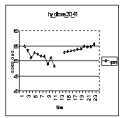


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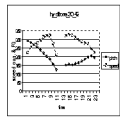


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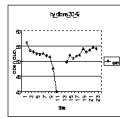


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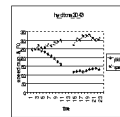


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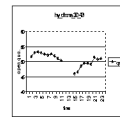


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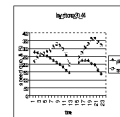


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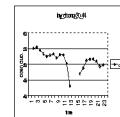


Figure 43.

Figure 36: This figure shows the parameters of F0 and speed quotient of ditone 41.

Figure 37: This figure shows the parameters of open quotient of ditone 41.

Figure 38: This figure shows the parameters of F0 and speed quotient of ditone 42.

Figure 39: This figure shows the parameters of open quotient of ditone 42.

Figure 40: This figure shows the parameters of F0 and speed quotient of ditone 43.

Figure 41: This figure shows the parameters of open quotient of ditone 43.

Figure 42: This figure shows the parameters of F0 and speed quotient of ditone 44.

Figure 43: This figure shows the parameters of open quotient of ditone 44.

3.5 Distinctive Features of Ditoneme

The patterns of F0, speed quotient and open quotient can be described and defined by the distinctive features, which are given in the following 3 tables. From these tables, relationships among these patterns can be easily seen.

F0		first		syllable	
		tone 1	tone 2	tone 3	tone 4
second	tone 1	H + H	R + H	D + H	F + H
	tone 2	H + R	R + R	D + R	F + R
syllable	tone 3	H + L	R + L		F + L
	tone 4	H + F	R + F	D + F	F + F

Table 1.

Table 1: Table 1 shows the patterns of F0 of ditonemes described by distinctive features of F0.

speed quo.		first		syllable	
		tone 1	tone 2	tone 3	tone 4
second	tone 2	H + H	F + H	HF + H	RF + H
	tone 3	H + F	F + F	HF + F	RF + F
syllable	tone 4	H + R	F + R		R + R
		H + R	F + R	HF + R	RF + RF

Table 2.

Table 2: Table 2 shows the patterns of speed quotient of ditonemes described by distinctive features of speed quotient. Although some of the feature letters, such as H, F and so on, are as same as those used in describing patterns of F0, they are quite different in values.

open quo.		first		syllable	
		tone 1	tone 2	tone 3	tone 4
second	tone 1	H + R	H + H	F + H	F + R
	tone 2	H + R	H + R	F + R	F + R
syllable	tone 3	H + R	H + R		F + R
	tone 4	H + R	H + H	F + H	F + R

Table 3.

Table 3: Table 3 shows the patterns of open quotient of ditonemes described by features of open quotient.

4. DISCUSSION

In the study of EGG signal, the way of data treatment is very important. Different results will be got by different methods just according to your research purpose. In this section, we will discuss it briefly.

4.1 EGG Parameter Treatment

The parameters, such as, F0, speed quotient and open quotient, extracted from EGG signals of different persons are quite different. Some of them are good and some of them are not good. The reasons are variable. The first reason is the EGG signal is not good, especially those got from females. The second is the algorithm used in parameter extracting and the control parameters of the program. The third reason is some persons' parameters, such as speed quotient, do not show clearly regular, but only a tendency. So different way of data treatment should be chosen according to the concrete parameters.

4.2 Common and Personal Features

In this study, we have found that parameters of different persons are quite different, which show strong personal characteristics. For instance, speed quotients of some persons are regular and stable, so the relationship with other parameters can be easily found. But others are not. For instance, speed quotient of M1 (male speaker no. 1) has his own characteristics. That is the speed quotient suddenly jumps from high to low at certain point of the fundamental frequency, which we call it as boundary frequency of speed quotient, whenever the fundamental frequency crosses the point from high to low or from low to high. So there are distances between the common features and personal characteristics. Another way is to classify data into several subclasses and then determine the common features of subclasses respectively.

5. CONCLUSION

The conclusion is that speed quotient, open quotients and F0 have close relations in ditones, which are different with those in the sustained vowels and show the changes of phonations in real speech of Mandarin. So the EGG model (model of F0 and phonation) of ditoneme is composed of the 3 patterns.

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* This research is a part of the project, "Acoustic Study on Phonation types of Languages in China", supported by China National Foundation of Natural Sciences. Ratified No: 19674075.

