RESEARCH ON THE SEMIVOWEL BY DYNAMIC PALATOGRAM IN STANDARD CHINESE

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ABSTRACT

Through the combination of acoustic analysis of speech and dynamic palatogram, researches are done on phonetic properties of /y, w, yu/ as initials and /i, u, v/ as main vowels and transition vowels (介音). This paper points out /y, w, yu/ as initials are of properties of semivowels; while /i, u, v/ as transition vowels still stick to properties of vowels, though they change more quickly and therefore can be called glides.

Key words: Standard Chinese, Semivowel, Dynamic palatogram.

1. INTRODUCTION

The semivowel is a segment, which carry the phonetic properties of vowel and can act as a consonant in terms of phonology. [1] Accordingly, a semivowel, first of all, has its properties of vowels which means that vocal cords are vibrating when pronouncing them. In the aspect of acoustics, they share the formant pattern of a vowel. Secondly, it can merely act as a consonant, a starting segment of a syllable, but not function as the core of a syllable like vowel. Lass [2] considered that /j/ (“y” in “yes”) and /w/ (“w” in “win”) were quick utterances of vowels /i/ and /u/ in English, and ascribes them to segments of [-cons] [-voc] in SPE system. Lass named this kind of sound “glide”.

In Standard Chinese, /y/ ("yan") , /yu/ ("yuan") and /w/ ("wan"), which only play a role of consonants phonologically, but have properties of vowels, are called “semivowels”. /i, u, v/ on the contrary, are vowels that can both act as main vowels and transition vowel of finals. For example: /i, u, v/ in “tiao”, “tui”, “juan”. (NB: /i, u, v/ are another written forms of /y, w, yu/ when they are transition vowels or main vowels.) This kind of transition vowels is similar to glide in English. Their common point is changing more quickly and shorter duration than vowels.

The purpose of this paper is to find out difference in phonetic properties between vowels and /y, w, yu/ as consonants or transition vowels, including physical-articulatory and acoustic aspects.

2. RESEARCH METHOD

2.1 Speech materials

Through the application of Electropalatograph(EPG) and acoustic analysis software of speech, we established corpus of dynamic palatogram of speech in Standard Chinese of two speakers (one male and one female). The research demonstrates the advantage of dynamic palatogram in the field of observing articulator features. For instance: closing phase (成阻) and closed phase (持阻) of consonant and can’t be detected in acoustic analysis, but shown clearly in dynamic palatogram [3]. The research collects 184 female samples of /y, w, yu/ in monosyllable words, BI-syllable words, phrases and sentences. These samples are respectively palatogram data and formants data of /y,w,yu/ in positions of initials, transition vowels and main vowels.

2.2 Experiment method

The standard of collecting data of semivowels and transition vowels is to pick up the formants and the palatogram of the starting point of a voice onset in syllables containing /y, w, yu/ as initials or transition vowels. If it is a main vowel, then pick up the mid-point of the stable segment in spectrogram. The sampling frequency of speech is 11k, LPC parameter is picked up by auto correlation method, 10ms frame size, 16 order filtering. The sampling frequency of dynamic
The palatogram is 200Hz, and continuous frame display frequency is 100Hz. Each frame has 96 contact points, divided into 12 lines from incisor to soft palate, reflecting the direction of movement of tongue. The amount of contact points at each line represents the Ratio of tongue-palate Contact Area (RCA).

Take semivowel /y/ as an example. In the sentence “在姐姐的桌子上发现了一封信”, the initial consonant /y/ of “yi” is selected in figure 1.

![Fig.1, Waveform, Spectrogram and Palatogram of /y-/]  

The cursor line in fig. 1 marks the starting point of the semivowel /y/ as an initial. The right down view is the palatogram at the same time as the cursor line. The acoustic data are: F(formant) 1=274, F2=2964, F3=3988, F4=4288; RCA= Amount of the activated contact point/96*100%=72%. There entered the contact area of each line in the actual measurement. The distance between the cursor line and the mark line on the right side indicates the duration of the semivowel /y/, while the distance between two mark lines shows the duration of the main vowel /i/.

Fig. 2 is the palatogram of 15 continuous frames interval 10ms after the cursor line. We can see the changes of tongue position, from a semivowel to a main vowel.

![Fig.2, Continuous palatograms display of /y-/ after the cursor line in “ ใน姐姐的桌子上发现了一封信”]

3. RESULTS AND DISCUSSION

3.1 data analysis

The Mean and the standard deviation of the formant data in the samples are calculated. The skewness and kurtosis of its normal distribution is observed to affirm the reliability of Mean data analysis. What follows are acoustic and palatogram features of three semivowels /y,w,yu/ in various positions of a syllable. (table 1)

<table>
<thead>
<tr>
<th></th>
<th>Mean F1(Hz)</th>
<th>F2(Hz)</th>
<th>F3(Hz)</th>
<th>F4(Hz)</th>
<th>RCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>SV/yu/</td>
<td>267</td>
<td>2719</td>
<td>3144</td>
<td>4121</td>
<td>69%</td>
</tr>
<tr>
<td>TV/v/</td>
<td>347</td>
<td>2544</td>
<td>3228</td>
<td>4093</td>
<td>65%</td>
</tr>
<tr>
<td>V/v/</td>
<td>336</td>
<td>2488</td>
<td>3181</td>
<td>4127</td>
<td>59%</td>
</tr>
<tr>
<td>SV/y/</td>
<td>286</td>
<td>2931</td>
<td>3602</td>
<td>4304</td>
<td>68%</td>
</tr>
<tr>
<td>TV/i/</td>
<td>348</td>
<td>2593</td>
<td>3406</td>
<td>4317</td>
<td>56%</td>
</tr>
<tr>
<td>V/i/</td>
<td>374</td>
<td>2765</td>
<td>3422</td>
<td>4281</td>
<td>51%</td>
</tr>
<tr>
<td>SV/w/</td>
<td>428</td>
<td>632</td>
<td>3508</td>
<td>4138</td>
<td>20%</td>
</tr>
<tr>
<td>TV/u/</td>
<td>516</td>
<td>1137</td>
<td>3432</td>
<td>4101</td>
<td>18%</td>
</tr>
<tr>
<td>V/u/</td>
<td>417</td>
<td>704</td>
<td>3522</td>
<td>4126</td>
<td>10%</td>
</tr>
</tbody>
</table>

Table 2 is the result of comparing semivowels with main vowels.
Table 2

<table>
<thead>
<tr>
<th></th>
<th>Dur</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>Ene</th>
<th>RCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>SV /y/</td>
<td>Sho</td>
<td>L</td>
<td>H</td>
<td>Her</td>
<td>W</td>
<td>Lar</td>
</tr>
<tr>
<td>SV /yu/</td>
<td>Sho</td>
<td>L</td>
<td>H</td>
<td>E</td>
<td>W</td>
<td>Lar</td>
</tr>
<tr>
<td>SV /w/</td>
<td>Sho</td>
<td>E</td>
<td>L</td>
<td>Ler</td>
<td>W</td>
<td>Lar</td>
</tr>
</tbody>
</table>

*compare semivowel with vowel=CSWV

Duration =Dur, Energy=Ene, Short=S, Low=L, High=H, Higher=Her, weak=W, Larger=Lar

Equality=E, Lower=Ler

semivowel=SV

Figure 3 is about the tongue-palate contact when the speaker pronounces /y/ and /i/. The horizontal axis of the coordinate is from L1(first line) to L12(twelfth line). The denominator in the blanket is the number of primary contact points of that line; and the numerator means the activated contact points. Two broken lines clearly show the difference of /y/ and /i/ (/y/>/i/).

**3.2 The properties of Semivowels**

Data in table 1 indicate semivowels /y, yu, w/ as initials have larger RCA than corresponding main vowels and transition vowels. /y/ and /yu/ share typical features as:

- Contact starts from 4L or 5L, while main vowels are 1 line behind.
- Entire contact occurs in 7L or 8L until 10L. This means the tongue surface reaches the hard palate, form a blocks to a certain degree. But it isn’t obstructed completely. When the turbulent flow passes by, the friction is caused. However, the laminar flow goes in the case of main vowels.

No contact occurs in central row at any line completely.

- Table 2 explains /y/ and /yu/ both have low F1 and high F2 close to F3. In some extreme situations, the formants above F2 are too weak to be displayed on the spectrogram (see Fig. 4).

The semivowel /w/ and the main vowel /u/ have slight difference in terms of contact area. /w/>/u/, mainly in 11L and 12L. In the aspect of acoustic features, their F1 are almost the same. F2 of /w/ is lower than /u/ obviously. The typical /w/ only has F1 (or overlapping F1 with F2), indicating that /w/ have a rounder lips shape and lengthen cavity than /u/.

The properties of semivowels are typical in isolated word, or in stressed syllables and initial syllable in phrase or sentences. However, these features get similar to main properties of vowels because of the influence caused by co-articulation.

**3.3 The problem of transition vowel**

In Standard Chinese, the transition vowel /i/ appears in final as /ia/, /ie/, /iao/, /iou/, /ian/ and /iang/. Among them, /iou/ is pronounced as /iu/ in a level (first) tone or a rising (second) tone; as /iou/ in a falling-rising (third) tone or a falling (fourth) tone. [5] /i/’s RCA in this research is 56%, between a semivowel and a vowel. There is no complete contact in any line. In the field of acoustic features, F1 is also in the middle, while F2 is the lowest among the three types. Physiological and acoustic data support it as a vowel instead of a semivowel.
Final containing the transition vowel /v/ are /ve/ and /van/. /v/’s RCA is 65%, between a semivowel and a vowel. There isn’t any complete contact in a line. Both F1 and F2 are in the middle. Physiological and acoustic data indicate it is also a vowel. The transition vowel /u/ occurs in /ua/, /uo/, /uai/, /ui/, /uan/ and /uang/. Among them, /ui/ is pronounced as /ui/ in level and rising tones, but as /uei/ in falling-rising and falling tones. [5] Though /u/’s RCA is close to that of the semivowel /w/, its F1 and F2 are the highest. This indicates /u/’s tongue position is lower than a main vowel; /u/ is influenced by the consonant ahead and has more contact between the tongue and the palate. In a word, transition vowel shares acoustic features with the vowel. The only difference is its shorter duration and glide.

4. CONCLUSION

4.1 In Standard Chinese, /y, yu, w/ as initials are “semivowels”. Compared with vowels, Typical features of /y/ and /yu/ are: large RCA with complete contact in 8L, 9L and 10L; low F1, High F2 and F3 with little power; /w/’s large RCA and extremely close F1 and F2; 4.2 /i, u, v/ as transition vowels are “vowels”. Though their RCA are close to semivowels, which is Caused by the consonant ahead, both their F1 and F2 are higher than semivowels and main vowels. It demonstrates that the three vowels in the position of transition vowels are likely to be affected by the preceding consonant and the following main vowel. Besides, their short duration, rapid changes and the weak energy differs them from vowels to some extent.

5. REFERENCE