

AN INVESTIGATION OF VOICING CONSONANTS IN CONTINUOUS SPEECH

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ABSTRACT

This paper shows the results of an investigation of consonant voicing in an utterance according to labeled read speech and spontaneous speech. Five speakers' materials were researched. Some interesting results were gotten from labeled materials.

1 INTRODUCTION

It is well known that there are no voiced stop and voiced affricative in Mandarin but only one voiced fricative [1]. However, the consonant can change from voiceless to voicing in continuous speech in Mandarin [2][3][4][5]. The author reports the result recently in read speech. This report will further investigate the case in spontaneous speech and give a comparative result with read speech.

2 MATERIALS AND METHODS

The materials come from a read speech database and a spontaneous speech database. Three speakers' materials were researched in read speech and two speakers' materials were used in spontaneous speech. Three speakers' materials were used. Spontaneous speech is a topic for one area, for example sport, traveling or city traffic. Two speakers spoke fluently. There is a little difference for two speakers. Table 1 gives each speaker's syllable numbers. Trained labeler with Praat software did labeling. Labeling results were checked again. Analysis and statistical were done with computer.

3 RESULTS

From the labeling materials, some results can be gotten.

3.1 The percentage results

3.1.1 Read speech

Fig.1 gives the distribution of consonants voicing in read speech. The total number of each consonant includes two parts, voiced and unvoiced. The percentage is the voiced number dividing the total number. Three speakers' materials were shown in Fig.1.

Fig.1 includes 7 voicing consonants. They are unaspirated stops [p], [t], [k], affricative [ts], [tʃ], [tʃ] and fricative[x]. The highest percentage is [t], and then [k]. The highest percentage [t] for speaker M003 is about 32 percent. The other two speakers are about 24 percent and 29 percent. The other voicing consonants are lower than 20 percent.

3.1.2 Spontaneous speech

Fig.2 shows the percentage distribution of each consonant voicing of two speakers. All voiceless consonants show the voiced case. It is evident that unaspirated stops have the most numbers among listed consonants. Then unaspirated affricative and fricatives [ʃ], [x]. Aspirated stops and affricatives have lower numbers.

Among the consonant, [k] has the highest percentage among three stops. The number of it exceeds 50 percentages for two speakers, which shows that it is more often voiced in spontaneous speech. [t] shows over 40 percentage. The percentage of [p] is higher for speaker S005 but lower for speaker S020. That means the two stops are often voiced in spontaneous speech. Unaspirated affricative and fricatives [ʃ], [x] are on the second level. Fricative [ʃ] shows 37 and 42 percentage separately and [x] shows 24 and 35 percentage separately. Total numbers of [p ʰ], [t ʰ], [s] are lower in S020 and [ts ʰ] lower in S005.

3.2 Correlation analysis

Fig.1 and Fig.2 show the difference among speakers. Do speakers show the different tendency in pronunciation? A correlation coefficient is got for each pair in read speech and spontaneous speech separately. Table2 gives the correlation coefficient results. The correlation coefficients are 96, 94 and 95 percent separately. It represents there is high pronunciation consistency among speakers. The correlation coefficient is 74 percent for S005 and S020 in spontaneous speech. The results show the pronunciation consistency is mostly good between speakers but it is lower than that in read speech.

3.3 The analysis of voicing consonants in different styles

According to the previous results, there are both similar and

different parts in read speech and spontaneous speech. Here lists the two parts and table3 gives the list from high to low.

3.3.1 the same part:

There is the same voicing tendency for voiceless stops in read speech and spontaneous speech. It represents the speakers' consistent pronunciation habits. According to the results, the number of voicing from high to low is as the following: unaspirated stops, unaspirated affricatives, fricatives, aspirated affricatives, and aspirated stops.

3.3.2 the different part:

The numbers of voicing consonants are different in two styles. There are 7 consonants in read speech but 17 consonants in spontaneous speech. The latter means all the voiceless consonants in Mandarin may be voiced in continuous speech.

The percentage for each consonant is higher in spontaneous speech than that in read speech. For example for dental stop [t], 45 and 62 percent for speakers S020 and S005 in spontaneous speech and 29, 24 and 31 percent age separately in read speech. The percentage of some consonants exceeds 40, which are unaspirated stops [p], [t], [k], unaspirated affricatives [tʃ], [tʃ], fricatives [ʃ]. The results show consonant voicing is evident in spontaneous speech and needs to be considered.

Table 3 gives the consonants list from high to low for each speaker according to the percentage. The symbols are Pinyin and IPA. [t], [k] show the evident advantage which take the first three positions. Then [ts], [tʃ], [tʃ] and [p] are in the second level. [ʃ] and [f] are higher than the other fricatives. There are no aspirated stops and affricatives in read speech and they are lower in spontaneous speech. It seems that aspirated stops and affricatives are not so easy to be voiced.

3.4 the position of voicing consonant syllable in a word

The voicing consonant often occurs in the final position in a word. According to the read speech materials, 95% of the voicing occurs at the final position in a word and 5% of the voicing occurs at the first position in a word [5]. How about the case in spontaneous speech? Fig.3 gives the results in spontaneous speech. The result shows that there is 84 percent at the final position in a word and 16 percent at the first position or as an isolate word. The total

voicing numbers are 785. Among all the numbers, 129 are at the first position in a word or as one syllable word.

4 DISCUSSION

There are some studies about voiceless and voicing stops [6][7]. This paper shows the results of voicing in continuous speech. There are some problems to be discussed. The first is the reason and mechanism of voicing. The second is the relation of voicing and articulation. The third is how to explain the phenomena in continuous speech. For the first question, the author is sure that voicing is used because of the high compactness between adjacent syllables. Voicing may be controlled by speakers. For the second question, the spectrograms show that during the consonant interval voicing is accompanied with friction. For the third question, there is no better explanation now.

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| Table 1 The syllable numbers of five speakers' materials | | | |
|--|-------|--------------------------------|-------|
| Read speech (syllables) | | Spontaneous speech (syllables) | |
| M001 | 2,900 | S005 | 3,000 |
| M003 | 2,900 | S020 | 2,500 |
| F001 | 2,900 | | |

Table 2 The correlation coefficient between each pair speakers

| Read speech | | Spontaneous speech | |
|-------------|-------------------------|--------------------|-------------------------|
| speakers | correlation coefficient | speakers | correlation coefficient |
| M001-M003 | 0.96 | S020-S005 | 0.74 |
| M001-F001 | 0.94 | | |
| M003-F001 | 0.95 | | |

Table 3 The list of consonants according to the voicing percentage

| | M001 | M003 | F001 | S020 | S005 |
|----|--------|--------|--------|----------|----------|
| 1 | d[t] | d[t] | d[t] | g[k] | g[k] |
| 2 | g[k] | g[k] | zh[t6] | d[t] | d[t] |
| 3 | j[t.] | j[t.] | g[k] | sh[6] | b[p] |
| 4 | zh[t6] | zh[t6] | b[p] | z[ts] | zh[t6] |
| 5 | z[ts] | z[ts] | j[t.] | f[f] | j[t.] |
| 6 | b[p] | b[p] | sh[6] | b[p] | sh[6] |
| 7 | sh[6] | h[x] | z[ts] | h[x] | h[x] |
| 8 | h[x] | sh[6] | h[x] | x[.] | z[ts] |
| 9 | | | | zh[t6] | f[f] |
| 10 | | | | t[t ́] | p[p ́] |
| 11 | | | | p[p ́] | k[k ́] |
| 12 | | | | ch[t6 ́] | x[.] |
| 13 | | | | q[t. ́] | t[t ́] |
| 14 | | | | j[t.] | q[t. ́] |
| 15 | | | | k[k ́] | c[ts ́] |
| 16 | | | | s[s] | ch[t6 ́] |
| 17 | | | | c[ts ́] | s[s] |

