

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 [ʃ]. 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

Figure1 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 Figure1.

Figure1 includes 7 voicing consonants. They are unaspirated stops [p], [t], [k], affricative [ts], [tʃ], [tʂ] 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

Figure2 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 percentages. 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], [tʂ], [s] are lower in S020 and [ts] lower in S005.

3.2 Correlation analysis

Figure1 and Figure2 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], [tʂ], 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], [tʂ] 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? Figure3 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. Speakers may control voicing. 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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Note: The symbols of consonants in Figure 1 and Figure 2 are PINYIN symbols, the relative IPA in the table1.

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摘要

本文考察在连续话语中清声母的浊化问题。包括朗读语料和口语语料，五位发音人的材料。朗读语料是同样文本的含 2900 音节的材料，口语包括两位发音人 2500 和 3000 音节语料。从结果看，浊化在所有清声母音节中都可以出现。从出现的频率看，不送气塞音最高，其次是不送气塞擦音。在两种语料中，浊化一般出现在词中非首音节的位置，极少出现在词首的位置。浊化现象主要是语音的非重读造成。

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[tʂ]	d[t]	d[t]
3	j[tʃ]	j[tʃ]	g[k]	sh[ʃ]	b[p]
4	zh[tʂ]	zh[tʂ]	b[p]	z[ts]	zh[tʂ]
5	z[ts]	z[ts]	j[tʃ]	f[f]	j[tʃ]
6	b[p]	b[p]	sh[ʃ]	b[p]	sh[ʃ]
7	sh[ʃ]	h[x]	z[ts]	h[x]	h[x]
8	h[x]	sh[ʃ]	h[x]	x[ç]	z[ts]
9				zh[tʂ]	f[f]
10				t[t̚]	p[p̚]
11				p[p̚]	k[k̚]
12				ch[tʂ̚]	x[ç̚]
13				q[tʃ̚]	t[t̚]
14				j[tʃ̚]	q[tʃ̚]
15				k[k̚]	c[ts̚]
16				s[s̚]	ch[tʂ̚]
17				c[ts̚]	s[s̚]

