ASPIRATED VS. NONASPIRATED STOPS AND AFFRICATES IN STANDARD CHINESE

Zong-j! Wu and Yi Xu

Institute of Linguistics
Chinese Academy of Social Sciences
Beijing, China

ABSTRACT

The distinction between aspirated and non-aspirated consonants in Standard Chinese (SC) is usually described in traditional phonetics as a difference in force or glottis opening. Our experiments, including acoustic analysis, manometers measurements and perception tests with synthesized consonants, revealed that information about aspiration is carried by prolonged turbulence with different features. The perceptual cues for aspiration in affricates also depend upon the tongue positions of the following vowels:

1. Before a high vowel; the aspiration is realized as a fricative /h/ immediately following the releasing noise, while before a low vowel, it is realized as the prolongation of the releasing noise.

2. In English, the aspiration of word initial stops is only a conditional feature; out in many tone languages, especially in Chinese, it is a phonemic feature. In traditional Chinese phonetic works, the nature of aspiration is mostly described in terms of the force of articulation; the aspirated consonants having greater force of articulation than the non-aspirated ones. One of the popular phonetic outline books states: "In aspirated articulation, the air stream expelled from the mouth cavity is stronger than in non-aspirated articulation." It is also mentioned here and there that "an air-flow after release is called aspiration," that "the air-flow in non-aspirated sound is weaker and shorter, and vice versa," and that "for an aspirated sound, the glottis is opened during release; the air pressure is large and the air-flow breathing out is obvious," etc.

In recent decades, thanks to the widely application of phonetic experimentation, phoneticians can study the problems of aspiration more deeply, and the veil of non-aspirate/aspirated distinction are now being raised gradually.

Those studies have brought the discussion of aspiration to a high level.

This paper intends to make further studies on the non-aspirated/aspirated consonants in Standard Chinese in order to raise and answer the following questions:

1. Which is the main perceptual cue for aspiration, the air-stream force, the duration or VOT, or the glottis opening?

2. What are the articulatory processes of these consonants?

3. Are there any different aspirator features between stops and affricates?

EXPERIMENT

Early in 60's we tested all the SC consonants, spoken by two speakers, a male and a female, of the Beijing dialect, using a level recorder (type: BK 2304) to measure the amplitudes and the length of the consonantal segments. The amplitude represents the overall acoustic pressure and the length was measured from the release point to the starting point of vowels.

For measuring the concentration area of noise and the VOT as well as the transition cue in stops and affricates, a Kay sonagram of model 7029 was used. The measurements were measured immediately after the release. The materials were spoken by a male Beijing native.

Two sets of manometers were used to
measured the supraglottic air-pressure and airflow rates; the equipments were constructed by Dr. P. T. L. Tseng, to the Department of Linguistics at UCLA, the experiments were done in their lab at Dr. P. T. L. Tseng's. Two informants male and a female were asked to produce all the stops and the affricates in Standard Chinese; each followed by three vowels (high or low).

For the perception test, a number of non-aspirated and aspirated stops and affricates were synthesized by a synthetic system designed by the phonetics apparatus of the Institute of Linguistics of the Chinese Academy of Social Sciences. (See a series of spectrograms were made of the synthesized syllables.

For comparison, spectrograms from Ming language in Guindu and Bai-ne language in Tibet, which have affricates, are being compared with those of non-assimilated fricatives, in order to examine the nature of the affricates. The materials were kindly supplied by the Institute of Language of the Chinese Academy of Social Sciences.

DISCUSSION

FORCE OR DURATION

To determine whether the force or the length of the noise plays the major role as the perceptual characteristic of the affricates, a number of experiments were carried out. As the strength of the present materials was limited, the stimuli selected were given in Fig.1 and Fig.2 are histograms of the amplitudes measured from the acoustic records, obtained by two subjects A and B (male and female) with a synthe-sizer, from the acoustic records of non-aspirated stops and affricates. These histograms give the distributions of the amplitudes of affricates, especially in /ts/a/ and /ts/, where the excitation of unaspirated stops is too low to be detected. But in the /ts/ and /ts/a/ and /ts/ in Fig.1, the results turned out to be just in the contrary. As we can see in Fig.3 and Fig.4, great differences can be seen in the measurements of the length of the affricates and non-aspirated consonants, that for the stops: the proportion of duration in the aspirated and non-aspirated consonants is 10% while that for the affricates the proportion of duration in the two categories is 14/10 and the proportion of duration in /ts/ is 120/46. On the average we can see that the differences are around 1.3 times in duration and 3.3 times in duration.

Table I gives the data of supraglottal air-pressures of non-aspirated and aspirated stops and affricates. There is no direct proportionality relationship between aspiration and affricates. Moreover, the proportion of air-pressure in /ts/ and /ts/ is 120/46 and in /ts/ and /ts/ is 39/99 by speaker 1 and /ts/ and /ts/ is 35/88 by speaker 2. The air-pressure of aspirated consonants is occasionally weaker rather than stronger than that of non-aspirated ones. Table I gives also the data of supraglottal airflow between aspirated and non-aspirated consonants. It is shown that the airflow between aspirated and non-aspirated consonants is much greater; it is easy to understand. In unaspirated stop consonants, the excitation noise of the consonants is short and is immediately followed by the vowel. There is sometimes a silent gap between CV instead of a noise. In aspirated consonants, although the friction seems to be the result of airflow, the air does not flow continuously out from the vocal tract, cause while the glottis were open. Moreover, the width of the glottis opening is much smaller than that of aspirated consonants (7). So their airflow rate could hardly be measured.

For comparison, the aspiration of consonant is usually defined as a noise. On the acoustic point of view, questions might be raised as: what are characteristic of these two kinds of noise or noise with different parameters? In the spectrograms of the consonants, in an aspirated stop as /ba/, the aspirated section is a sequence of non-periodical noise. So the aspiration produces the noise with characteristics similar to that of fricative /f/ and /h/ and the second part is the same as /b/. Thus a clear boundary between them is shown.

Table II and Table III are histograms of the duration of non-aspirated and aspirated consonants respectively. The results mentioned above, a number of features similar to that of fricative /h/ and /f/ and in Standard Chinese. These can be explained by the different articulation. When the vowel follows an aspirated /ba/, the part of aspiration is longer than that of the consonant as in /ba/; so, the sequence of /ba/ and /ba/ is released and the tongue moves to /ba/; no turbulence is produced. In the case of fricative /h/ and /f/ the aspiration has to be formed by another way; so a /f/ like turbulence is produced. The data of this experiment can be seen in the X-ray film. But in /ts/ and /ts/ and /ts/ when the vowel starts; the tongue position does not move far from the vowel place for the posture of the vowel is homorganic with that of /ts/ and the aspiration is slightly reduced and the turbulence is dissipated by the voice.

RECEPTION TEST

In order to prove the results mentioned above, a number of perception tests were carried out with the aid of a synthe-sizer. Some of the consonants given in Fig.1-4 are synthesized by rules in which the aspirated sections are changed by doubling the amplitude and doubling the length of the fricative part. The spectrograms of the fricative part of the affricates are given based on the results in Table I. The results are shown in the same as the fricative of consonants. Fig.2 is a sample of an affricate /ts/ followed by an open vowel /a/. From left to right /ts/ is a non-affricate /ts/.
is "s" plus "h" with a boundary in the friction, while "p'i" is a prolonged "pi" without any boundary in the friction.

CONCLUSION

The stops and the affricates in Standard Chinese exist two manners of articulation: non-aspirated and aspirated. The perception cues are mostly based upon the noise duration rather than the force. Moreover, the acoustic features of the aspirated noise are different in two types according to the following vowels. The aspiration is formed by adding a /h/ sound after release if it is followed by an open vowel; while formed by prolonging the length of noise if followed by a high vowel homorganic with the consonant.

REFERENCE


It is interesting to have this results revealed in certain minority languages in China. For example, there are non-aspirated/aspirated pairs in Miao language of Guizhou; both the affricates and fricatives can be aspirated. Fig.7 shows two pairs of "sa'/s'a" and "si'/si" in which we can see that "s'a" is prominent.

Fig.5 Spectrograms of synthesized affricates /tp/ in different manners followed by vowel /a/ (see text).

Fig.6 Spectrograms of synthesized affricates /tp/ and /tp/ in different manners followed by vowels /a/ and /i/ respectively (see text).

Fig.7 Spectrograms of non-aspirated and aspirated fricatives /s/ and /p/ in Miao language.