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LARYNGEAL ADJUSTMENTS OF FUKIENESE STOPS
——— Initial Plosives and Final Applosives———

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Abstract

In the present investigation, both initial and final stops in Fukienese were studied by fiberoptic observation with reference to acoustic data.

Initial stops in Fukienese have three categories; voiced, voiceless inaspirates and voiceless aspirates, whereas in syllable final position this distinction is neutralized into one category, including the sounds -p, -t, -k and -ʔ, which are characterized by the absence of the oral release.

As for the initial stops, it was found that if compared with those in Mandarin Chinese, the laryngeal adjustments for the two voiceless types were not influenced by the existence of the voiced type.

As for the final stops, a closed glottis without glottal vibration but with glottalization could be observed at least in the isolated form. The glottalization found in the isolated form, however, sometimes disappears due to speech tempo or the following phonetic environmnnts when the test words were pronounced in the sentence or phrases.

A phonological implication of the study is discussed.

1. Introduction to Fukienese Phonology

Fukienese is a dialect (or language) spoken in the southern coastal region of China.[1] Like many other southern Chinese dialects, such as Cantonese and Hakka, Fukienese has many phonological characteristics which are different from northern dialects like Pekinese.

Restricting the discussion to the consonantal system, the two main characteristics of Fukienese will be discussed. Fukienese has three voiceless types of initial stops, voiced, voiceless inaspirates, and voiceless aspirates, at least in the phonetic level. Pekinese, in contrast, has only two types, voiceless inaspirates and voiceless aspirates.[2] In addition, Fukienese has final stops, -p, -t, -k and glottal stop ʔ, besides final nasal stops, -m, -n, and -ŋ, while Pekinese has only two final stops, -n, -ŋ.[3] These -p, -t, -k, -ʔ sounds as well as -m, -n, -ŋ are characterized by the absence of the oral release and the perceptual cue for identifying -p, -t, -k, -ʔ should lie in the formant transition of the on-glide. (W. S-Y Wang, 1959)

The above-mentioned phonetic characteristics, however, present themselves under certain phonological conditions. As for the intial consonants, it has been described by linguists that the oral voiced stops are followed only by oral segments; oral vowels and oral endings (stops), thus they show complementary distribution with the nasal initial stops, which occur only when they precede nasalized vowels and nasal endings (stops). Thus voiced stops can phonologically be formalized as follows;

$$b, l, g \longrightarrow m, n, ŋ \;/\; \underline{\qquad} \text{ nasal segments}$$

Notice here that the voiced oral stop which corresponds to the nasal stop [n] is [l] instead of [d] in Fukienese, where the [l] sound is said to be pronounced more like a plosive rather than a lateral.[4] Furthermore some phonologists have pointed out that the voiced oral stops in this language are pre-nasalized. (M. Nakajima 1973)

As for the final -p, -t, -k, -ʔ, these sounds can be found in so-called "entering" tone (staccato tone) syllables. In contrast, final -m, -n, -ŋ and ϕ (that means the final segment is a vowel) occur in "non-entering" tone (legato tone) syllables.[5] Entering tone syllables are commonly said to be characterized by the shorter vowel duration. Accordingly, the appearance of final -p, -t, -k and -ʔ is phonologically conditioned by the tonal categories.

Non-entering tones are comprised of five lexical tones as characterized by the vowel pitch contour, and entering tones are comprised of two. (Table I) However, these basic contours are realized only in isolated form or before certain syntactic boundaries (as shown in Table I). Under the other environments, these tones undergo tone sandhi. The syntactic environments of tone sandhi have been discussed by R. L. Cheng (1968), M. Nakajima (1972). W. S-Y Wang (1967) formulated this phonomenon beautifully with a single phonological rule.

Table I

Basic form			Sandhi form	
[non-entering tones]				
Tone 1	high level	→	Tone 7	
2	high falling	→	1	
3	low falling	→	2	
5	high rising	→	7	
7	mid level	→	3	
[entering tones]				
4	short low	-p, -t, -k →	8	
		-ʔ →	2	(non-entering tone)
8	short high	-p, -t, -k →	4	
		-ʔ →	3	(non-entering tone)

In Table I, the number for each of the tones is in accordance with the elementary text book for Japanese students compiled by Y-D Wang (1972). 6) Notice that after the sandhi rule is applied, syllables with final -ʔ shift to non-entering tones' where there is no glottal stop ending while those with -p, -t, -k remain within the entering tones'.

2. The aim of this paper

In a preceding paper (Iwata and Hirose 1976), we reported on the fiberoptic observations of the laryngeal control for the initial consonants of Mandarin Chinese. In the present paper, we have applied the same approach to the study of Fukienese syllable initial and final oral stops. The aim of the paper is to answer the following questions:

1) Does the existance of initial voiced stops cause changes in the laryngeal adjustments for the other types of initial stops, voiceless inaspirates and aspirates, in Fukienese as compared with those for voiceless stops in Mandarin?

2) What are the characteristic laryngeal features for the final applosives -p, -t, -k and glottal stop -ʔ ?

The main body of the present analysis is divided into two parts: in Part I we will deal with initial stops, in Part II with final stops.

3. Subjects and test utterances

3 1. Subjects

In the present experiments, three native speakers of Fukienese (Taiwan dialect) served as subjects.

Subject A: From Tai-Bei (Northern Taiwan). Graduate student of Tokyo University, Lingustics Department.

Subject B: From Tai-Nan (Southern Taiwan) Graduate student of Tokyo University of Foreign Studies, Japanese Linguistics Department.

Subject C: From Tai-Zhong (Central Taiwan) Graduate student of Tokyo University, Chinese language and Literature Department.

All the subjects spoke Mandarin and Japanese fluently. Dialectally subject A's language differed slightly from the other two subjects, whose languages were very similar to each other.

Experimental data of initial plosives was obtained from subjects A and B, and those of final applosives were mainly from subject B, and supplementally from subjects A and C.

3-2 Test utterances

Part I : Initial stops

The following monosyllabic morphemes (written in Chinese characters) were selected for the examination of initial plosives.

bi^7	li^7	gi^7
pi^7	ti^7	ki^7
$*\pi i^7$	$*\tau i^7$	$k\pi i^7$

(* = nonsense syllables)

These monosyllabic morphemes were read in the following carrier sentence.

[li^1 $t\pi e^3$ _____ # $t\int it^8$ $\begin{matrix} li^3 \\ d\mathfrak{z}i^3 \end{matrix}$ ho^3 i^1]

" You take this letter _____ to him "

Tones in the sentence were cited in a form that had received the sandhi rule. Therefore except two syllables, the sentence final one and the test syllable, which were pronounced before the syntactic boundary # , all other syllables were pronounced in the changed form. The morpheme that means "character" was pronounced [li^3] by subject A, and [$d\mathfrak{z}i^3$] by subject B as wall as subject C.

Part II-1 : Final stops in the isolated or citation form

The following morphemes were selected for the examination of the syllable final applosives;

it^4 $*it^8$ tit^4 tit^8 $*lit^8$ τit^8 $ti\text{ʔ}^4$

(* = nonsense syllables)

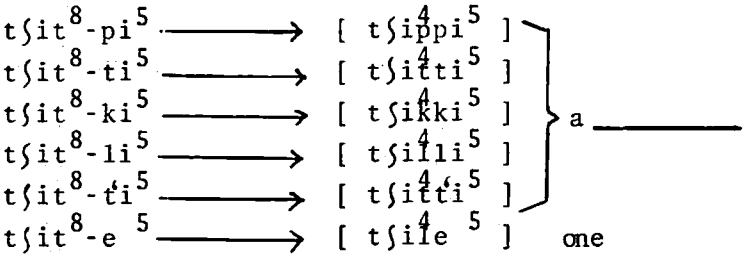
and supplementarily for subject C;

$ti\text{ə}k^4$ $d\mathfrak{z}ip^8$ $ti\text{ʔ}^8$

These syllables were read first in the isolated form and then in the carrier sentence cited above. In this way we observed the laryngeal gestures for final applosives in the isolated form and before the syntactic boundary.

Part II-2: Final stops without following syntactic boundary

The following phrases which consisted of two morphemes were selected for the purpose of examining the closely connected consonant clusters without syntactic boundaries in between;



In these phrases, final applosives of the first syllable are phonetically assimilated to the following initial stops or vowel. (T-H Tong et. al. 1967, pp. 13-14)

For subject C, some more sentences or phrases were prepared for the examination of final stops followed by vowels like,

[Kin^{7}- a^{1}- dʒit^{8}# u^{3}iŋ^{7}bo^{5}] " Are you free today ? "

[Liok^{4} i^{7}-su^{1}] " Doctor Liok "

4. Experimental Methods

4-1 Fiberoptic observation of laryngeal gesture

By use of a fiberscope, 16mm/sec films of the larynx were taken at a rate of 50 frames/sec during the articulation of the test utterances. The speech signals were recorded simultaneously on magnetic tape in order to relate each film frame to the corresponding acoustic events. When the glottis was open, the glottal width was estimated by measuring the distance between the vocal processes frame by frame. When the glottis was closed, observations were made on the false vocal folds, arytenoids, and epiglottis as will be elaborated below.

4-2 Acoustic analyses

The speech signals recorded during the fiberoptic experiments were used for the detailed acoustic analyses. In addition, supplementary acoustic data was obtained from subject B and C.

For the initial stops:

1. Voice onset time (V. O. T.)
2. Articulatory closure duration and the duration of the preceding vowel.
3. Fundamental frequency after voice onset (voiceless type) and after release (voiced type)

For the syllables with final oral stops,

1. Fundamental frequency (F0) for the vowel
2. Duration of the vowel.

The above items were measured on the oscillogram.

5. Results

Part I: Initial plosives

5-1 Temporal change of glottal width

Figure 1 shows typical contours of the temporal change of glottal width for the two types of voiceless stops used in the fiberoptic experiments. In each subset, curves are superimposed with the line-up point at the articulatory release.

In the voiced type, closed glottis with vibration was always observed throughout the whole oral closure period for both subjects A and B.

In the voiceless unaspirated type, closed vocal processes with a spindle-shaped gap in the membranous portion of the glottis could be observed in six samples out of fifteen for subject A. Nine samples for subject A and all samples for subject B show a distinct open glottis. At the moment of oral release, the vocal processes were completely closed (in subject A) or the distance betweenthem became narrower (in subject B).

In the voiceless aspirated type, a wide opening of the glottis was always observable irrespective of the subjects and the points of articulation. However, as for the time when the maximum glottal opening was achieved an idiolectal difference was found to exist. First in subject B, maximum glottal opening was achieved after release in almost all samples. In contrast, in subject A, it was achieved after release for [k^{ϵ}], and before or at the same time for [p^{ϵ}] and [t^{ϵ}].

5-2 Acoustic characteristics

5-2-1 Voice onset time (measured with an accuracy of 1 msec)

The V.O.T. for the voiced type (voicing lead) was identical to the closure duration, as the vocal folds' vibration was maintained all through the closure periods. Three types of stops have clearly been distinguished by V.O.T. (L. Lisker and A.S.Abramson 1964), but it should be noticed here that the acoustic distance in subject B is superior to that in subject A.

5-2-2 Articulatory closure duration and the duration of the preceding vowel

These items were measured with an accuracy of 5 msec.

In both subjects, closure duration for the voiceless unaspirated type was generally longest, voiceless aspirates next, and the voiced type was shortest. On the contrary, duration of the preceding vowel for the voiced type was generally longest except subject B's labial series, while no significant difference could be seen between the two voiceless types.

5-2-3 Fundamental frequency (measured with an accuracy of 0.1 msec.)

There was a general tendency for the F0 for the voiced type to be lower than that for the voiceless types, although this tendency was not so distinct in subject B.

Acoustic characteristics mentioned above are summarized in Table II.

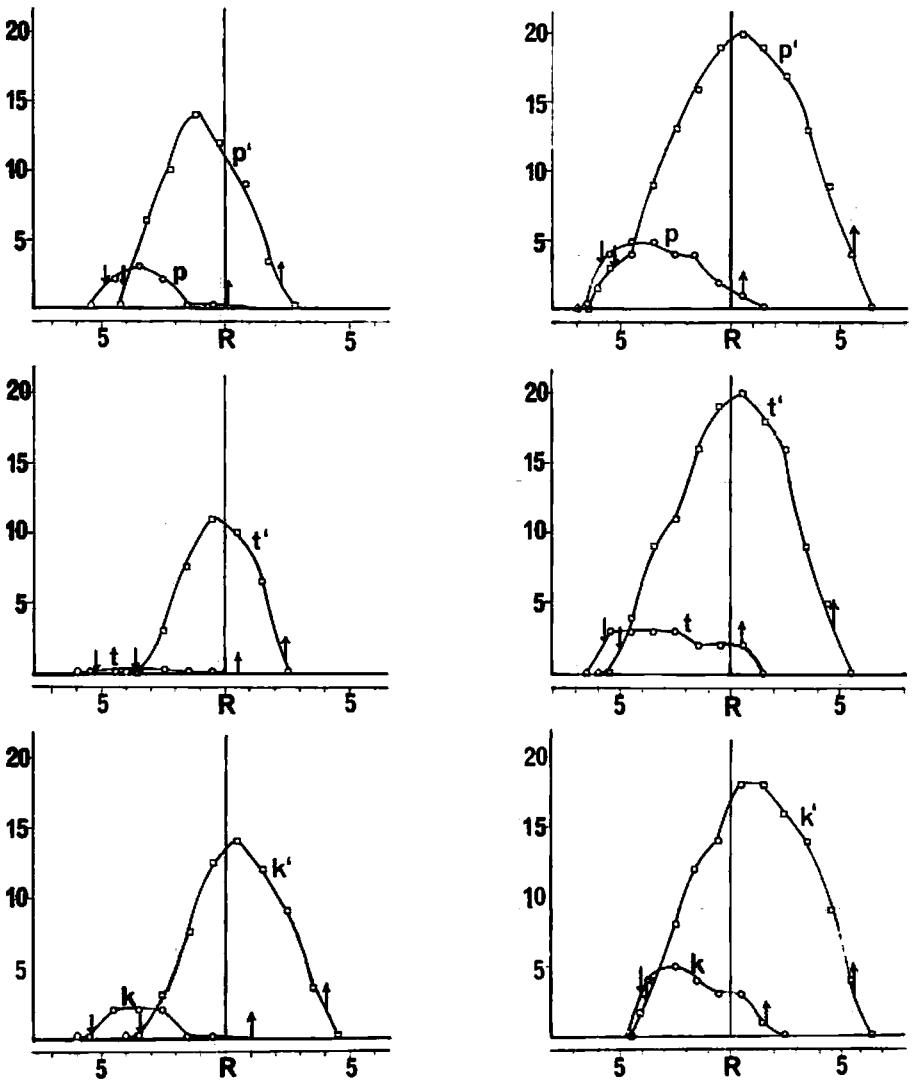


Fig. I: Typical contours of glottal width for voiceless types of stops. In the figures, "o" represents the unaspirated type, and "□", aspirated type. The abscissa represents the frame number counted back from the time of articulatory release, one frame corresponds to the apparent glottal width in an arbitrary scale. "↑" represents voice onset time, "⌂" articulatory implosion, "↓" voice offset of the preceding vowel.

	Subject A			Subject B		
	voiced	voiceless inaspirates	voiceless aspirates	voiced	voiceless inaspirates	voiceless aspirates
V.O.T. in msec. range; average	V. T.	p : 0—8 ; +2 t : 7—10 ; +9 k :15—31 ; +22	p': 30—50; +42 t': 49—72; +59 k': 72—82; +75	V. T.	p : 0—14 ; +7 t : 8—11 ; +10 k : 0—30 ; +21	p': 99—129 ; +118 t': 89—117 ; +100 k': 105—140; +116
F_0 in Hz. range; average	b : 133—139; 136 l : 129—134; 131 g : 124—135; 129	p : 137—149; 144 t : 146—158; 150 k : 134—142; 138	p': 139—152; 145 k': 142—158; 149 k': 138—147; 143	b : 136—144; 140 l : 130—138; 135 g : 127—136; 130	p : 139—158; 145 t : 136—148; 142 k ; 132—149; 140	p': 136—155; 145 k': 142—152; 145 k': 135—150; 145
Closure duration	b,l,g < p',t',k' < p,t,k			b,l,g < p',t',k' < p,t,k		
Duration of preceding vowel	b,l,g > p,t,k ; p',t',k'			l,g > t,k ; t',k' (no significant difference in b,p,p')		

Table II Acoustic Data for Initial Stops

In the table, V. T. means voicing through: that is, the duration of the voicing lead for the voiced type corresponds to the closure duration. Fundamental frequencies were measured near the voice onset for the voiceless type, and near the release for the voiced type.

Part II : Final applosives

5-3 Isolated form

5-3-1 -p, -t, -k

Selected frames of the laryngeal views for a typical sample of the isolated form are shown in Figure II. Closed glottis without vibration is consistently observed for the syllable final -t. Also it should be noted that a rapid adduction of the false vocal folds takes place immediately after the oral closure.[7] The distance between the edges of the false vocal folds was measured at their ends as is shown in the figure. The distance reaches its minimum at about 100-120 msec after the implosion. We regard this activity of the false vocal folds as a characteristic feature of "glottalization" (Fujimura and Sawashima 1971).

Fundamental frequency of the vowels were measured on the oscillogram with an accuracy of 0.1 msec for each of the fundamental periods.

F_0 for the preceding short vowel is in some cases unchanged throughout the whole period, while in some samples a slight drop of F_0 (about 10 Hz) can be observed towards the end of the vowel.

5-3-2 - ʔ

For the syllables with final-ʔ, adduction of the false vocal folds can already be observed soon after the onset of the vowel, with the distance between the false vocal folds reaching its minimum at about 40-60 msec. after the cessation of the vowel, as shown in Figure III. Duration of the vowel with ʔ is commonly longer than that with following supraglottal stops.

A gradual fall in F_0 (about 20-30 Hz) can be observed from the beginning, or sometimes from the midpoint of the vowel portion.

The above mentioned glottalization observed for subject B in the production of final stops was also observed for subject C, in which the glottalization was manifested by a decrease in the distance between the epiglottis and the arytenoid.

5-4 Citation form

In this section, information is available from the observation of final stops followed by the syntactic boundaries.

5-4-1 -p, -t, -k (subject B)

When the test sentence was uttered at a slow tempo, a closed glottis with glottalization was observed for the final stops just as was seen in isolated form. (An example is shown in Figure IV.) In a few samples, however, where the sentence was read at a faster rate and the closure duration became shorter (for the consonant sequence of final stop and [tʃ]), the glottalized gesture was hardly recognizable though the glottis remained closed. An example of such cases is shown in Figure V.

F_0 for the preceding vowel was almost unchanged as was observed in the isolated form, irrespective of the presence or the absence of a following glottalization.

5-4-2 - ʔ (subject B)

For the syllable with a final glottal stop, the glottalization can be observed from the beginning of the vowel portion as was seen in the isolated form. A gradual F_0 drop begins from the former part of the vowel in some

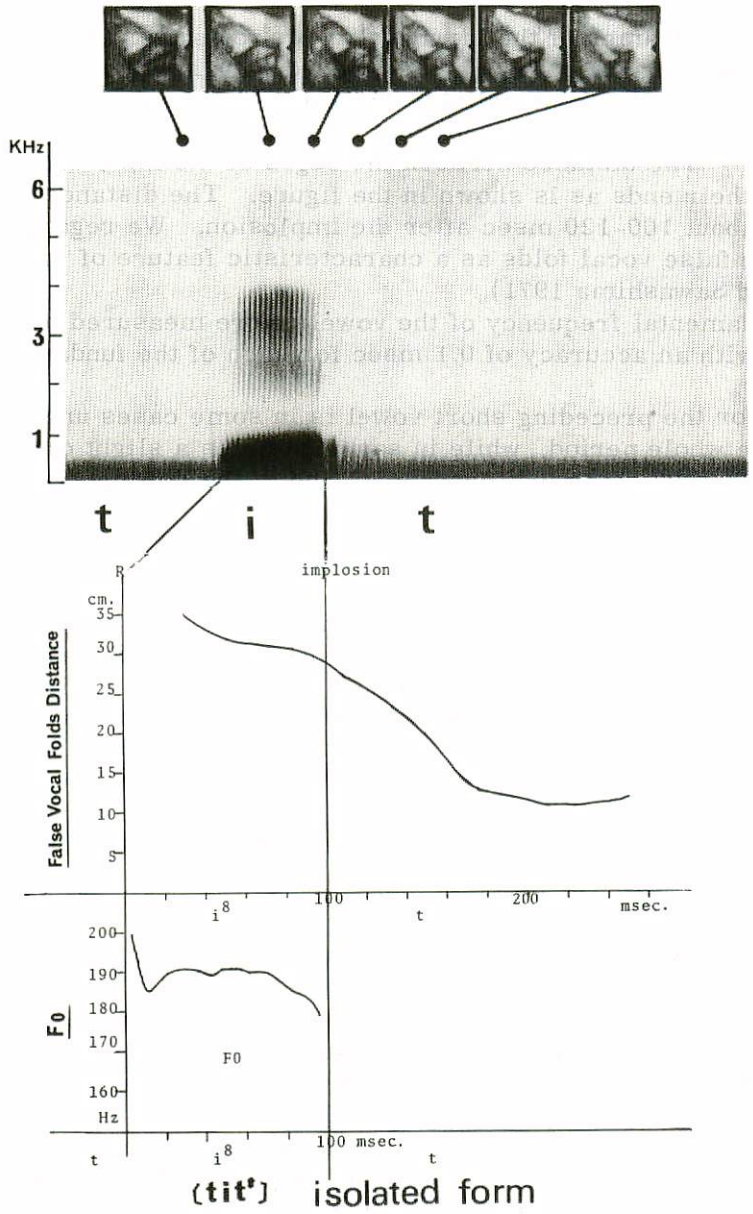


Figure II: Selected frames of the glottal view for [tit 8] in the isolated form with the wideband spectrogram, temporal contour of the distance between the false vocal folds, and the pitch contour of the vowel [i8].

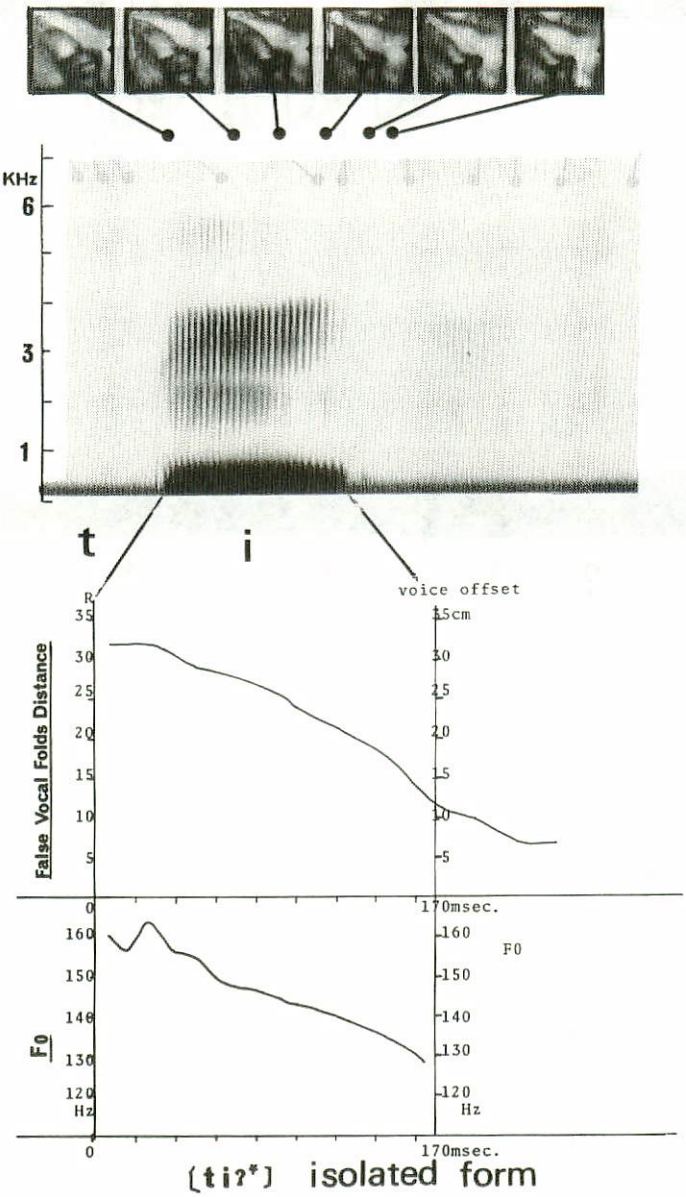


Figure III: Selected frames of the glottal view for [ti 2^4] in the isolated form with the wideband spectrogram, temporal contour of the distance between the false vocal folds and the pitch contour of the vowel [i^4].

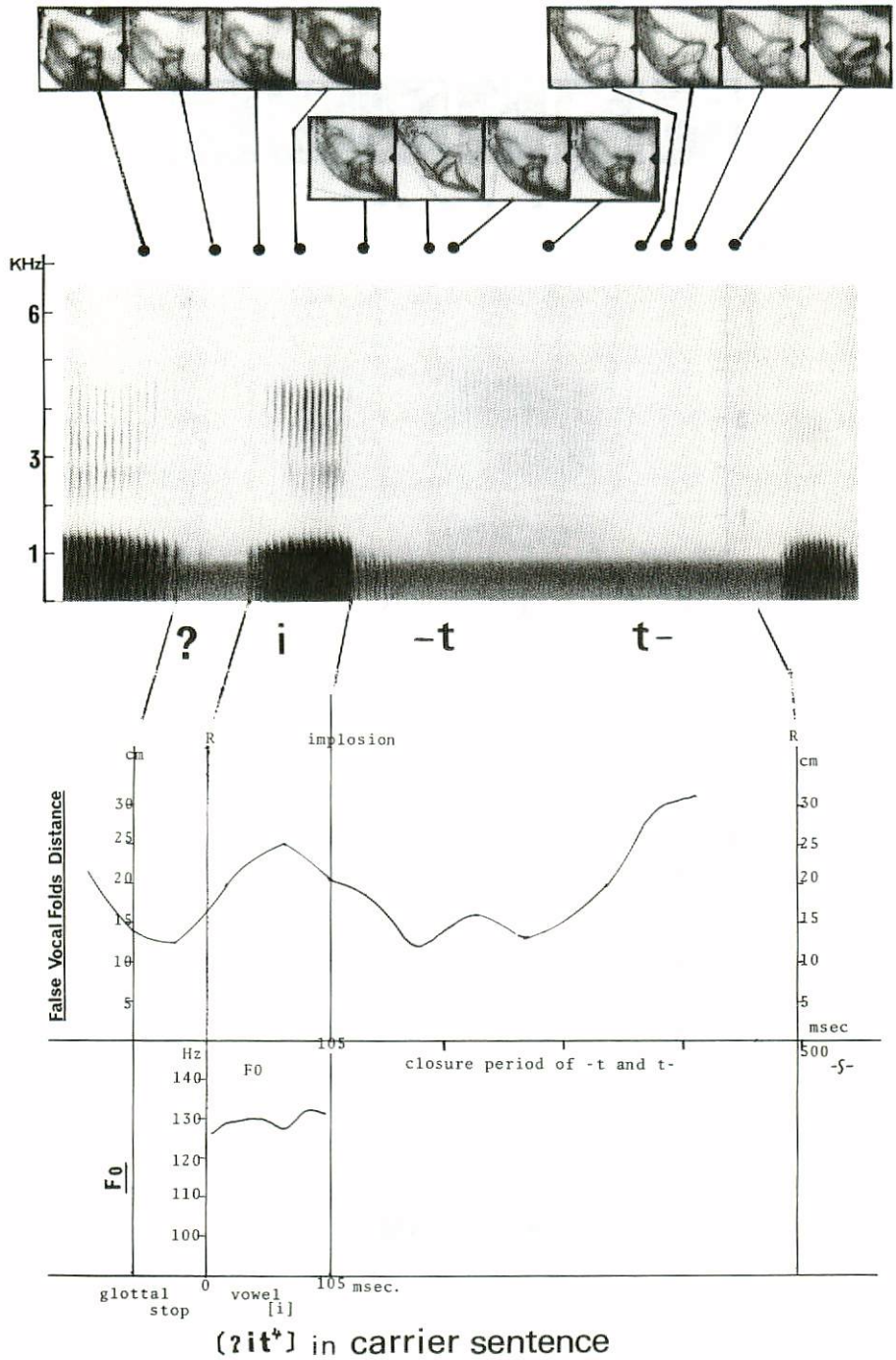


Figure IV: Selected frames of the glottal view for [ʔit^{4}] in the carrier sentence with the wideband spectrogram, temporal contour of the distance between the false vocal folds, and the pitch contour of the vowel [i^{4}].

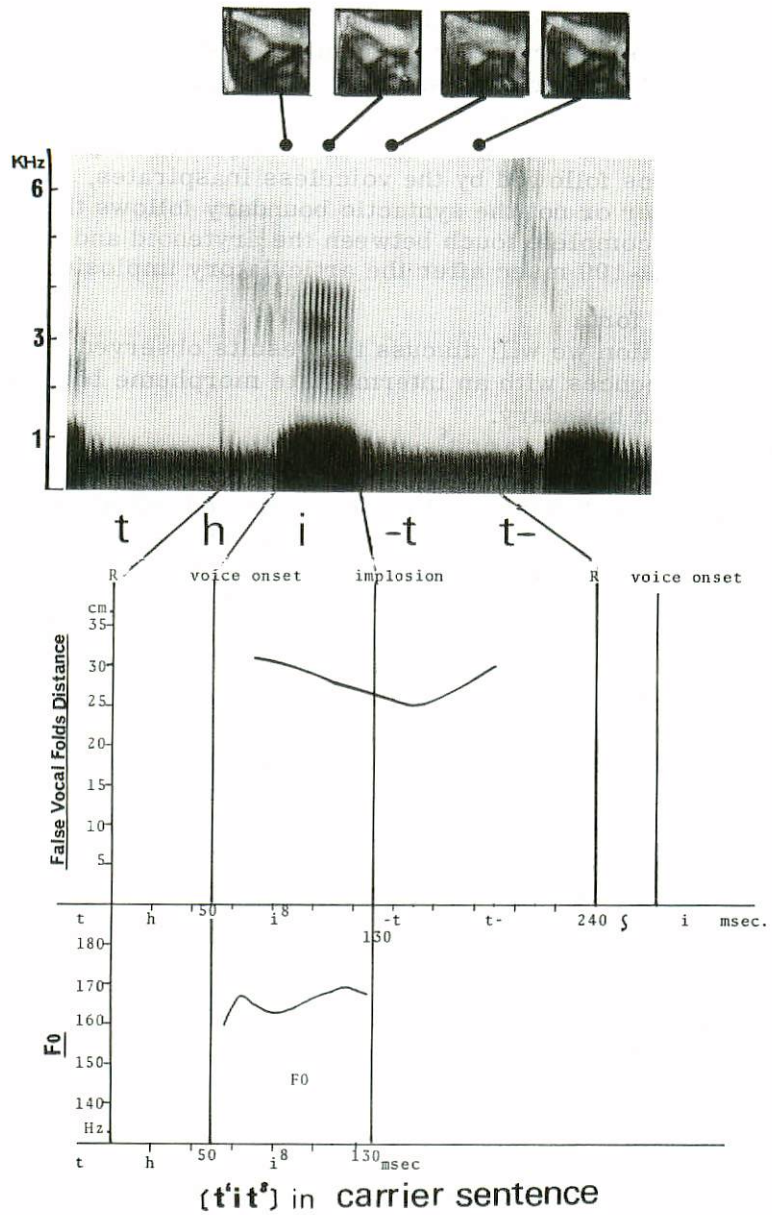


Figure V: Selected frames of the glottal view for [t'it ^{8}] in the carrier sentence with the wideband spectrogram, temporal contour of the distance between the false vocal folds and the pitch contour of the vowel [i ^{8}].

samples, whereas in some other samples from the latter part.

5-4-3 Supplementary data from subject C

In subject C, none of the samples with final -p, -t, -k show the closed glottis; in all samples, the distinct open glottis is shown soon after the oral closure as is observed for the geminated stops; this will be discussed below. On the other hand samples with final - ʔ show glottalization just as was found in the production of the isolated form

Final stops followed by vowels were examined only for subject C. Unlike the final stops followed by the voiceless inaspirates, the glottalization emerges whether or not the syntactic boundary follows them. In such cases minimum or complete touch between the arytenoid and the epiglottis is achieved about 80-100 msec after the articulatory implosion.

5-5 Geminated form

In this section we will discuss the results observed for closely connected stop sequences with an intermediate morpheme boundary but without the syntactic boundary.

5-5-1 -t + -p, -t, -k or t'-

Acoustically, closure duration for the voiceless segments becomes longer as compared with intervocalic non-geminated initial stop, while the duration of the preceding vowel remains short. This evidence is confirmed by the independent recording for subject C, in which several quasi-minimal pairs of geminates and non-geminates like [tʃitti$^{4\ 5}$] and [tʃi^{3} ti^{5}] are uttered several times.

A slightly open glottis (in subject B and C) or closed vocal processes with a spindle shaped gap in the membranous portion of the glottis (in subject A) can be observed provided that the following initial stop is a voiceless inaspirates(cf. M. Sawashima 1971). If the following segment is voiceless aspirated stop, the glottis can be seen to be wide open regardless of the subject. The temporal contours of the glottal width are quite comparable to those found for non-geminated initial stops (Figure VI).

5-5-2 -t + l- or vowel

As was shown in 3-2, the -t + l- sequence is pronounced as a geminated lateral, and in the -t + vowel sequence /tʃit^{8}e^{5}/, the final stop is pronounced like an initial lateral. Geminated lateral does not show any significant elongation of closure duration. Therefore only the feature that the vowel is short remains as the syllabic characteristic of the preceding staccato syllable in these sequences.

5-6 Tonal value of the staccato syllables

Fundamental frequency of tone 4 ranges from about 120 to 160 Hz in the stationary portion. That of tone 8 ranges from 150 to 200 Hz. However there is a general tendency for the tonal value in the isolated forms to be higher than those in the citation forms. This type of evidence was available mainly from subject B. (See the measurements by H. Chiang 1966, R. L. Cheng 1968 .)

6. Discussion

Part I : Laryngeal adjustments of initial polsives

Acoustically three types of stops in Fukienese are clearly discriminated in terms of voice onset time like other languages which have three types of stops, e. g. Thai, Eastern Armenian (Lisker and Abramson 1964). Moreover in the present experiments, three types of stops in

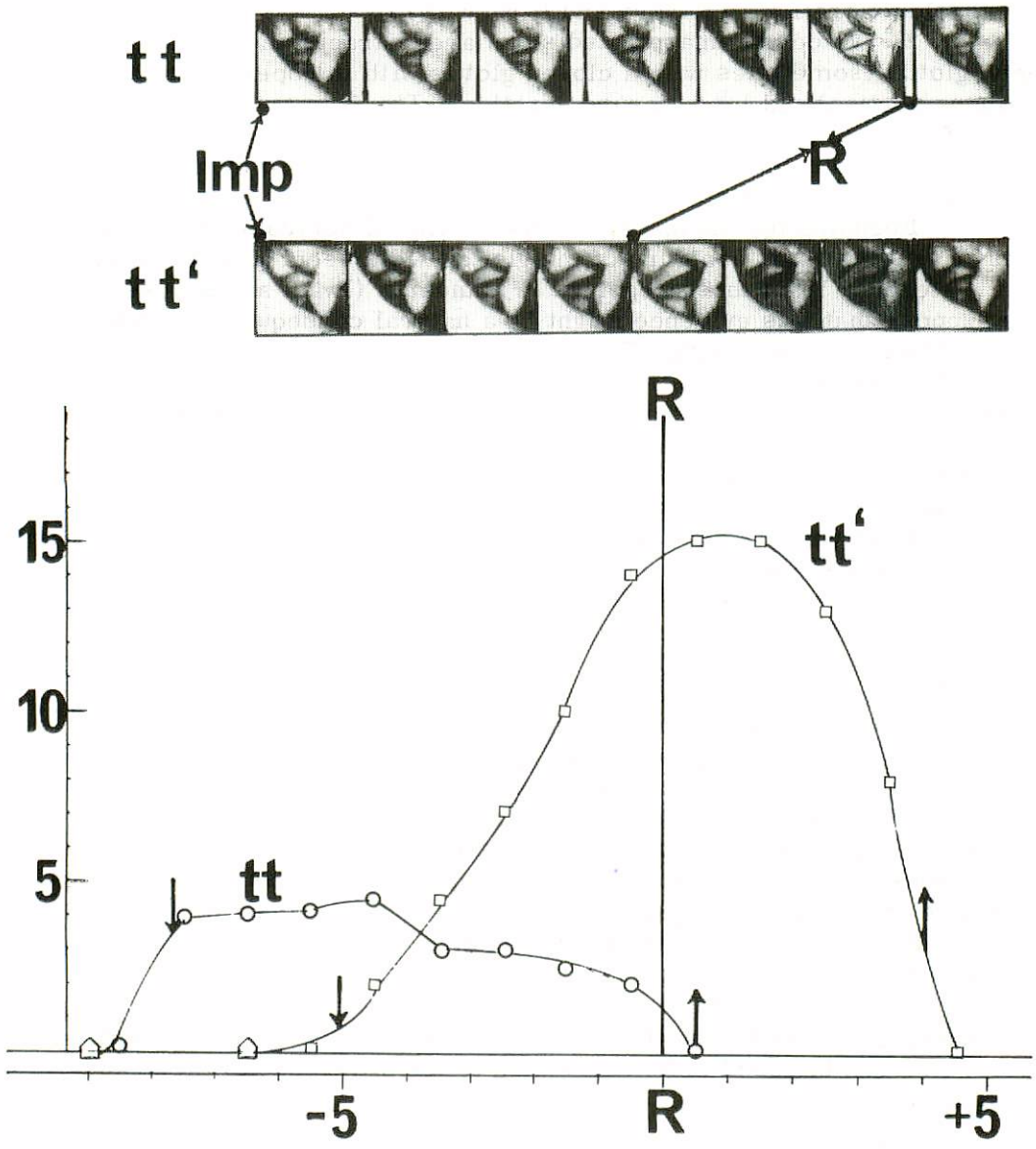


Figure VI: Selected frames of the glottal view for the [tt] in [$t\int i^4tti^5$] and [tt^{ϵ}] in [$t\int i^4tt'i^5$] and the typical contours of the glottal width, corresponding to them.

Fukienese present their physiological characteristics as follows;

1. Voiced stops are characterized by a closed glottis and short closure duration, both of which are favourable for the maintenance of the vocal folds vibration. (Kayaya and Hirose 1975)

2. Voiceless unaspirated stops are characterized by a slightly open glottis (sometimes with a closed glottis with the opening in the membranous portion) and long closure duration. The former characteristics are reflected in the short voicing lag.

3. Voiceless aspirated stops are characterized by a wide open glottis, which is reflected in the long voicing lag.

Focusing the dissussion on the laryngeal controls of the two voiceless types, temporal contours of the glottal width seem to show no significant difference from those reported in Mandarin (Iwata and Hirose 1976). We suppose that this evidence might be a natural consequence in the universal phonetic framework. That is, in the languages in which different types of consonants are distinctly discriminated by the corresponding V.O.T. values, the laryngeal control for each type of consonants has its intrinsic range corresponding to the V.O.T. range. In Fukiensee V.O.T values for voiceless types of stops are comparable to those of Mandarin (Iwata and Hirose 1976), with a certain range of individual variation. The values for the voiced type (i.e., voicing lead) are, on the other hand, far away from voiceless ones. These rather consistent V.O.T. values for voiceless types of stops between the two languages could be caused by the categorical laryngeal control which is common to the languages.

Furthermore idiolectal evidences can be pointed out as below, although these idiolectal characteristics might be caused by the difference of the speech rate between the two subjects.

1. In subject B, maximum glottal width for aspirates was always achieved after or at the same time of the oral release, whereas in subject A, it was achieved before release in many samples. As a result, superior acoustic distance was favoured in subject B over subject A. Shorter as it was, acoustic distance in subject A is adequately permissible in Fukienese, thus a relatively wide range of the laryngeal control seems to be permissable in Fukienese, as we reported for Mandarin Chinese (Iwata and Hirose 1976).

2. In Subject A and sometimes also in subject B, timing difference for reaching the maximum glottal width, as reflected in the different values of V.O.T, can be found to be correlated to the difference of the oral closure point.

Part II: Laryngeal adjustments of final applosives

A sudden stop of vocal folds vibration in syllables with oral applosives is caused by the formation of the oral closure. In the production of the syllables ending in a glottal stop, the closure is formed at the larynx resulting in the comparatively longer duration of the vowel with gradual F_0 drop (J. Lindqvist 1969).

Furthermore what is of interest in the production of final oral applosives is that the closed glottis without glottal vibration accompanied by the glottalization is always observed at least in pronouncing the isolated form. It may be assumed that in order to prevent the vocal folds vibration in the production of voiceless stops, there are two means of laryngeal

adjustments; one is to open the glottis and the other is the present case. (J. Lindqvist 1972) Thus the glottalization observed for the final applosives in Fukienese may be considered to result in a reinforcing effect for the prevention of the vocal folds vibration.

In geminated forms, the laryngeal adjustments are similar to those of initial plosives, while the duration of the oral closure becomes longer than that of initial polsives and the duration of the vowels for the preceding staccato syllables remains short. It is assumed that in the closely connected stop cluster without intermediate syntactic boundary, the feature of the final stop is assimilated to the following stop. However, the syllabic feature associated with the final stop is conserved as a short duration of the preceding vowel and a long duration of the oral closure.

So far as the preceding discussion is concerned, it seems to be probable that the presence or absence of the following syntactic boundary sets the laryngeal feature for final applosives. However these are merely the extreme cases. The situations are far more complicated when the syllables are uttered in a sentence.

In the citation form, in which final applosives are followed by the syntactic boundary, at least three stages of laryngeal gestures can be observed. The first one is exactly the same type as was found in the isolated form. The glottalization could be observed in the citation form of subject B in which the whole sentence was read at a relatively slower tempo and the closure duration was longer. Even though uttered by the same speaker B, the glottalized gesture showed no extremity when the sentence was read at a faster tempo and the closure duration was shorter, in spite of the glottis being completely closed. The third stage could be found in the citation form uttered by subject C at a relatively higher tempo and the closure duration was rather short compared with that in subject B. In that case, neither the glottalization nor the closed glottis could be observed. The glottal condition was just the same as that observed in the geminated form.

Moreover, in the utterance of subject C, the glottalization could always be observed irrespective of the presence or absence of the following syntactic boundary provided that the final applosives were followed by the vowels. This phenomenon may be attributed to the glottal stop for the initial position of the following syllables. (cf. E. Gårding 1971)

Finally, when we observe the syllable[t ʃ it^{8}], such as found in the carrier sentence cited above and followed by the voiced affricates [d ʒi^{3}] without syntactic boundary, it was found that the final applosive [-t] is assimilated to the following voiced segment and pronounced as a voiced stop.

On the other hand the glottalization in the syllables ending in the glottal stop is always present wherever it is followed by a syntactic boundary while it is absent wherever it is not followed by the syntactic boundary. Characteristics of final stops and their syllables are summarized in Table III.

Accordingly as far as the present data is concerned, it can be concluded that the presence of the glottalization for final applisives (-p, -t, -k) is determined by the phonetic environments, such as speech tempo and the following segments, rather than the syntactic or phonological information.

		Environments		Subject	Features of final stops (applosives)				Syllabic features		
		Syntactic boundary followed	Phonetic conditions		Closure duration	Laryngeal features: Open glottis	Voicing	Glottalisation	F0 drop	Duration of vowel	shorter than in the legato tone syllables
Isolated form				B/C		−	−	+		ʔ > t (only in subject B)	
In the sentence	Citation form	+	before voiceless unaspirated [tʃ]	B	long	−	−	+	ʔ : +	ʔ > p, t,	
				B	short	−	−	−	p, t, k : −	k	
				C	short	+	−	−			
	Others	+	before vowel [u]	C	short	−	−	+			
		−	[i]	C	short	−	−	+			
		−	before voiced [dʒ]	B/C	short	−	+	−			
Geminated form		−	pp, tt, kk	A/B/C	> p-, t-, k-	+	−	−			
			tt'	B/C	> t'-	+	−	−			
			tl	B/C	≒ l-	−	+	−			

Table III: Characteristics of final stops and their syllables

6. Concluding Remarks

In the present paper, the laryngeal adjustments for both initial and final stops in Fukienese were investigated.

In conclusion, we would like to discuss the phonolgoical implication of the laryngeal admustments found for the final stops. We assume that the closed glottis without glottal vibration but with glottalization at least in the isolated form might come about because of phonological requirements on the syllabic structure of Fukienese. That is to say, the syllabic or morphemic ending may be signified by the glottalization in the syllables ending in the oral applosives. This demarcating signal, however, is often less marked in the sentences or phrases under the influence of phonetic conditions like speech tempo or the following segments, and final applosives are assimilated to the following segments. Nevertheless what we should keep in mind here is that the final applosives themselves by no means influence the articulation of the following syllables. Notice that in most of the Chinese dialects the "liaison" or the progressive assimilation of the syllable initial segments to the preceding syllable final ones can rarely be found . This evidence might be correlated with the idiosyncracy of the syllabic structure of Fukienese described above.

In contrast, in Korean where the "liaison" or the progressive assimilation of the initial segment is found under certain circumstances, open glottis is always observed even in the production of final applosives in the isolated forms. (Sawashima and Park. 1979) Therefore in the surface syllabic structure, Fukienese could be considered to be set apart from the languages like Korean. We must further speculate whether the same laryngeal adjustments can be confirmed in the other southern dialects, such as Cantonese and Hakka. [8)]

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Notes

1) Chinese languages, exclusive of many languages spoken by the "minority races", are roughly subgrouped into five or seven (Y-D. Wang 1960. J-H Yuan 1960). Fukienese falls under the "Min" group. In a strict dialectal sense, the dialect under discussion should be called a Taiwan dialect of the Min-nan (South Min) dialects group. The Amoy dialect is generally assumed to be representative of Min-nan dialects.

2) From a historical perspective, voiced stops in Fukienese correspond to the Ancient Chinese nasal stops. This is a peculiarity of Fukienese which sets it apart from dialects like the Wu group, which has voiced (aspirated) stops corresponding to the Ancient Chineve voiced stops.

3) Cantonese and Hakka have final stops, -p, -t, -k besides -m, -n, -ŋ; Nan-chaŋ dialect, representative of Gan group, have -t, -k and -n, -ŋ. Wu dialects such as Su-zhou have glottal stop ʔ and -n, -ŋ. Among the northern dialects, some dialects like those in Shan-xi provicne have ʔ in addition to nasal stops.

4) See C. Luo (1930) pp. 6, M. Nakajima (1973) pp. 78-79. Nakajima observed [^{n}d] in some morphemes uttered by a speaker from Taiwan.
5) As for the phonological status of "entering" tone syllables, see T-H Tong (1961), R. Li (1951), Chapter 9.
6) For the readers who are more familiar with the traditional terms of Chinese tones, correspondences between the present and traditional systems are introduced as follows; Tone 1 in the present system is "Yin-Ping" in the traditional one, tone 2 is "Yin-Shang", tone 3 "Yin-Qu", tone 4 "Yin-Ru", tone 5 "Yang-Ping", tone 7 "Yang-Qu", tone 8 "Yang-Ru". Absence of tone 6 is explained by the historical merger of Yin-Yang Shang tones in Fukienese.
7) Glottal vibration ceases immediately after the articulatory implosion. This has been further substantiated by some tentative experiments using Dynamic Palatography.
8) M. Hashimoto (1973) pp. 89 stated for the final applosives in Hakka ".. The ending stops [-b̰^{o}], [-d̰^{o}], and [-g̰^{o}] are also applosives. At the moment of occlusion, whatever the point of articulation is, the glottis is left open. These applosives may therefore be considered as lenes..."
In contrast, C. Y-Y Fok (1974) observed the glottalization for the articulation of final applosives in Cantonese.

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(*Transliterations from Chinese are based on the "Pin-yin" romanized system with the exception of some authors' names.)

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