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ABSTRACT

This study is the sixth in the series "Studies in the Phonology of Asian Languages." A phonetic and phonemic analysis of the three complex nuclei of Vietnamese (Hanoi dialect), spelled (1) ye-, -ie-, -ia, (2) -u'o'-, -u'a, and (3) -uo-, -ua, was carried out using the sound spectrograph. The relative domains of the target qualities of the complex nuclei were established and then compared with those of the eleven simple vowels. Further analysis was done, varying the environment with regard to type of syllable, tone, and initial and final consonants. Regardless of environment, a relative distinctiveness of domain seems to be maintained. (Author/DD)

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STUDIES IN THE PHONOLOGY OF ASIAN LANGUAGES

VI

COMPLEX SYLLABLE NUCLEI
IN VIETNAMESE

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PREFACE

This study, Complex Syllable Nuclei in Vietnamese, is the sixth publication in the series Studies in the Phonology of Asian Languages. It is a result of a research project sponsored by the Office of Naval Research, whose financial support of the project is gratefully acknowledged. This volume serves as a technical report for the contract NR 049-183, Nonr 228(28).

The first volume of the series, Acoustic Phonetics of Korean, Technical Report No. I, was devoted to the acoustic-phonetic study of Korean vowels. The second volume was Duration of Korean Vowels; the third, Acoustic Characteristics of Korean Stop Consonants; the fourth, Vietnamese Vowels; and the fifth, Acoustic Features in the Manner-Differentiation of Korean Stop Consonants. The present volume, VI, is devoted to the study of complex syllable nuclei in Vietnamese. Studies on other phonological features of Korean, Vietnamese, and other Asian languages are in progress and the results will be reported in the near future.

Much of the experimental work of this study was carried out by Michael Earle, while the editorial work was done by Haruo Furukawa and Sylvia Buck.

Mieko S. Han

Los Angeles, California

January 1968

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Chapter 1

PROBLEMS IN THE ANALYSIS OF VIETNAMESE COMPLEX SYLLABLE NUCLEI

In volume IV of this series, Studies in the Phonology of Asian Languages: Vietnamese Vowel, the eleven simple vowel phonemes of the Hanoi dialect of Vietnamese were studied and described. Formant 1 and Formant 2 of the eleven vowels were measured and analysed; the domains of the vowel phonemes relative to one another were studied; tonal and consonantal influences on vowel quality were noted; and a study on the inherent duration of each of the eleven vowels was carried out.

The eleven simple vowels occur as syllable nuclei carrying one of the six phonemically distinct tones. In addition to these simple vowels, there are certain other sequences which also occur as syllable nuclei. Such sequences are found in the following examples.

1) The sequences spelled:

yê-	as in	"yêm"	(to salt or pickle)
-iê-	as in	"tiên"	(immortal)
-ia	as in	"tia"	(jet; ray)

These three sequences all seem to have similar phonetic qualities in that they all sound like a high front unrounded vowel [i] which changes to a mid front vowel slightly more

centralized than [e]. This sequence is tentatively transcribed [Iɜ].

2) The sequences spelled:

-ub²- as in "tường" (bean sauce)
-uá as in "tựa" (preface)

These two sequences both sound like a high central unrounded vowel [w] which moves to a mid central unrounded vowel. Our tentative phonetic symbolization for this sequence is [wɪ].

3) The sequences spelled:

-uô- as in "tuôn" (to throng)
-ua as in "tua" (fringe)

These two sequences both sound like a high back rounded vowel [u] which moves to a mid back vowel slightly more centralized than [o]. Our phonetic symbolization for this sequence is [Uθ].

The first segments of each of these sequences [Iɜ], [wɪ], and [Uθ] have been analysed as /i/ /w/ and /u/ by most analysts who have worked on Vietnamese phonology, but the second segments have caused disagreement. Auditory impressions of [ɜ], [ɪ], and [θ] vary depending on the hearer's own speech background. The American English speaker tends to hear all three as something like schwa [ə], while speakers of other language backgrounds may hear something else.

These three complex syllable nuclei are heard as being distinctly different from the combination of a vowel plus a semivowel. The stress on the second element of the sequences,

[Iɜ], [wɛ], and [Uθ], is heard as being at least equal to the stress on the first element. This suggests the presence of two target vowel qualities rather than a vowel plus a semivowel.

With regard to articulatory characteristics, all three sequences have tongue movement from higher to lower position. It is observed that the second segment of [Iɜ] is pronounced with the lips noticeably less spread than they are for [e]. The second segment of [Uθ] has much less lip rounding than [o].

The several analysts who have worked on Vietnamese phonology disagree in the analysis of these three complex syllable nuclei. The analyses of Nguyễn Đình Hoà, Lê-Văn-Lý, Murray B. Emeneau, and Laurence C. Thompson concerning the complex syllable nuclei in Vietnamese are summarized in the following paragraphs. It will be noted that their interpretations vary considerably. Only those portions of their works which deal explicitly with the phonemic analysis of the problem are presented here. One liberty which has been taken in presenting their analyses is the modification of their phonemic notation to make it conform to that used in this work. This was done to facilitate the understanding of the points of difference between these analysts and to enable one to compare their analyses.

Hoà¹ analyses the above mentioned complex nuclei as "vowel clusters" that are composed of /i/, /w/, /u/ plus the

¹Nguyễn Đình Hoà, Speak Vietnamese (Rev. ed.; Rutland & Tokyo: Charles E. Tuttle Co.: Publishers, 1966).

phoneme /ʌ/. Therefore,

"tiêṅ" is analysed as /tiʌn/

"tu'òh" is analysed as /tʷʌn/

"tuôṅ" is analysed as /tuʌn/

According to Hoà's analysis, the second segment of each of the three complex nuclei is regarded as being the same phoneme [ʌ] in all three cases.

Emeneau's analysis¹ is similar to that of Hoà's.

Emeneau describes the clusters in question as involving movement from the higher vowels /i, ʷ, u/ to /ʌ/. He interprets the clusters phonetically as [iʌ]², [ʷʌ], and [uʌ] and phonemically as /iʌ/, /ʷʌ/, and /uʌ/, respectively.

On the other hand, Lê-Văn-Lý³ analyses the sequences as [ie], [wə], and [uo] and stresses the "monophonematic" character of the sequences, saying that the two constituent elements [i] and [e], [w] and [ə], and [u] and [o] are indissociable, thus proving that they are single phonemes. This makes the total inventory of Vietnamese vowels as follows:

¹Murray B. Emeneau, "Studies in Vietnamese (Annamese) Grammar," University of California Publications in Linguistics, VIII (1951), 10ff.

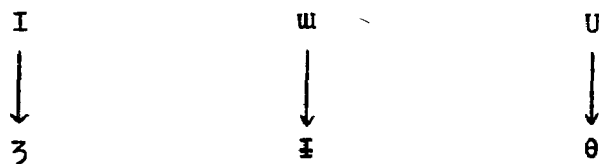
²[ʌ] = unstressed [ʌ]

³Lê-Văn-Lý, Le Parler Vietnamien (2nd ed.; Saigon: Bộ Quốc-Giá Giáo-Dục, 1960).

/i/	/w/	/u/ ¹
/ie/	/wə/	/uo/
/e/	/ə/	/o/
/ɛ/	/ʌ/	/ɔ/
	/A/	/a/

Laurence C. Thompson² views a "vowel cluster" as that which contains two dissimilar vowels in sequence, neither of which is enough less prominent than the other to qualify as a semivowel. In Thompson's analysis the sequences spelled "-ia," "-uā," "-ua" in final position are /i, w, u/ followed by /ʌ/, while the sequences spelled "-iê-," "-uô-," "-uô-" in medial position are /i/ + /e/, /w/ + /ə/, and /u/ + /o/, respectively.

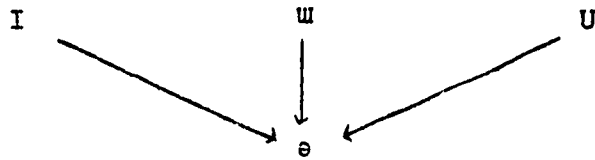
The main point of disagreement in the various analyses seems to spring from the varying interpretations of the phonetic quality of the second segment in question. The first question is, then, are the sequences [Iɜ], [wɪ], [Uθ] three separate phonetic movements from three high vowels to three mid vowels as diagramed below,



¹Note that this table is from Văn-Lý, Le Parler Vietnamiens, pp. 43-44, but the symbols have been changed to follow those used in this study.

²Laurence C. Thompson, A Vietnamese Grammar (Seattle: University of Washington Press, 1965), pp. 30ff.

or are the three segments tentatively described as [ɜ], [ɪ], [θ] phonetically similar enough to be interpreted as one mid central vowel [ə], as the following diagram shows?



Also, are the differences between the sequences spelled -ia, -wa, and -ua in open syllables and those spelled -iâ-, -ub̄, and -uô- in closed syllables so great that they should be considered as two different syllable nuclei, or is the difference a conditioned one?

In order to arrive at a satisfactory phonetic and phonemic interpretation of these complex nuclei, techniques of acoustic-phonetic analysis with the aid of the sound spectrograph were applied. In this way the impressions based on hearing were re-examined and re-evaluated. Data obtained by the spectrograph offer objective facts concerning speech sounds, while human interpretation of these sounds is often subjective, being influenced by the speaker's language background.

The major part of investigation of this study will be concerned with determining the target qualities of the complex nuclei segments, i.e., whether or not the second segments of these nuclei are actually all one vowel or three different vowels, and what are the conditioned variants, if any.

After a careful examination a phonemic interpretation of the complex nuclei will be proposed.

Chapter 2
MATERIALS AND TECHNIQUE

This chapter describes briefly the materials and technique used in the analysis, the results of which will be described in subsequent chapters.

Informants

The four informants who supplied data for analysis are the same as those who assisted in our previous study of Vietnamese Vowels, Vol. IV of this series. Biographical sketches of these informants are briefly presented here.

Informant 1 Nguyễn Hữu Quảng--male, age 30, was born in Haiphong and lived 18 years in Hanoi. He moved to South Viet Nam in 1954 and there attended the University of Saigon. From 1962 through 1965, he resided, as a student, in the United States. His native language is the Hanoi dialect of Vietnamese and he is also fluent in French and English. QUANG believes that his residence in the Saigon dialect area has not affected his speech, as his language habits were already well established by the time he moved to South Viet Nam.

Informant 2 Phạm Gia Huấn--male, age 21, was born in the vicinity of Hanoi. His family moved to Paris, France, at

the time he entered primary school. Though his formal education was conducted in French, Vietnamese was used at home and with friends. His parents were born in Hanoi and lived there until they moved to Paris. He returned to Saigon for his secondary school education and resided there for seven years before coming to the United States in 1962. HUAN speaks both the Hanoi and Saigon dialects but distinguishes the two. According to another native speaker of the Hanoi dialect, the Saigon dialect has not affected HUAN's original Hanoi dialect.

Informant 3 Pham Thị-Ánh Tuyét--female, age 22, sister of HUAN, was born in the vicinity of Hanoi. She had one year of school there before going to Paris with her family. French was used in her formal education, and Vietnamese was used at home. Her secondary education was received at a French school in Saigon where she lived for several years before coming to the United States in 1962. In addition to the Hanoi dialect, she speaks the Saigon dialect, French, and English; but, she feels that her Hanoi dialect is not affected by these other languages.

Informant 4 Phạm Văn Đông--male, age 22, is not related to HUAN and TUYET. His parents came from North Viet Nam, and the Hanoi dialect was always used in his home. For business reasons his family moved frequently around Northern and Central Viet Nam. DONG was born in Đa Nang but moved early in his life to the North. His elementary and high school education was received in either Vietnamese or French, according to the

school attended. DONG attended the University of Saigon for one year and came to the United States in 1962. Because of his frequent changes of residence, DONG is familiar with the Huế and Saigon dialects of Vietnamese, in addition to the Hanoi dialect; but, he regards the latter as his native dialect and feels that he clearly distinguishes the three. He is also fluent in French and English.

Tape Recordings

The prepared scripts were recorded by the informants in a sound proof booth using an AKG C-60 condenser microphone with a pre-amplifier and an Ampex PR-10 single-track tape recorder. Speech was recorded on Scotch or Ampex magnetic tape at a speed of 7.5 inches per second.

Since the informants were experienced in making tape recordings, they were relaxed and relatively at ease in front of the microphone. They were asked to use their normal speech tempo and to pronounce the words as they used them in their everyday speech. As the informants had assisted in drafting the recording scripts, the material was in their own handwriting and they had a certain degree of familiarity with the content of each script. This familiarity enabled them to read smoothly and without hesitations, lapses, or errors. As a part of each recording session, the informants listened to the tapes that they had recorded, checking the script as they listened. This ensured that each utterance recorded passed

the test of acceptability to the native speaker.

The Spectrograph and Spectrograms

An Ampex PR-10 single-track tape recorder was used to reproduce the recorded speech which was channeled directly into a modified model 661A Sound Spectrograph (Kay Sona-graph).

The sound spectrograph is a device which can analyse a sound segment of up to 2.4 seconds in duration. The sound segment is recorded on a disc inside the machine which repeats it constantly while a band-pass filter scans it, moving up the frequency scale from zero to 8000 cycles per second.

The signal from the scanning filter is transmitted to a stylus which is in contact with specially sensitized paper attached to a revolving drum. The resulting artifact is called a sound spectrogram and is a permanent record of the recorded speech segment. The spectrogram shows frequency in the vertical dimension, duration in the horizontal dimension, and gives a rough indication of intensity by the relative darkness of various portions of the spectrogram.

The spectrogram can be made with the band-pass filter set at either 45 or 300 cycles per second which produces narrow-band and wide-band spectrograms, respectively. It is also possible on this machine to record the portion from 0 to 4000 cps twice, one above the other, once with narrow-band and once with wide-band. As the essential features of vowels are realized in this frequency range and as each band-width has

certain advantages, composite spectrograms were most frequently used in this study.

Formants and Formant Measurement

Vowels are characterized by their relatively great resonance compared to consonants. This resonance is strengthened in various areas according to the configurations of the articulatory organs characteristic of each speech sound. These areas of strengthened resonance are called FORMANTS. Each vowel has a characteristic formant pattern, and it has been demonstrated experimentally that the first two formants carry most of the information about the qualities of vowels. In this study, measurements of the first two formants are studied in detail.

While it is easier to identify formants on a wide-band spectrogram, it is possible to be more accurate in the measurement of narrow-band spectrograms. This is the chief benefit of the composite spectrogram.

The procedure for measurement is to measure from the zero line, which is a part of every spectrogram, to the exact center of the formant. On a good narrow-band spectrogram, it is possible to measure reliably to within ± 25 cps. In almost all cases, it is possible to measure to within ± 50 cps.

The steady state of a vowel is defined as that portion of the vowel in which the formants are parallel to the zero line. When there is a steady state of a vowel present, measurements are made at that point in time. Movements of formants

associated with initial and final consonants are called TRANSITIONS. Typically, there is a transition from an initial consonant to the steady state of the vowel and a transition from the steady state of the vowel to the final consonant. In some cases there is no steady state of the vowel since the transition from the initial consonant through the vowel to the final consonant is continuous. In this case the mid-point of the vowel is arbitrarily selected as the point of measurement on the assumption that, at this point, the effect of the initial and final transitions cancel each other out.

Amplitude

The Kay Sona-graph comes with an attachment for measuring and recording on a spectrogram the amplitude contour of a given utterance of up to 2.4 seconds in duration. This contour appears in reference to a base line on the upper portion of the spectrogram. However, there are many factors affecting the amplitude display and care must be taken to avoid invalid comparisons between two amplitude contours.

For our purposes, the amplitude display was referred to only as an aid in distinguishing the most prominent segment of the syllable and in comparing the relative amplitudes of different portions of a single syllable.

CHAPTER 3
TARGET QUALITIES OF COMPLEX NUCLEI

To provide a basis for the analysis of the complex nuclei [Iɜ], [wɛ], and [Uθ], the eleven simple vowels of each informant were re-examined. Our previous study revealed that vowel formant measurements are influenced considerably by neighboring consonants and the accompanying tone. We, therefore, obtained measurements of the eleven simple vowels in a fixed environment which could serve as the basis for comparison with the complex nuclei. Any two phonemically identical sounds may differ phonetically even in the same environment; but, if the environment is specifically limited, similar phones will recur within a small domain definable by a boundary. In the analysis that follows, the relative domains of the eleven simple vowels and also the relative domains of the vowel target qualities of the complex nuclei were obtained. These were then compared with each other to determine the phonetic qualities of the complex nuclei in question.

The eleven simple vowels and three complex nuclei were recorded in the environment /t - n/ with level tone /-/ by the informants. This phonetic environment was selected for several reasons. First, /n/ and /t/ are the only consonants which can

occur after every vowel; and, /n/ was preferred to /t/ because /t/ occurs only with rising tone /˨˨/ and drop tone /˨˨˨/, while /n/ occurs with all six tones. The initial consonant /t/ was then selected because most of the /t - n/ syllables form real words in the Vietnamese language. These syllables were therefore familiar to the informants and could be spoken without hesitation.

The frame sentence "I say the word (); (), (), ()." was used, the test word being uttered four times; e.g., /tōy c̣k̄ cū t̄n̄; t̄n̄, t̄n̄, t̄n̄./ Narrow-band spectrograms were made of five recordings, resulting in 20 sets of Formant 1 and Formant 2 measurements for each vowel. These measurements were then plotted on a formant chart to establish the domain of each of the simple vowel phonemes. The same procedure was followed in making spectrograms, measurements, and charts for the complex syllable nuclei. Then the charts of the complex nuclei were compared to the charts of the simple vowels.

Because Informants 1 and 2 left us before the experiments had been completed, only a limited number of their recordings and spectrograms were available. Informants 3 and 4 furnished most of the data used in this analysis.

Table 1 shows the formant measurements of the eleven simple vowels of Informant 4 in the environment /t - n/ with level tone.

Figure 1 is the corresponding representation on the formant chart of the F1 and F2 measurements presented in Table 1.

The domain of each vowel is represented by twenty occurrences of that vowel in the environment indicated. The formant chart used in this study is the same as that used in our previous study, Vol. IV of this series. The reason for the choice of this formant chart was explained on pp. 69-72 of Vol. IV.

Table 2 represents the F1 and F2 measurements of the eleven vowels of Informant 3 in the environment /t - n/ with level tone. As is known to most workers in acoustic phonetics, it is quite difficult to obtain accurate formant measurements of a female voice since a soprano or alto voice has wide formant bands and widely spaced harmonics which make it difficult to identify the exact frequency value of the formants. To overcome these difficulties and to reduce marginal errors, a large amount of data was utilized and extra care was taken in measuring.

Figure 2 represents the domains on the formant chart of the eleven vowels in the environment /t - n/ with level tone spoken by Informant 3.

As can be seen in Figure 2, the domains of Informant 3's vowels cover a much greater area than do those of Informant 4. Given the above-mentioned characteristics of the female voice, this is to be expected. However, in order to show that these domains are truly representative, we prepared additional material to show the effect of the six tones on the formant measurements of vowels in isolation and, also, material to show the effect of initial consonants on vowel formants.

TABLE 1

Formant measurements of simple vowels in the environment /t - n/: Informant 4 cycles/second

Vowel [i] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tīn	300	2350	3100	300	2300	3050	300	2300	3100	300	2250	3000
	300	2400	3200	300	2350	3150	300	2250	3100	300	2350	3100
	300	2400	3100	300	2300	3200	325	2350	3000	300	2250	3000
	300	2450	3150	325	2350	2950	350	2300	3050	325	2300	3000
	300	2350	3000	300	2350	3000	300	2350	3050	300	2250	3000

Vowel [e] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tēn	600	2100	2850	550	2050	3000	550	2000		600	2000	
	550	2100	2850	550	2050	2900	550	2100	2800	600	2000	2800
	650	2100	2800	625	2100	2850	650	2100	2800	650	2000	2850
	600	2100	2850	600	2100	2800	600	2100		600	2000	2800
	650	2150	2900	650	2100	3000	650	2100	2950	650	2050	2800

Vowel [ɛ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tēn	700	2000	2900	700	1900	2800	700	1900	2850	700	2000	2900
	750	2000	2850	700	2050	2950	700	2000	2950	750	1900	2800
	700	1900	2850	750	1950	2850	700	2100	2850	700	1950	2800
	700	2000	2800	700	2000	2800	700	2000	2800	700	2000	2800
	750	2100	2850	750	1900	2800	750	2000	2850	750	1950	2800

Vowel [a] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tān	900	1500		900	1450		900	1400		900	1350	
	900	1550		900	1500		900	1450		900	1450	
	900	1500		900	1550		900	1500		900	1450	
	900	1550		900	1500		900	1450		900	1500	
	900	1550		900	1500		900	1500		900	1500	

Vowel [A] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tĀn	825	1400		825	1500		825	1500		850	1500	
	850	1400		850	1400		850	1450		850	1450	
	850	1500		850	1450		850	1400		850	1400	
	850	1500		900	1400		900	1500		900	1500	
	900	1500		850	1550		900	1450		900	1450	

Vowel [A] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tĀn	750	1500		775	1400		750	1350		750	1400	
	700	1500		700	1450		700	1450		700	1400	
	750	1400		750	1350		750	1350		750	1350	
	750	1400		750	1350		750	1350		750	1400	
	750	1500		750	1450		750	1400		750	1350	

Vowel [ə] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tĕn	650	1400		600	1400		625	1300		600	1350	
	600	1400		600	1350		600	1250		575	1350	
	650	1400		625	1400		600	1400		650	1450	
	600	1400		600	1400		600	1400		600	1350	
	600	1400		600	1400		600	1400		600	1400	

Vowel [ɐ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tĕn	500	1400	2800	500	1450	2800	475	1400	2800	500	1350	2850
	550	1500	2800	550	1400		550	1450		550	1450	2900
	550	1450	2900	550	1450	2900	550	1450	2850	550	1450	2900
	525	1400	2900	525	1450	2850	550	1400	2750	550	1450	2900
	550	1400	2900	550	1400	2800	550	1350	2950	550	1350	2850

Vowel [ɔ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tōn	700	1000		700	950		700	950		700	1000	
	700	1050		700	1100		700	1050		700	1000	
	700	1050		700	1100		700	1050		700	1000	
	700	1100		700	1000		700	1050		700	1050	
	750	1050		750	1050		750	1050		750	1050	

Vowel [o] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tōn	550	1100		500	1000		500	1100		550	1100	
	500	1000		500	1050		550	1000		550	1000	
	600	1050		600	1050		600	1050		600	1050	
	600	1050		600	1050		600	1050		575	1050	
	550	900		550	950		550	1000		550	1000	

Vowel [u] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tūn	300	800		300	800		300	800		300	800	
	300	800		325	800		325	800		350	800	
	300	800		300	800		300	800		300	800	
	300	800		300	800		300	850		300	850	
	300	800		300	800		300	800		325	850	

Blank spaces indicate where precise measurements were not obtainable.

FIGURE 1

Simple vowels in the environment /t - n/

Level tone

Informant 4

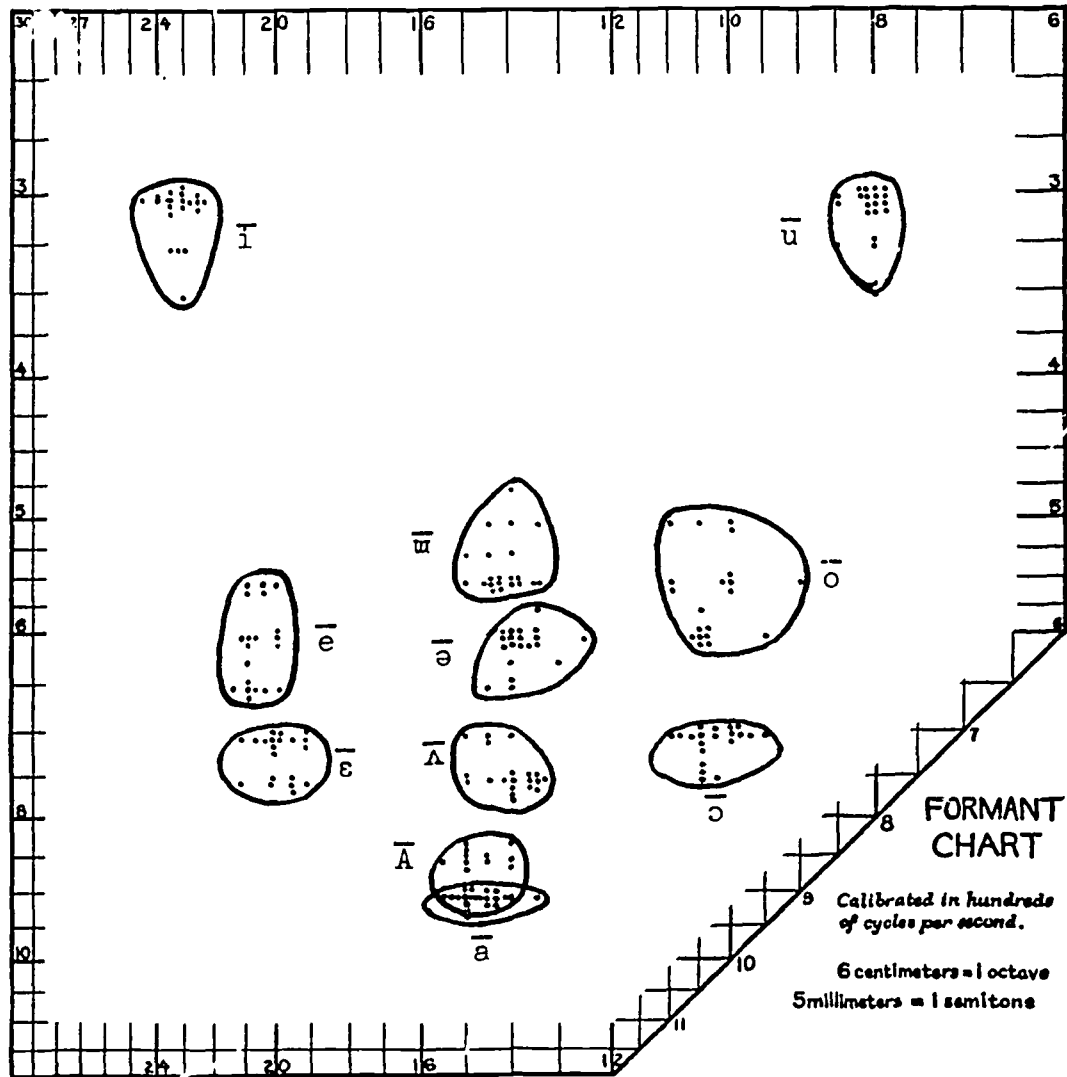


TABLE 2

Formant measurements of simple vowels in the environment /t - n/: Informant 3 cycles/second

Vowel [i] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tīn	400	2650		400	2650		400	2750		400	2800	
	400	2650		400	2700		400	2700		400	2700	
	400	2700		400	2700		400	2750		400	2750	
	400	2750		400	2700		400	2650		400	2750	
	400	2800		400	2750		400	2700		400	2700	

Vowel [e] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tēn	550	2500	3050	550	2550		550	2450		550	2450	3000
	525	2450		500	2550		500	2500		500	2550	
	525	2450		500	2550		525	2450		500	2350	
	550	2450		550	2400		550	2400		600	2400	
	550	2400		525	2400		500	2350		550	2400	

Vowel [ɛ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tēn	800	2300	3200	750	2350	3100	775	2350	3150	800	2350	3150
	750	2350	3100	800	2350	3150	800	2450	3200	800	2300	3150
	800	2400		800	2400	3150	800	2350	3150	800	2350	
	750	2350	3100	750	2400		750	2350		750	2400	
	750	2300		750	2350		775	2350		800	2350	

Vowel [æ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tān	950	1650		950	1600		1050	1600		900	1650	
	1000	1650		950	1600		1000	1650		900	1550	
	1000	1700		1000	1700		900	1700		900	1700	
	950	1600		1000	1650		950	1700		900	1600	
	950	1650		950	1650		900	1600		900	1600	

Vowel [ʌ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tān	850	1750		850	1700		850	1700		800	1650	
	825	1650		850	1750		900	1750		800	1600	
	900	1850		900	1850		900	1550		800	1550	
	800	1550		800	1650		800	1600		850	1750	
	825	1650		800	1650		800	1650		800	1650	

Vowel [ʌ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tān	850	1450		800	1600		800	1600		800	1500	
	800	1650		750	1500		800	1600		800	1550	
	800	1650		800	1600		750	1550		800	1500	
	800	1650		750	1550		750	1550		750	1600	
	800	1650		750	1550		750	1550		800	1600	

Vowel [ə] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tān	700	1350		700	1350		650	1350		650	1350	
	650	1350		650	1350		650	1350		650	1350	
	700	1350		650	1350		650	1350		650	1350	
	650	1350		650	1350		650	1300		650	1300	
	600	1350		650	1350		650	1350		650	1350	

Vowel [ɪ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tān	450	1450		550	1250		550	1250		550	1300	
	550	1350		400	1250		400	1250		550	1350	
	550	1400		550	1400		550	1400		525	1350	
	400	1450		500	1350		400	1200		550	1200	
	500	1400		550	1350		550	1350		525	1300	

Vowel [ɔ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tān	800	1050		750	1000		800	1050		750	1025	
	750	1050		800	1050		750	1025		800	1050	
	800	1050		750	1000		750	1000		750	1050	
	825	1100		800	1050		750	1050		800	1050	
	800	1050		750	1025		750	1025		750	1000	

Vowel [o] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tān	550	1100		500	1000		525	1000		500	1000	
	500	1050		525	1050		500	1050		500	1000	
	550	1050		600	1050		600	1000		600	1050	
	525	1050		525	1100		650	1050		525	1050	
	500	1050		650	1050		600	1000		600	1050	

Vowel [u] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tūn	400	850		400	825		400	800		400	800	
	350	850		350	850		350	850		400	800	
	400	800		400	825		400	800		400	800	
	350	800		400	800		350	750		400	850	
	350	850		400	800		400	800		400	800	

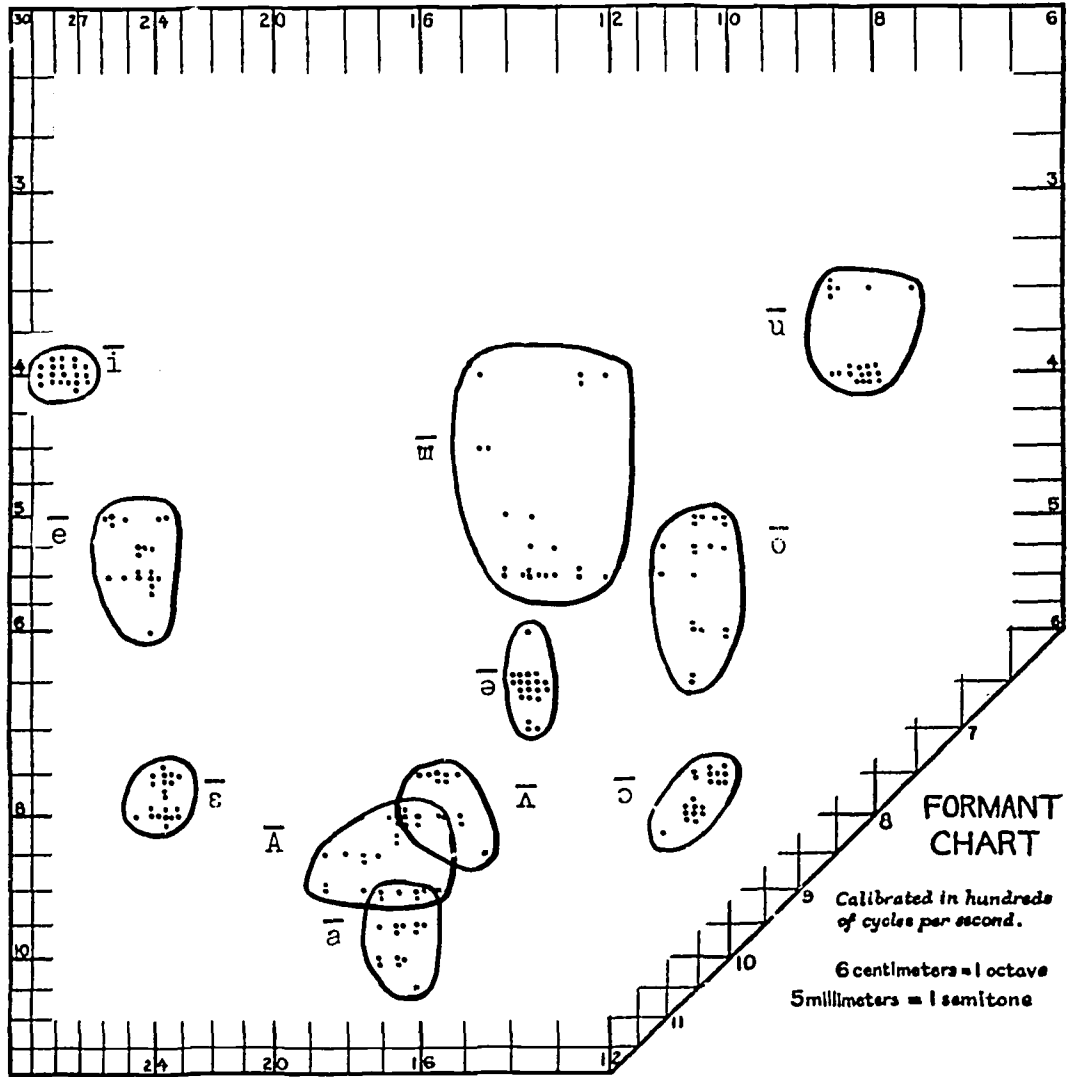
Blank spaces indicate where precise measurements were not obtainable.

FIGURE 2

Simple vowels in the environment /t - n/:

Level tone

Informant 3



Informant 3 had previously made recordings of vowels in isolation with each of the six tones of Vietnamese. Although not all such isolated vowels are meaningful, this sort of exercise is quite common for students of Vietnamese. Since Informant 3 had often demonstrated these vowels and tones as a teacher of Vietnamese, she showed no hesitation in producing them for our study. Spectrograms were made from these recordings, and the F1 and F2 measurements were compiled.

Table 3 presents the F1 and F2 measurements of the vowels in isolation with each of the six tones. Figure 3 is the corresponding graphic representation of these F1 and F2 measurements on the formant chart.

In order to estimate the range of variation which might be associated with different initial consonants, Informant 3 was asked to record each vowel in various syllables composed of one initial consonant and the vowel with level tone. These syllables were recorded as a list of eighteen items in a fixed order, each stressed equally, e.g., /tī, thī, cī, kī .../. Table 4 represents the F1 and F2 measurements obtained from these recordings, and Figure 4 is the corresponding formant chart.

It must be noted that the two vowels /ʌ/ and /a/ occur only in closed syllables and so could not be included in this experiment. Figures 3 and 4 therefore present data for only 9 of the 11 simple vowels of Vietnamese.

TABLE 3

Formant measurements of simple vowels in isolation: Informant 3 cycles/second

Vowel [i] with all tones

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
i	300	2950		300	2750		300	3000				
i	300	2900		400	2850		300	3100		300	2800	
i	275	2950		275	2950		275	2900				
i	400	2800		400	2900		400	3050				
i	350	2850		400	2750		400	2850				
i	350	2900		350	2950		350	3000				
i	400	2950		450	3000		400	3050				
i	450	2800		400	2850		400	2800				

Vowel [e] with all tones

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
e	550	2600		550	2750		550	2700				
e	550	2850		550	2700		550	2750				
e	600	2650		600	2650		600	2650				
e	650	2450		650	2600		600	2650				
e	650	2550		550	2450		650	2550				
e	700	2600		700	2550		700	2650				
e	700	2550		650	2600		600	2550				

Vowel [ɛ] with all tones

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ɛ				900	2700		900	2700		900	2650	
ɛ				650	2650		850	2550		850	2550	
ɛ	850	2600		850	2650		850	2550				
ɛ	850	2500		750	2650		750	2600				
ɛ	900	2450		850	2500		850	2500				
ɛ	850	2400		900	2500		850	2450				
ɛ	850	2500		850	2450		850	2550				
ɛ	850	2500		800	2400		800	2450				

Vowel [ɜ] with all tones

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ɜ				600	1250		600	1250		600	1250	
ɜ				550	1200		400	1150		400	1150	
ɜ	450	1200		450	1200		450	1200				
ɜ	525	1350		525	1350		525	1200				
ɜ	400	1250		500	1300		500	1350				
ɜ	450	1100		500	1150		500	1200				
ɜ	475	1450		450	1350		450	1350				
ɜ	550	1350		600	1450		600	1400				

Vowel [ɛ̄] with all tones

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ɛ̄				850	1450		850	1450		900	1450	
ɛ̄				850	1600		850	1700		800	1650	
ɛ̄	1150	1600		1150	1600		1000	1400				
ɛ̄	950	1550		950	1550		900	1600				
ɛ̄	1000	1600		1000	1450		1050	1600				
ɛ̄	1050	1650		1050	1600		1050	1550				
ɛ̄	1000	1550		950	1550		950	1500				
ɛ̄	900	1500		950	1500		950	1500				

Vowel [o] with all tones

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
o	600	1000		600	1000		550	1150				
o	650	1100		600	1000		600	1000				
o	550	950		550	900		600	850				
o	650	1100		650	1150		650	1100				
o	700	1000		650	1000		650	950				
o	650	1050		650	1150		525	1050				
o	650	1050		550	1000		500	1000				
o	650	1050		600	1000		500	1000				
o	500	1050		500	1000		500	1000				
o	500	1050		500	1000		500	1000				
o	550	1050		600	1000		525	1050				

Vowel [ə] with all tones

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ə	750	1300		750	1250		650	1250				
ə	750	1350		750	1300		750	1300				
ə	750	1200		750	1250		700	1300				
ə	850	1300		800	1250		800	1200				
ə	850	1250		850	1250		850	1200				
ə	850	1350		850	1350		850	1400				
ə	850	1300		900	1400		900	1400				

Vowel [u] with all tones

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
u	400	1050		400	1050		400	1050				
u	400	850		400	800		350	750				
u	350	950		350	900		350	850				
u	450	900		450	950		450	900				
u	450	850		400	850		400	800				
u	300	900		300	900		300	950				
u	400	1000		400	1100		400	1000				
u	400	1000		400	850		400	850				
u	450	900		450	900		450	900				
u	300	900		300	900		300	850				
u	300	1000		300	1000		300	850				
u	400	1150		450	1200		450	1150				
u	300	1000		300	850		300	850				

Vowel [ɔ] with all tones

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ɔ	950	1150		950	1200		950	1150				
ɔ	900	1300		950	1250		900	1250				
ɔ	900	1100		900	1100		850	1150				
ɔ	850	1100		900	1150		900	1150				
ɔ	850	1250		900	1200		900	1200				
ɔ	850	1150		850	1150		850	1100				
ɔ				900	1200		850	1200		850	1150	
ɔ				850	1150		850	1100		850	1100	
ɔ	850	1100		850	1250		800	1100		850	1100	
ɔ				750	1000		750	1000		750	1000	
ɔ				800	1050		800	1050		800	1050	
ɔ				800	1100		800	1050		850	1100	
ɔ				800	1050		800	1050		800	1050	
ɔ				750	1050		800	1050		800	1050	
ɔ				800	1050		800	1050		800	1050	
ɔ	00	1100		750	1050		750	1000		750	1000	

Blank spaces indicate where precise measurements were not obtainable.

FIGURE 3

Simple vowels in isolation

All six tones Informant 3

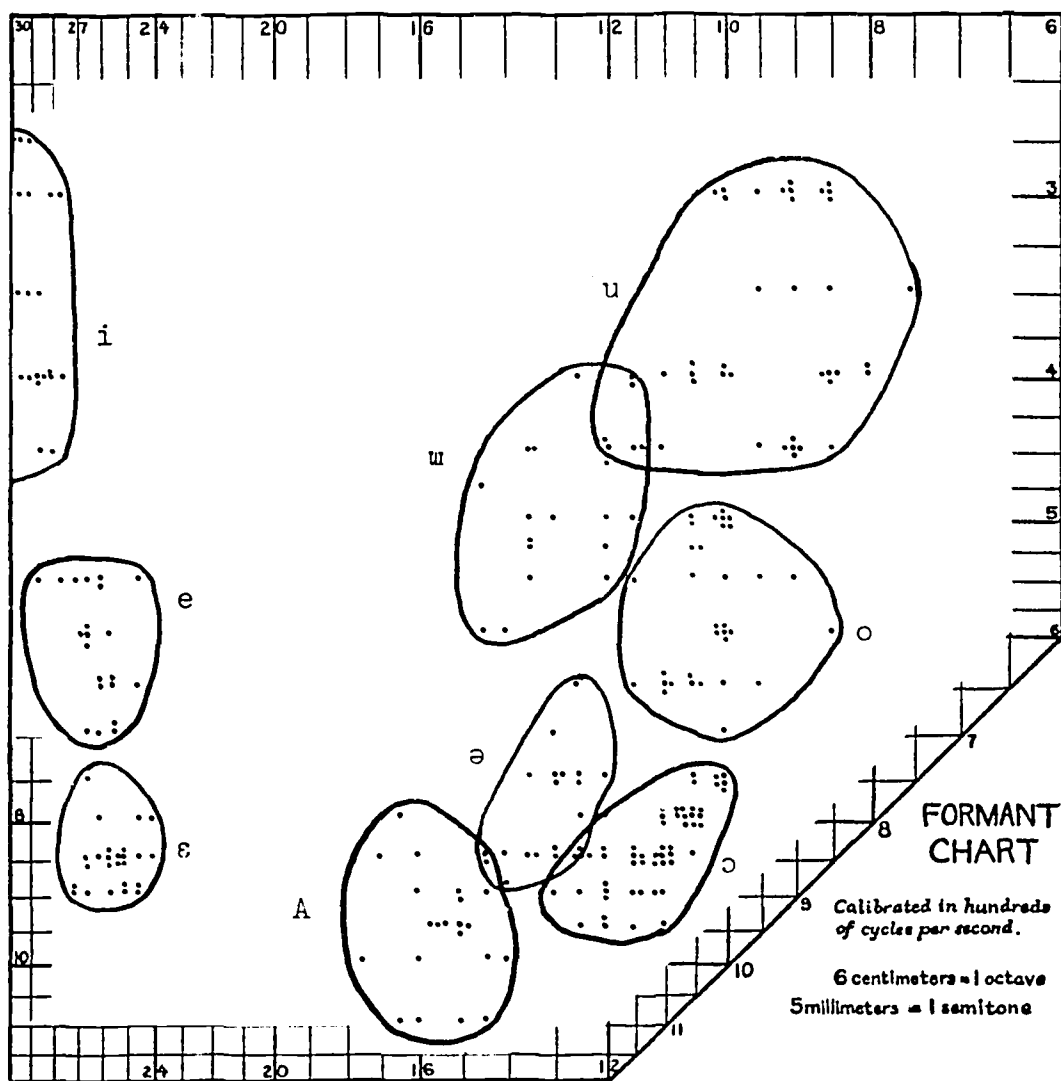


TABLE 4

Formant measurements of simple vowels in open syllables: Informant 3 cycles/second

Vowel [i] with tone [-]

Word	F1	F2
tī	300	2800
t ^h ī	275	2600
cī	400	2850
kī	300	2750
bī	300	2950
dī	275	2850
fī	250	2800
vī	250	2800
sī	400	2900
zī	300	2950
xī	250	2750
gī	400	2850
mī	400	2950
nī	300	2950
ŋī	350	2800
qī	350	2900
hī	275	2850
lī	350	2750

Vowel [e] with tone [-]

Word	F1	F2
tē	525	1350
t ^h ē	550	1350
cē	650	1300
kē	525	1300
bē	525	1300
dē	650	1400
fē	600	1350
vē	600	1300
sē	600	1400
zē	650	1600
xē	500	1350
gē	600	1500
mē	600	1300
nē	650	1450
ŋē	600	1500
qē	600	1500
hē	600	1250
lē	650	1500

Vowel [e] with tone [-]

Word	F1	F2
tē	550	2450
t ^h ē	550	2450
cē	525	2450
kē	550	2600
bē	525	2600
dē	500	2600
fē	525	2400
vē	525	2450
sē	500	2500
zē	500	2500
xē	500	2600
gē	500	2500
mē	500	2400
nē	500	2700
ŋē	500	2550
qē	500	2500
hē	500	2500
lē	500	2500

Vowel [ɛ] with tone [-]

Word	F1	F2
tɛ	800	2450
t ^h ɛ	750	2350
cɛ	750	2300
kɛ	750	2550
bɛ	750	2600
dɛ	700	2500
fɛ	750	2400
vɛ	700	2500
sɛ	700	2300
zɛ	750	2300
xɛ	750	2550
gɛ	700	2500
mɛ	750	2650
nɛ	700	2550
ŋɛ	700	2550
qɛ	700	2550
hɛ	700	2500
lɛ	700	2500

Vowel [ɔ] with tone [-]

Word	F1	F2
tɔ	800	1050
t ^h ɔ	750	1000
cɔ	750	1100
kɔ	800	1050
bɔ	750	1000
dɔ	850	1200
fɔ	750	1000
vɔ	750	1000
sɔ	850	1200
zɔ	850	1200
xɔ	800	1150
gɔ	800	1100
mɔ	750	950
nɔ	750	950
ŋɔ	750	1000
qɔ	750	1000
hɔ	800	1150
lɔ	850	1200

Vowel [u] with tone [-]

Word	F1	F2
tū	300	1500
t ^h ū	400	1450
cū	400	1400
kū	400	1450
bū	400	1450
dū	350	1500
fū	400	1400
vū	400	1350
sū	550	1500
zū	550	1650
xū	400	1400
gū	400	1500
mū	400	1350
nū	400	1650
ŋū	400	1600
qū	500	1400
bū	350	1600
lū	500	1600

Vowel [ʌ] with tone [-]

Word	F1	F2
tʌ	750	1750
t ^h ʌ	750	1800
cʌ	750	1750
kʌ	750	1750
bʌ	850	1650
dʌ	950	1700
fʌ	850	1500
vʌ	950	1550
sʌ	700	1650
zʌ	850	1800
xʌ	950	1650
gʌ	950	1800
mʌ	800	1650
nʌ	800	1850
ŋʌ	700	1850
qʌ	700	1850
hʌ	800	1650
lʌ	900	1600

Vowel [u] with tone [-]

Word	F1	F2
tū	400	850
t ^h ū	400	850
cū	400	825
kū	400	950
bū	400	850
dū	425	950
fū	400	850
vū	400	825
sū	425	800
zū	400	850
xū	400	900
gū	425	800
mū	400	1000
nū	425	850
ŋū	425	800
qū	400	1000
hū	400	850
lū	425	950

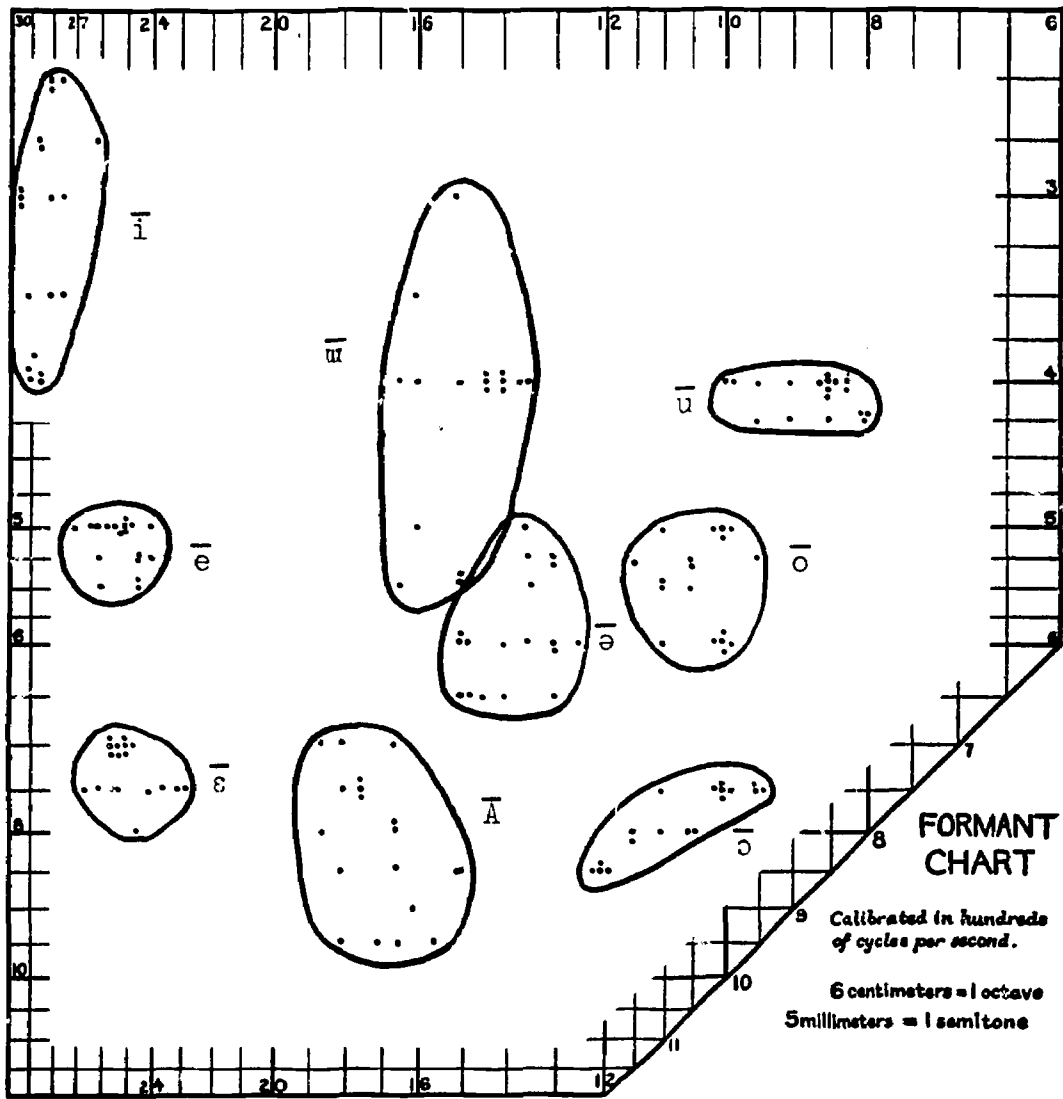
Vowel [o] with tone [-]

Word	F1	F2
tō	550	1100
t ^h ō	525	1050
cō	550	1100
kō	525	950
bō	600	1000
dō	600	1000
fō	600	1000
vō	600	1000
sō	600	1000
zō	550	1050
xō	525	1050
gō	525	1150
mō	500	1000
nō	500	1000
ŋō	500	1000
qō	500	1000
hō	500	1100
lō	600	1100

FIGURE 4

Simple vowels in open syllables

Level tone Informant 3



In looking at Figures 2, 3, and 4, one gets the impression that the vowel domains in these three figures show some difference. This is due to the previously mentioned characteristics of the formant bands of a female voice which make the identification of the center of formants very difficult. However, a careful comparison reveals that the relative positions of the vowel domains in each chart are comparable, and also that the vowels in the /t - n/ environment represented in Figure 2 seem to represent accurately the relative position of each vowel to the others. Figure 3 and Figure 4 may be regarded as extra data supporting 9 of the 11 vowel domains presented in Figure 2. In any event, the relative positions of /e/, /ə/, and /o/ which are of prime importance to this particular study are defined adequately. Therefore, the domains of /e/, /ə/, and /o/ as presented in Figures 1 and 2 will be used when comparing the phonetic qualities of simple vowels with the phonetic qualities of [ɜ], [ɛ], and [θ] in the following experiments.

Informant 1 had previously recorded syllables with the eleven simple vowels in the environment /t - n/ with level tone for a study of the inherent duration of vowels in Vietnamese. He left before we could make recordings of the complex nuclei in the same environment. However, from other recordings prepared by him, we selected some examples of syllables with complex nuclei in similar environments.

The measurements of Informant 1's simple vowels in the environment /t - n/ are reproduced in Table 5, and the graphic representation on a formant chart is seen in Figure 5.

Informant 2, also, had not recorded the desired material for this study before he left us. However, Informant 2's formant measurements were published in substantial amount in our Vol. IV and were useful as references in analysing his complex nuclei.

Spectrograms No. 1a - 11a show typical spectrograms of the simple vowels in the environment /t - n/ as spoken by Informant 4. The same vowels spoken by Informant 3, a female speaker, are shown in Spectrograms No. 1b - 11b. Typical spectrograms of the complex nuclei [Iɜ], [uɪ], and [Uθ] as spoken in the environment [t - n] are shown in Spectrograms No. 12a - b, 13a - b, and 14a - b, for Informants 4 and 3 respectively.

In the changing formants of the complex nuclei, there are no obvious points indicated at which the measurements should be taken. To determine the most reasonable points to be considered as the target or near target qualities of the complex nuclei, several steps were taken. Taking the complex nucleus [Iɜ], for example, first, the boundary between the two segments of the nucleus was identified with extreme care. Observation of steady states, upper formants, and amplitude contour, as shown in Spectrogram No. 15, served to identify the most logical point in time which could be considered as

TABLE 5

Formant measurements of
simple vowels in the environment /t - n/: Informant 1 cycles/second

Word	1		2		3		4	
	F1	F2	F1	F2	F1	F2	F1	F2
tīn			350	2250	350	2250	350	2250
tēn			525	1900	500	1900	525	1950
tēn			600	1900	600	1900	600	1950
tān			800	1400	800	1400	800	1400
tĀn			1000	1350	1000	1350	1000	1400
tĀn			650	1400	650	1400	650	1400
tēn			575	1200	575	1200	550	1200
tūn			375	1300	375	1300	375	1300
tōn			600	1050	650	1100	625	1100
tōn			525	1050	550	1000	525	1000
tūn			350	850	350	850	350	850

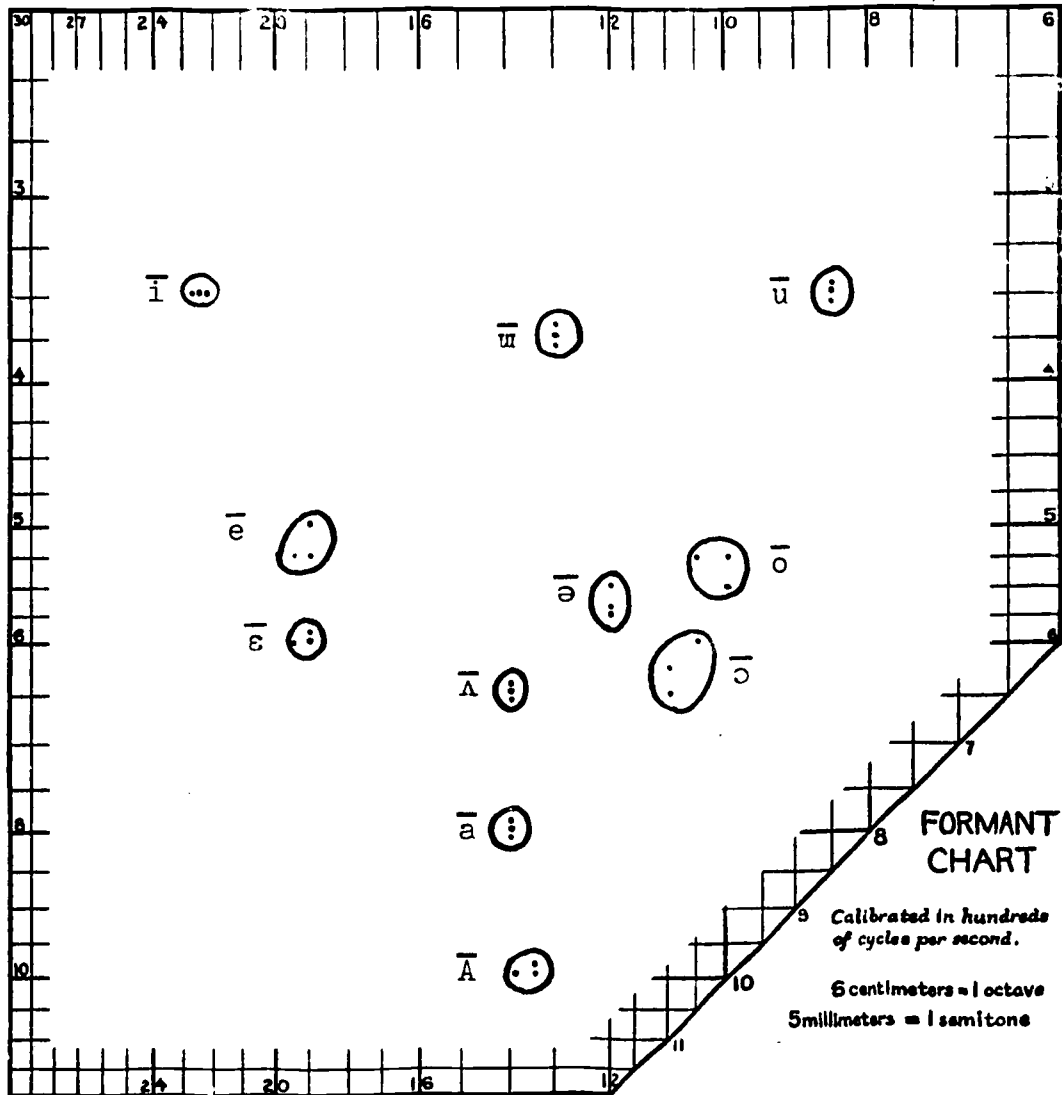
Blank spaces indicate where precise measurements were not obtainable.

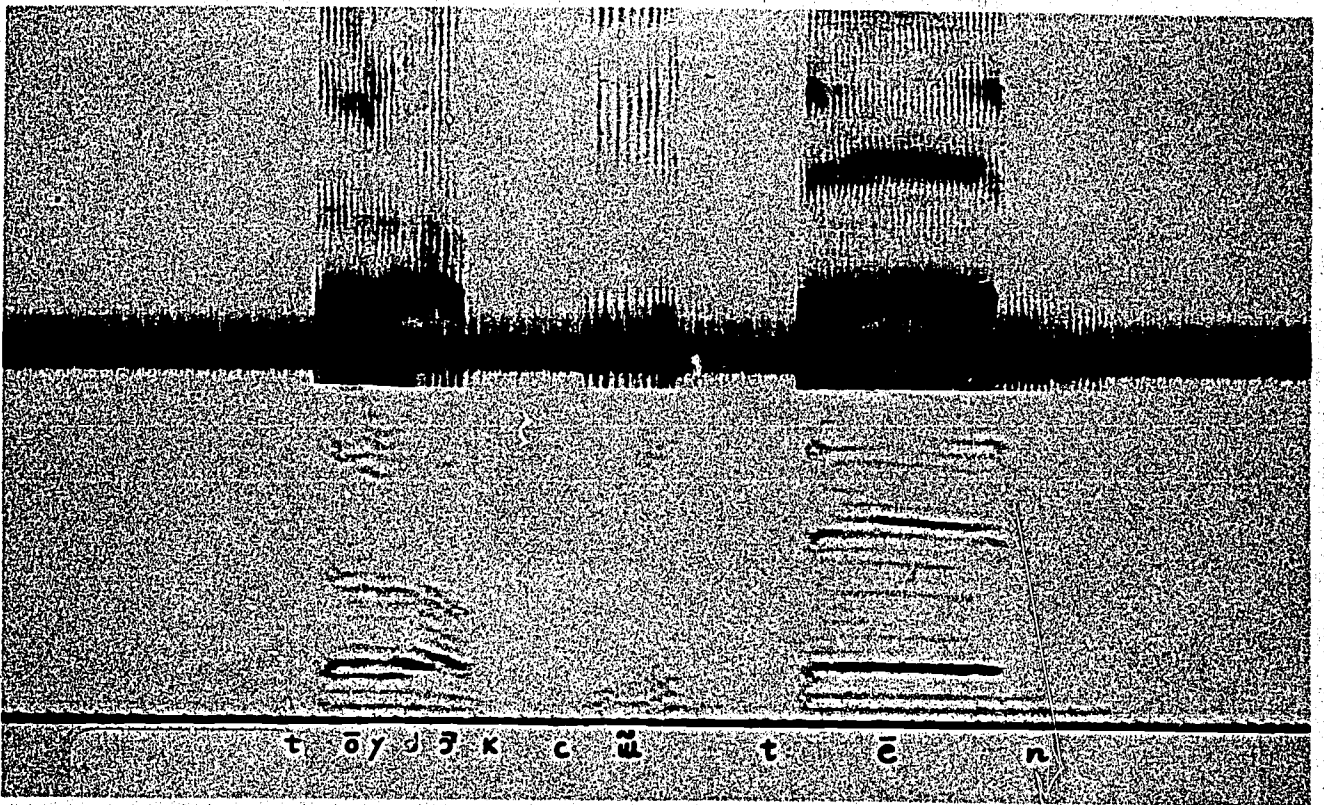
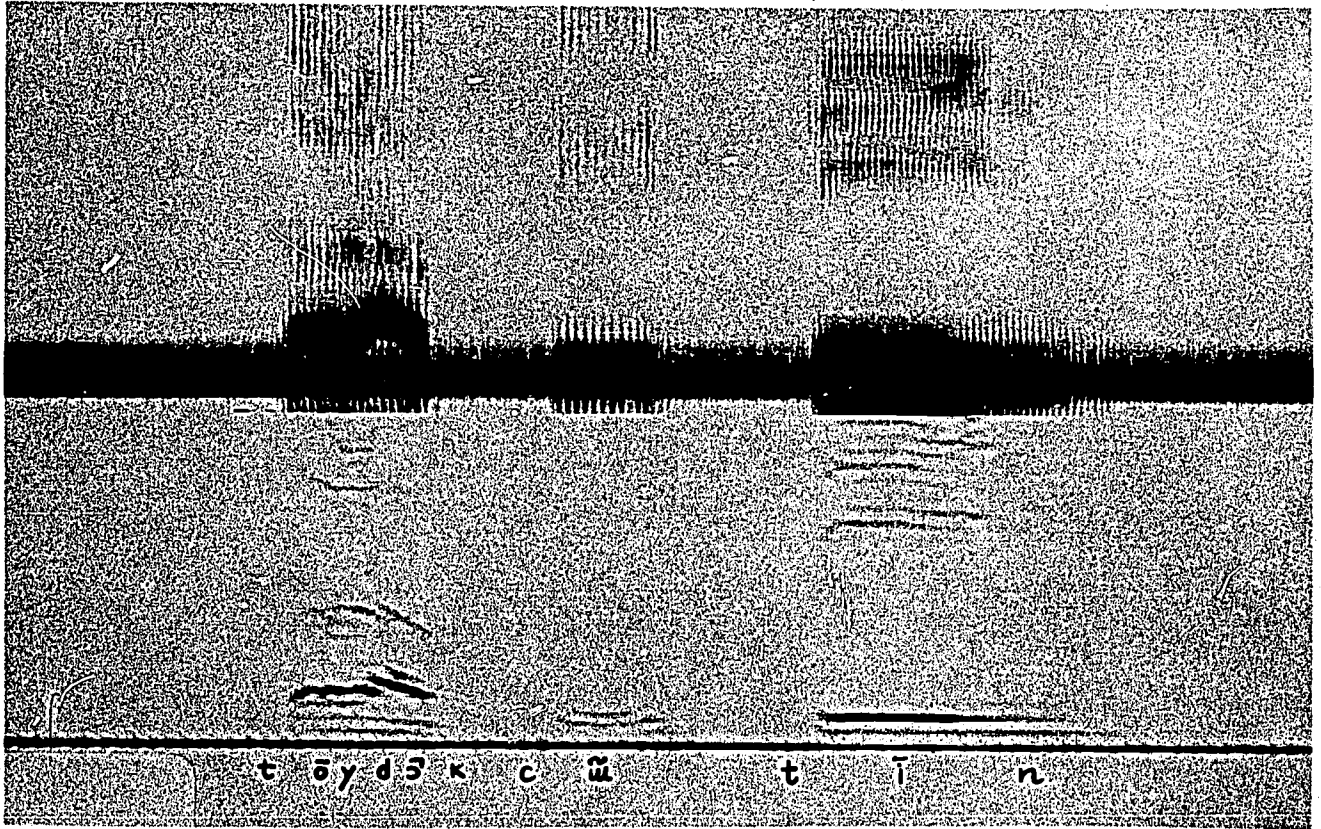
FIGURE 5

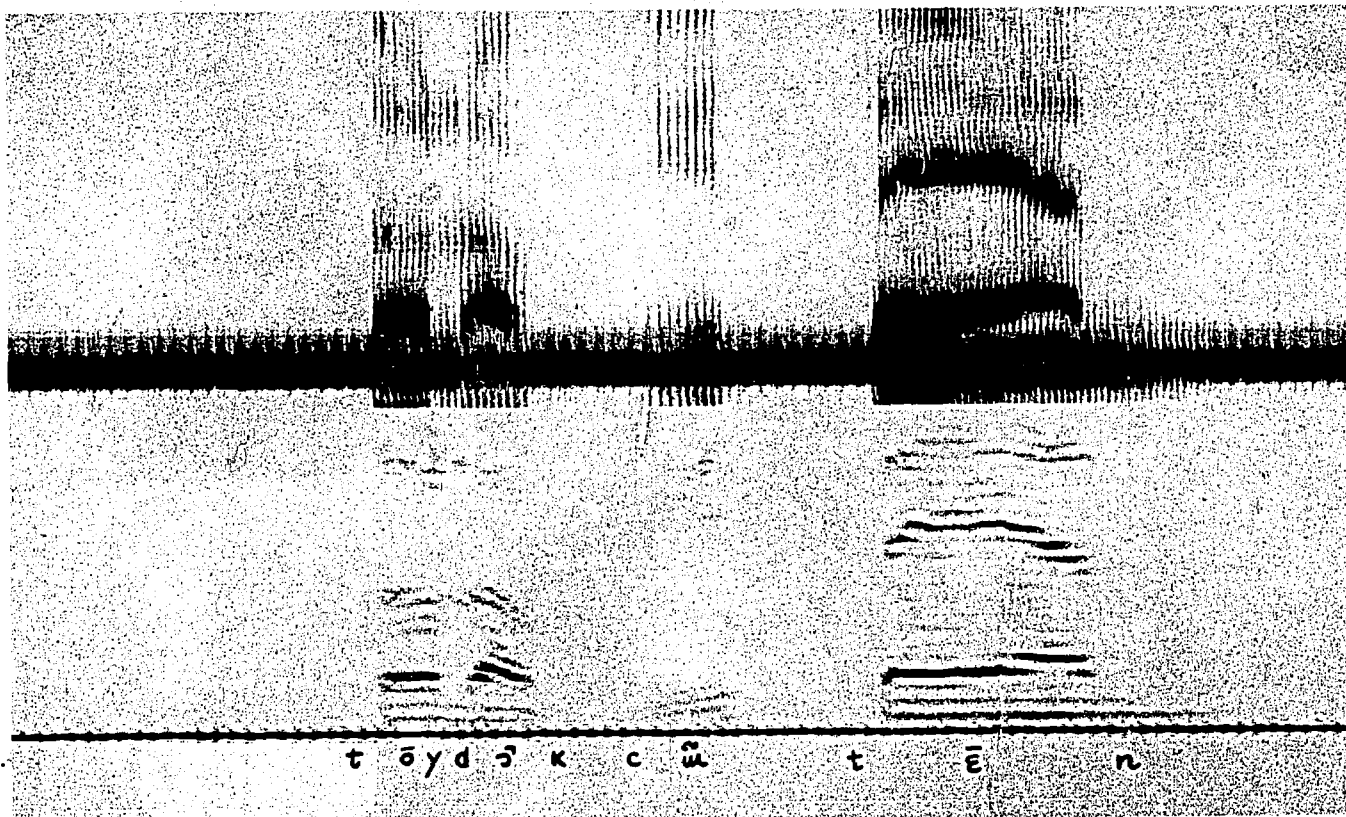
Simple vowels in the environment /t - n/

Level tone

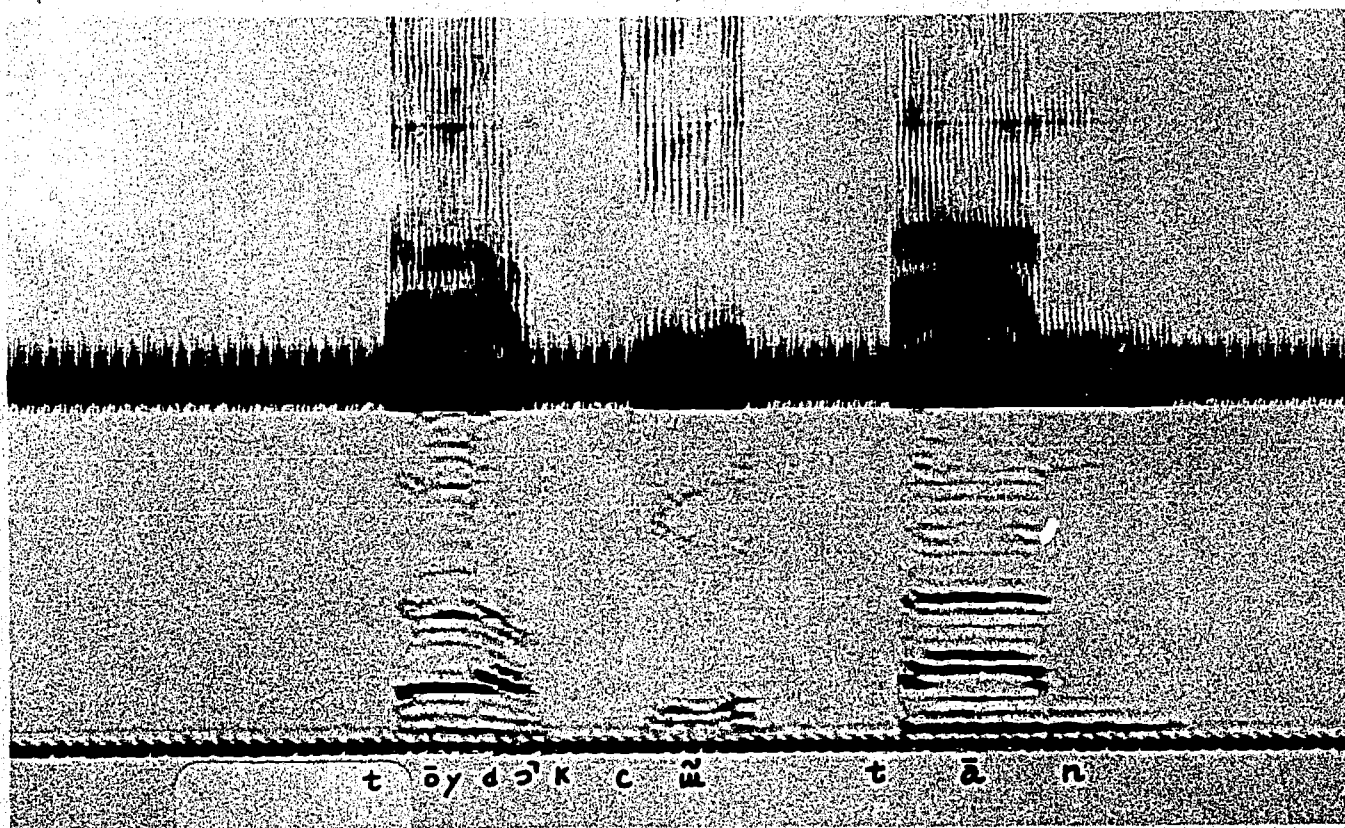
Informant 1

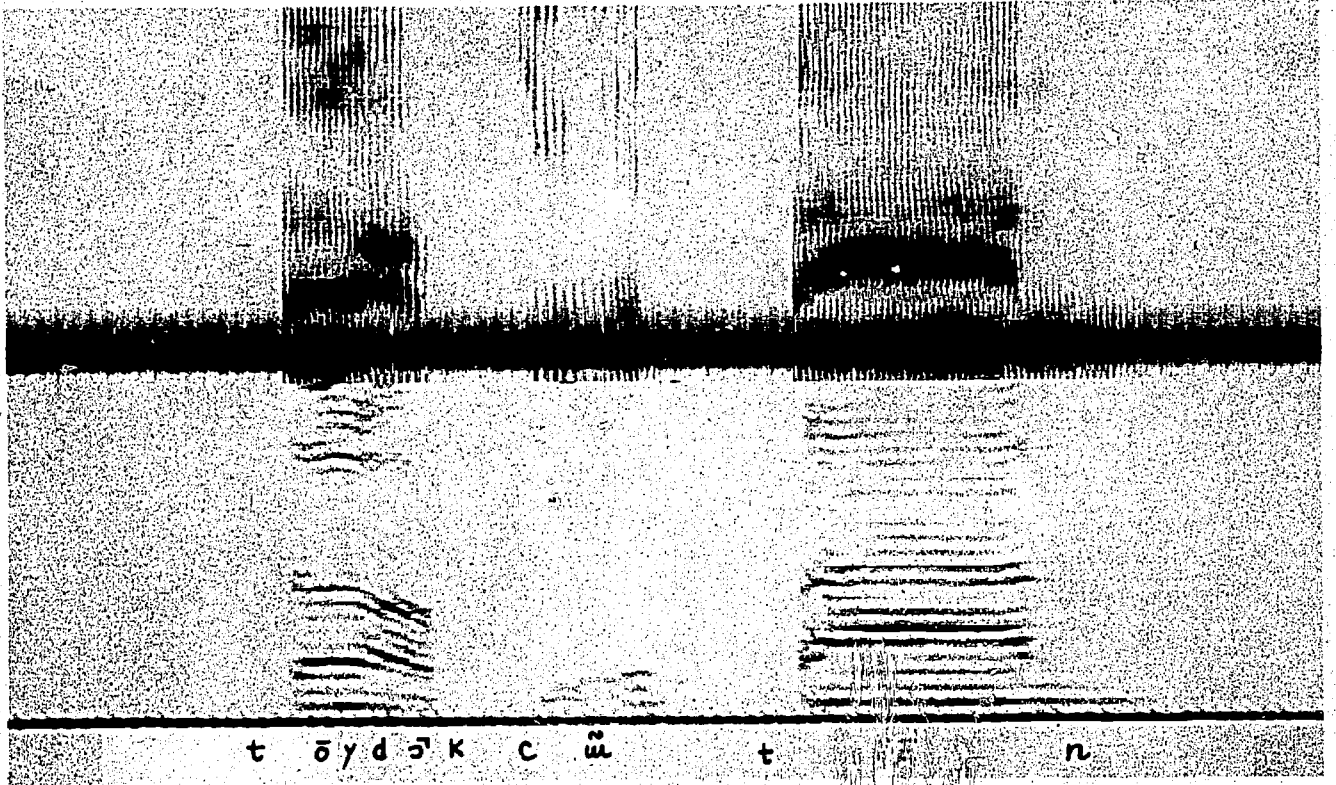




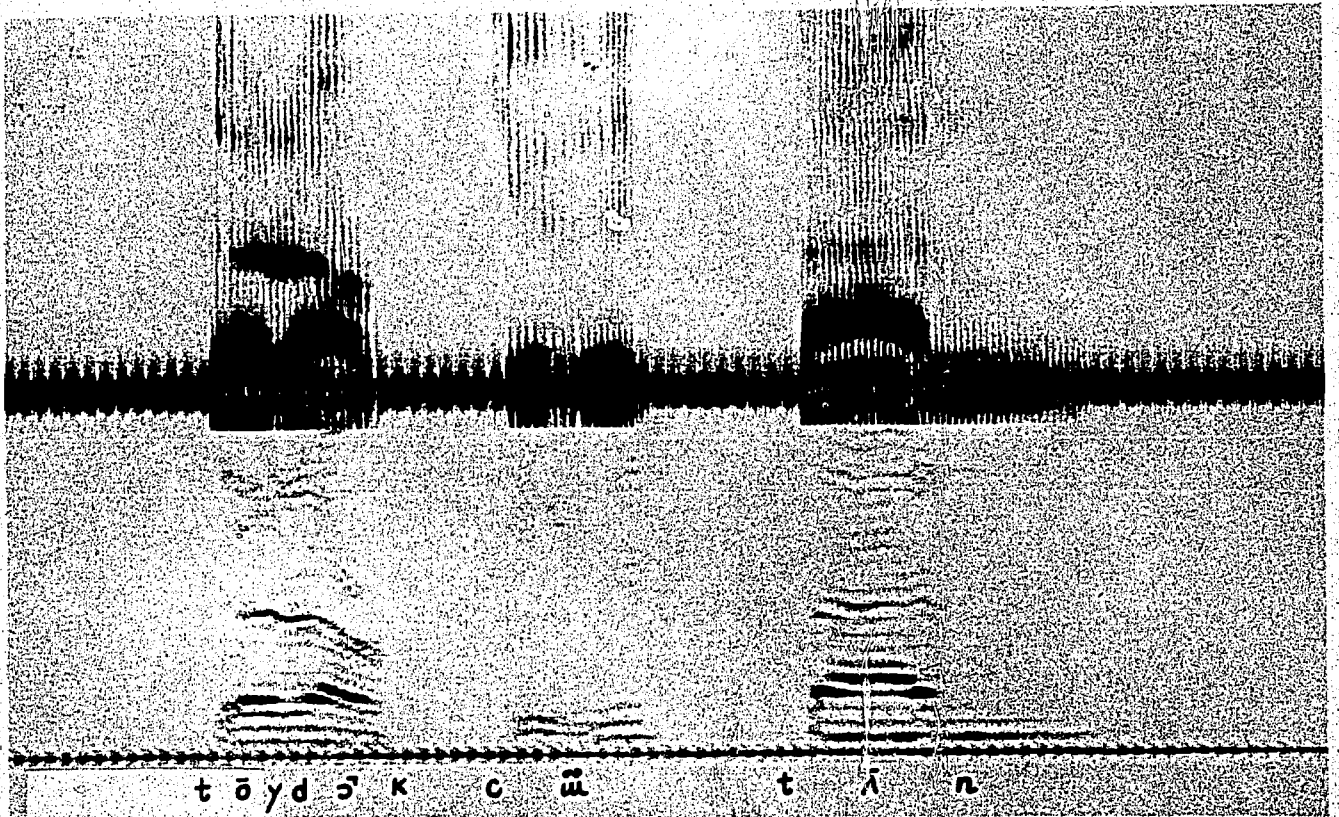


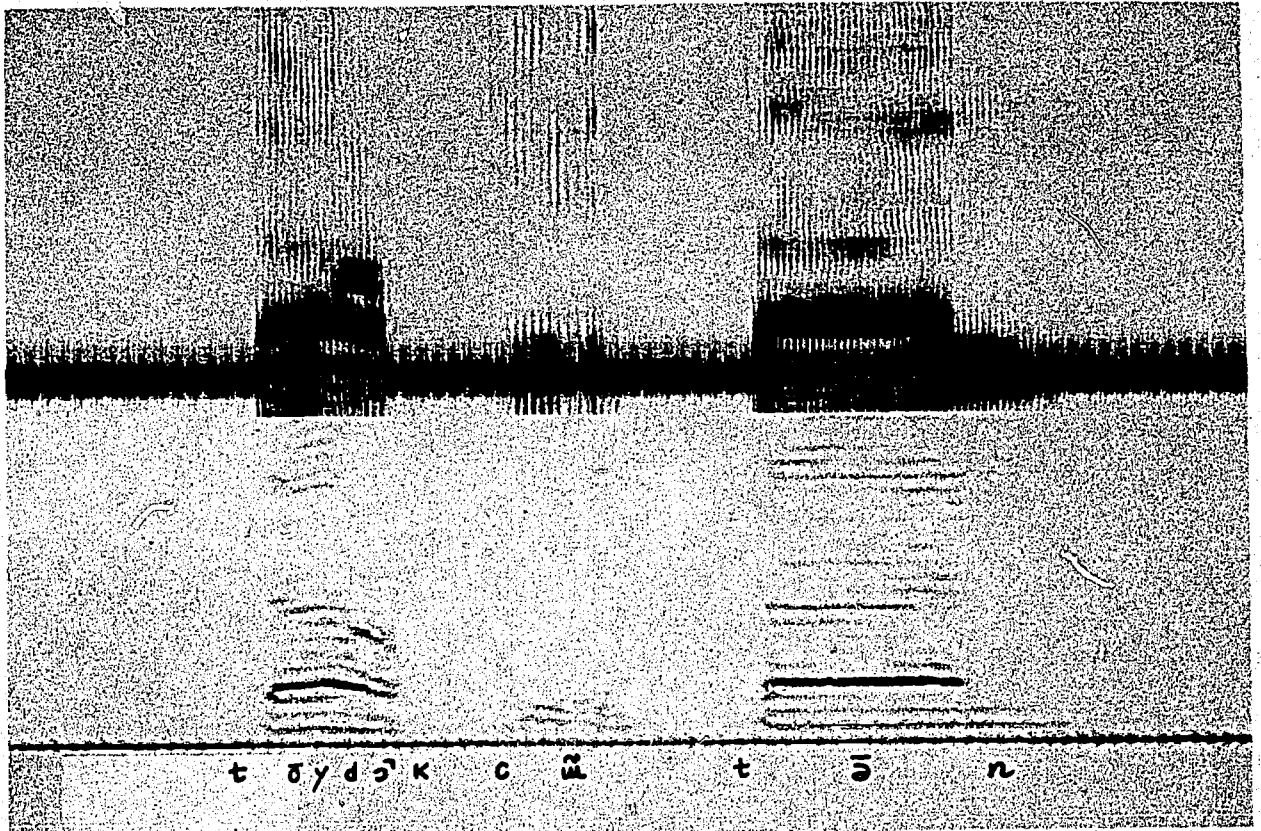
SPECTROGRAM NO. 4a



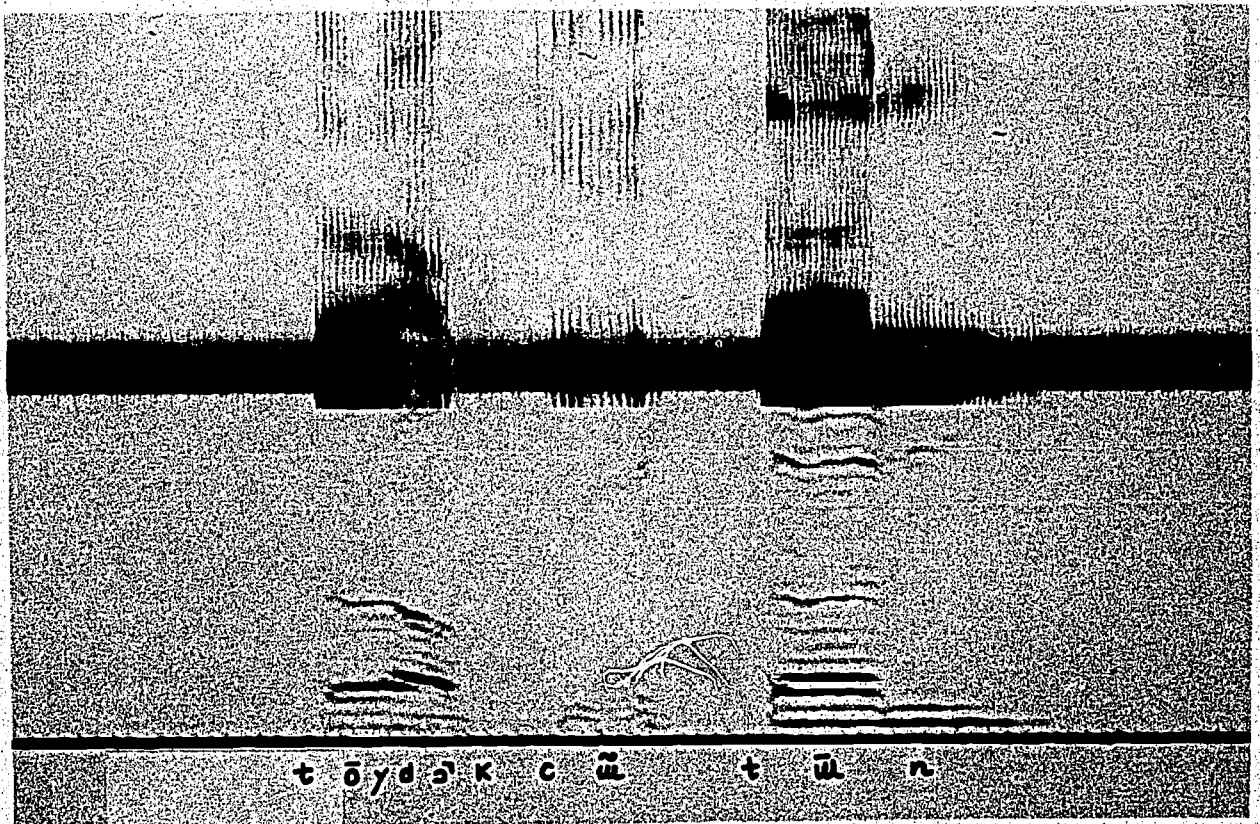


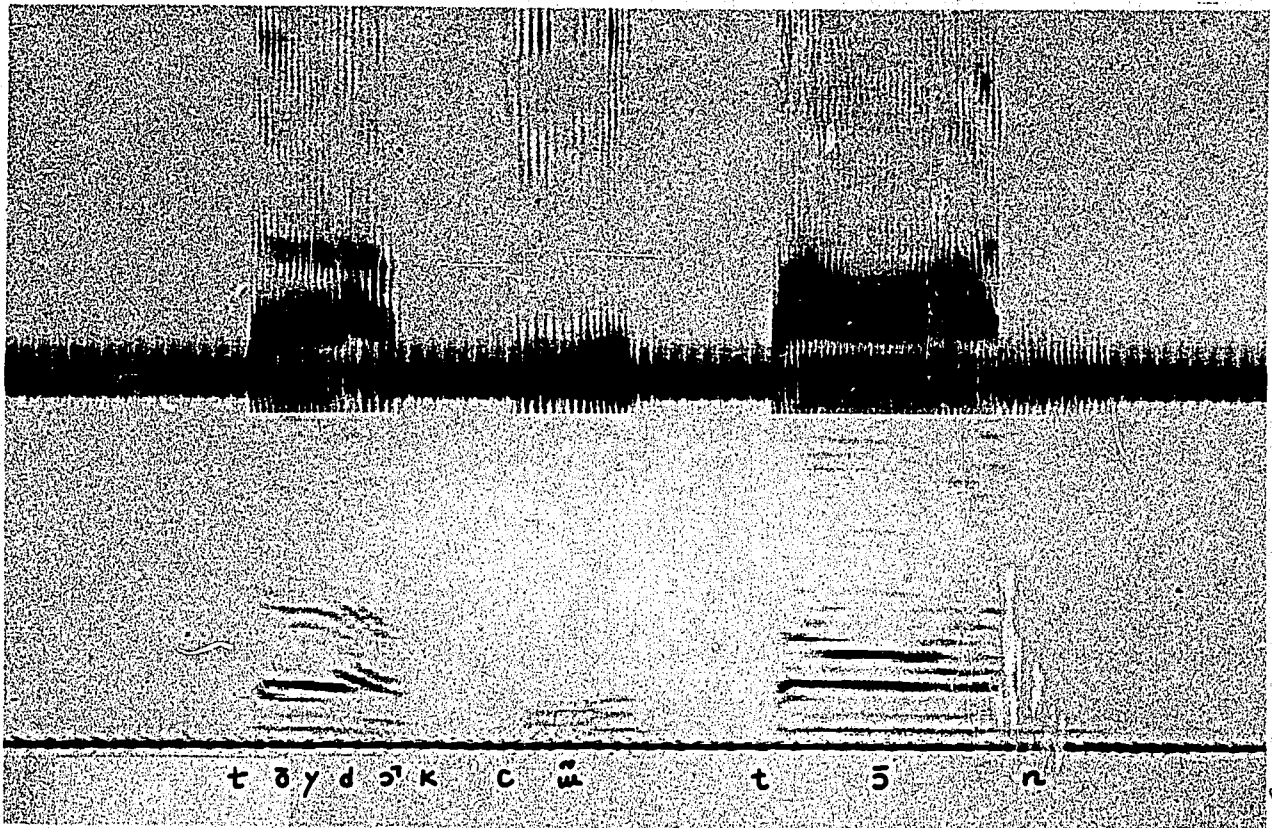
SPECTROGRAM NO. 6a



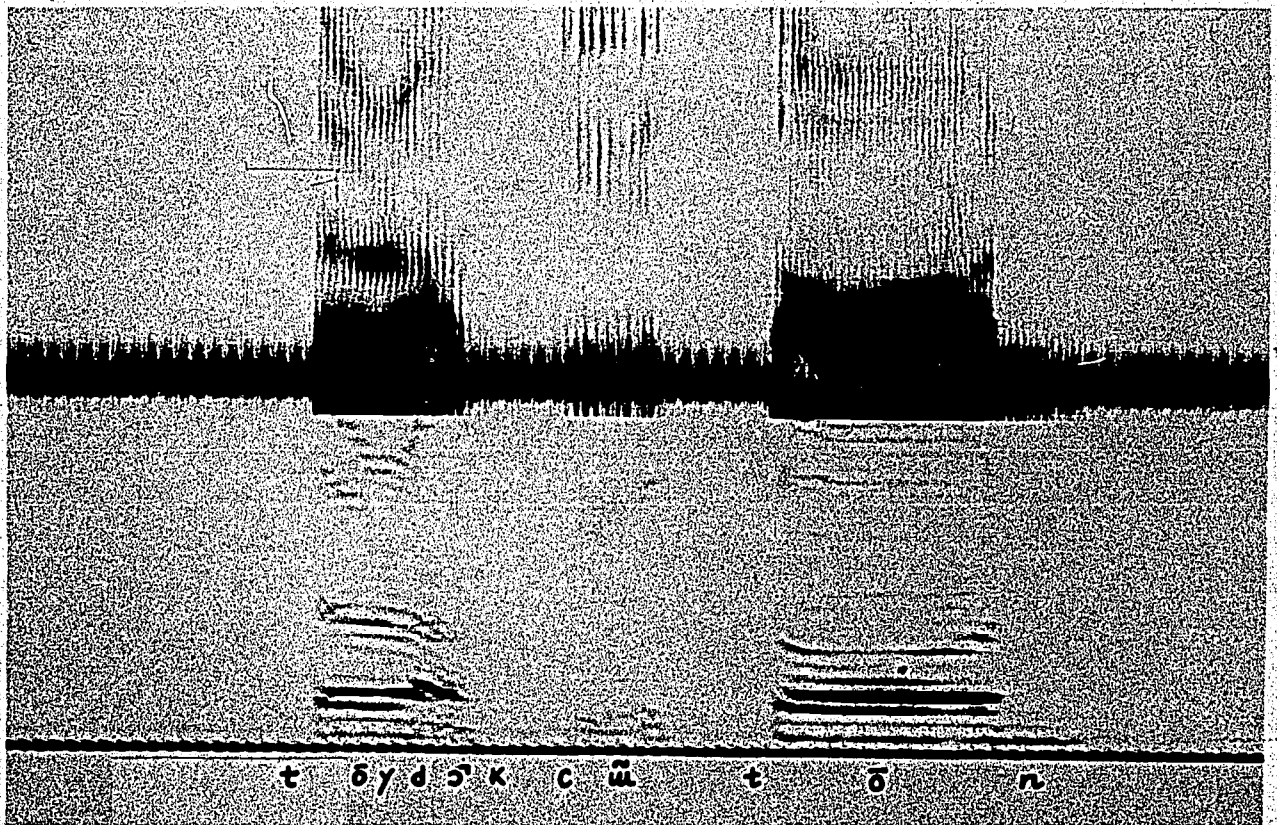


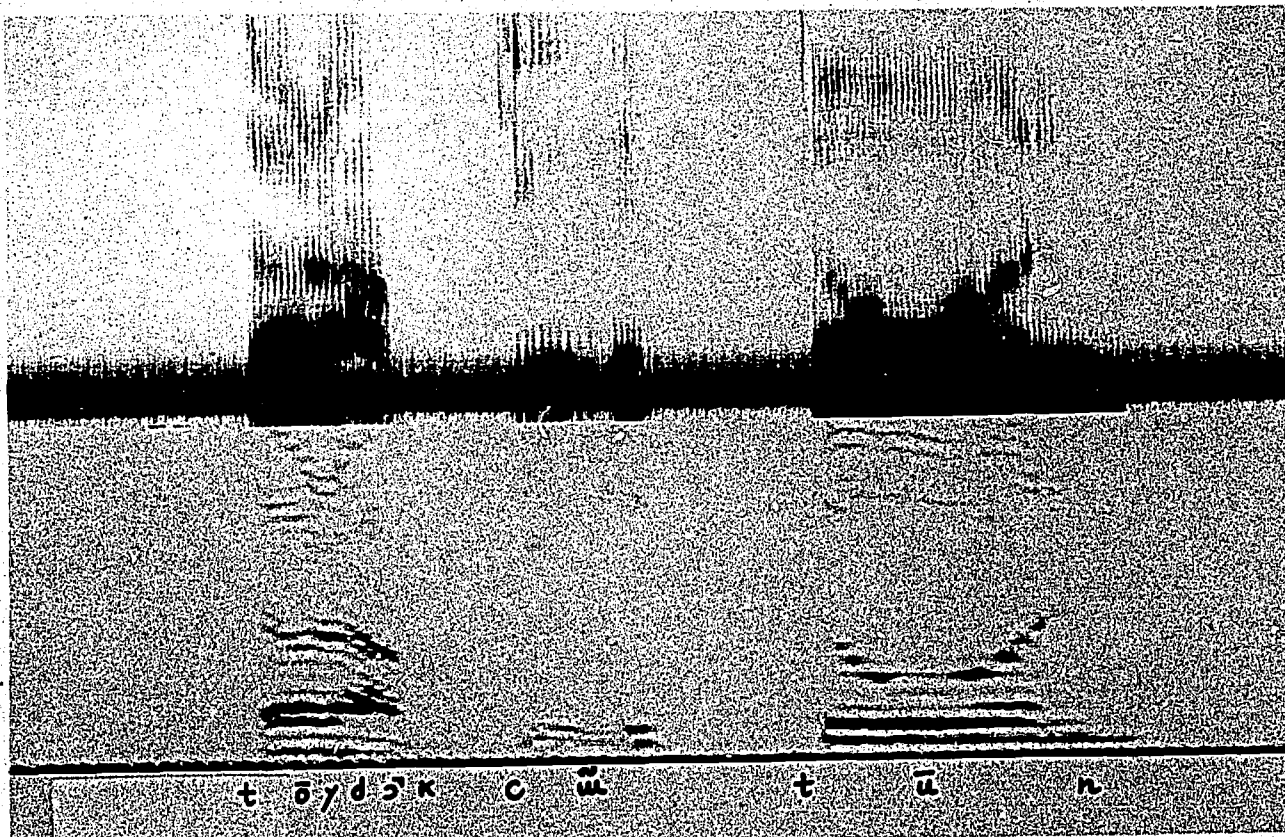
SPECTROGRAM NO. 8a



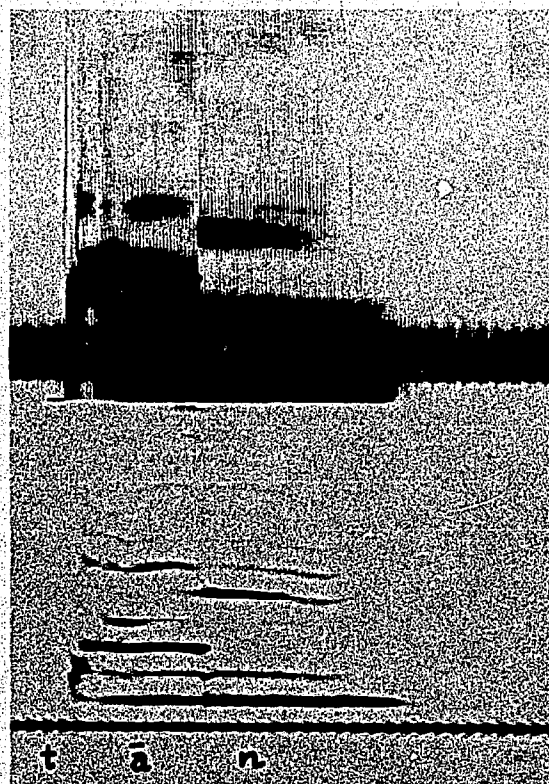
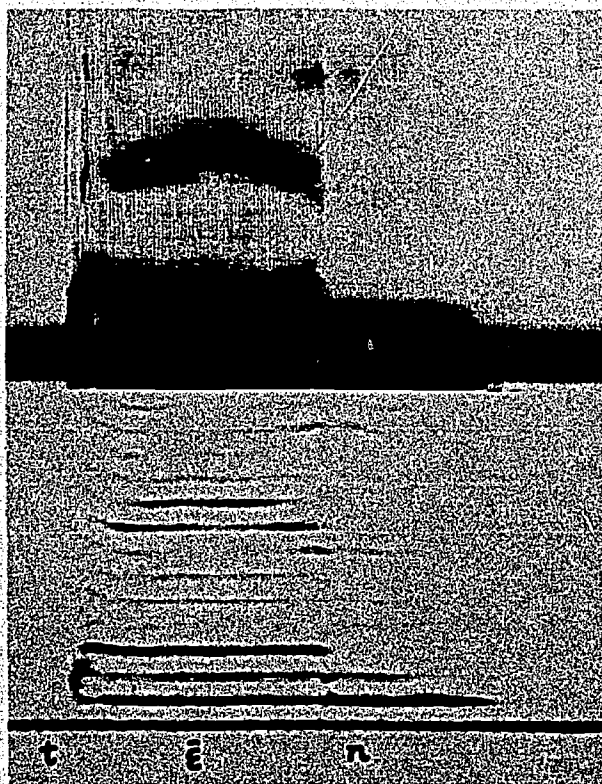
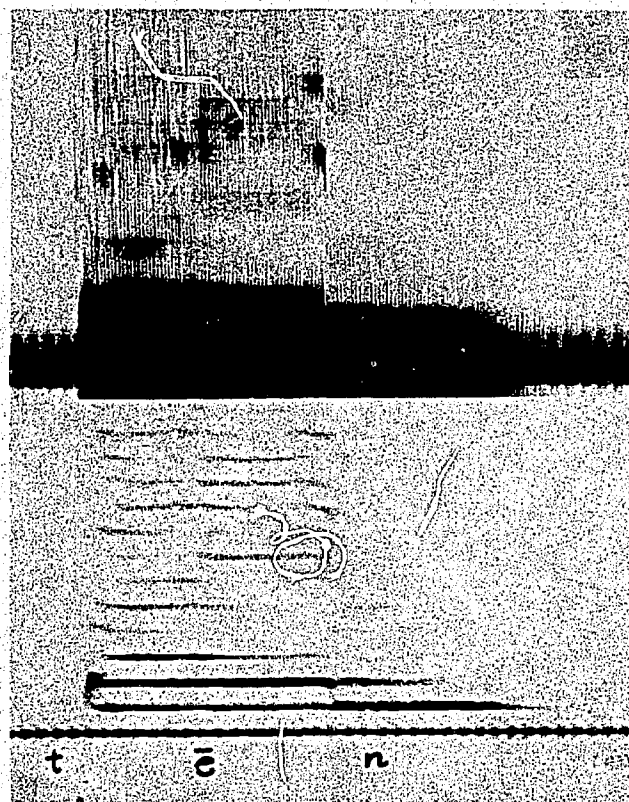
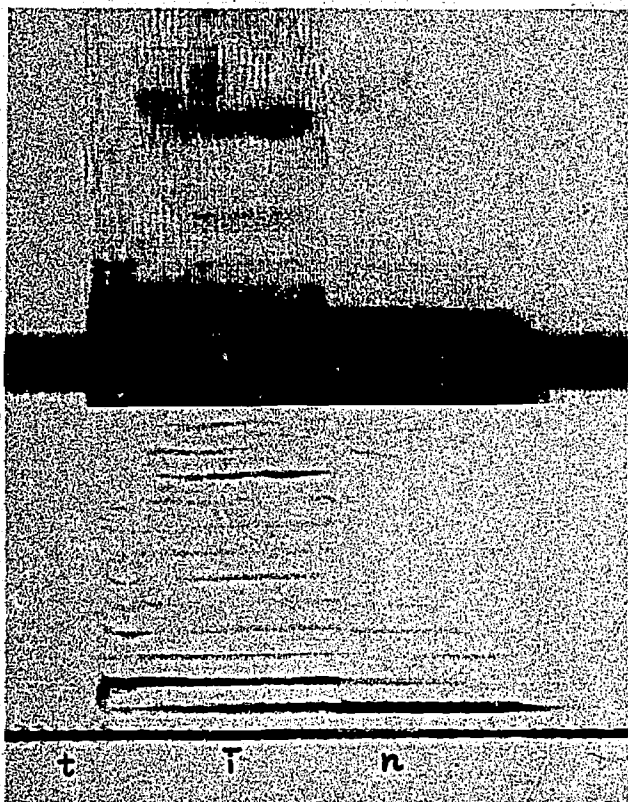


SPECTROGRAM NO. 10a





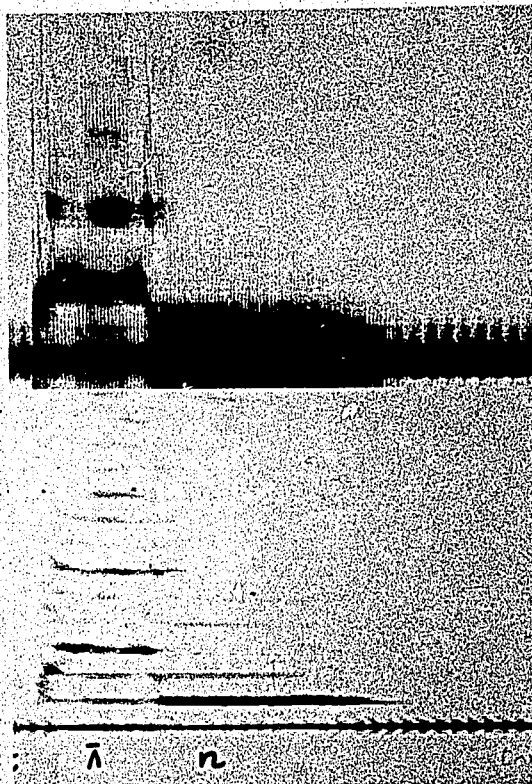
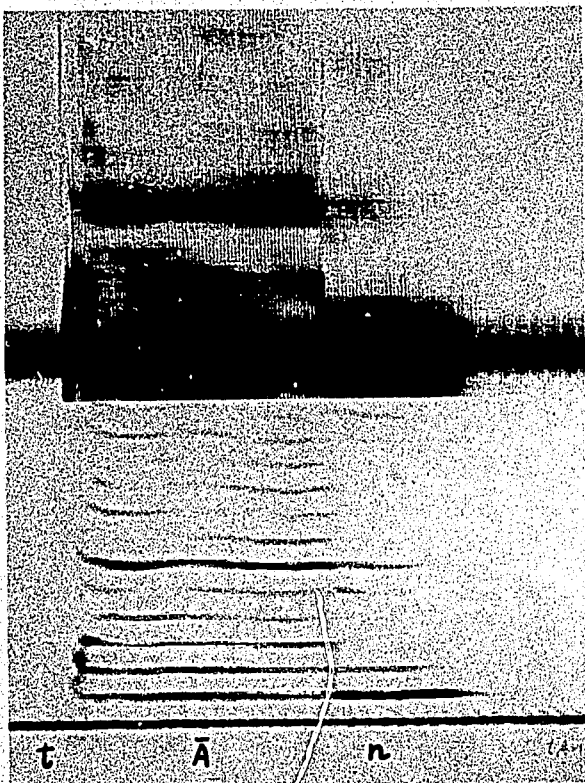
Informant 3



SPECTROGRAM NO. 5b

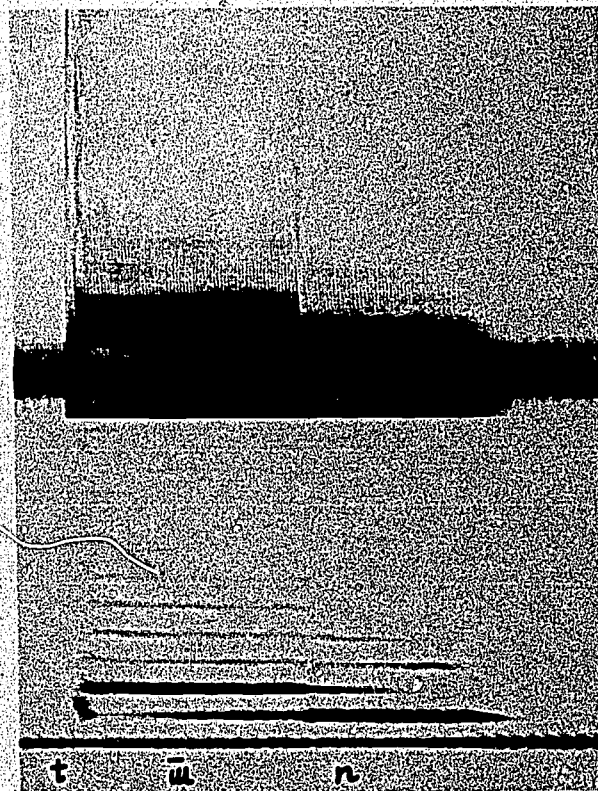
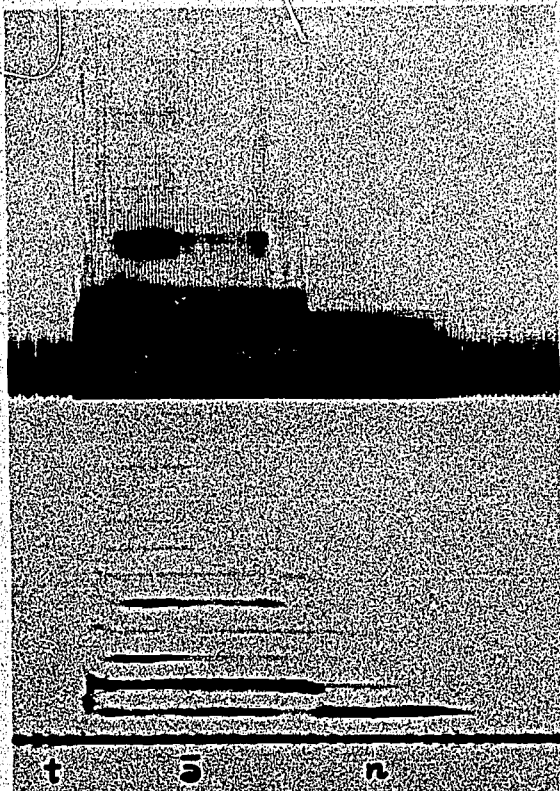
SPECTROGRAM NO. 6b

Informant 3

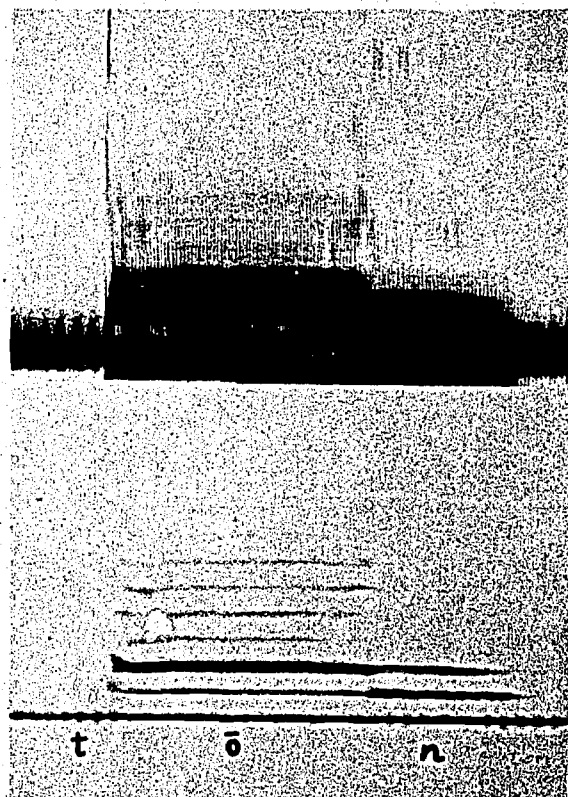
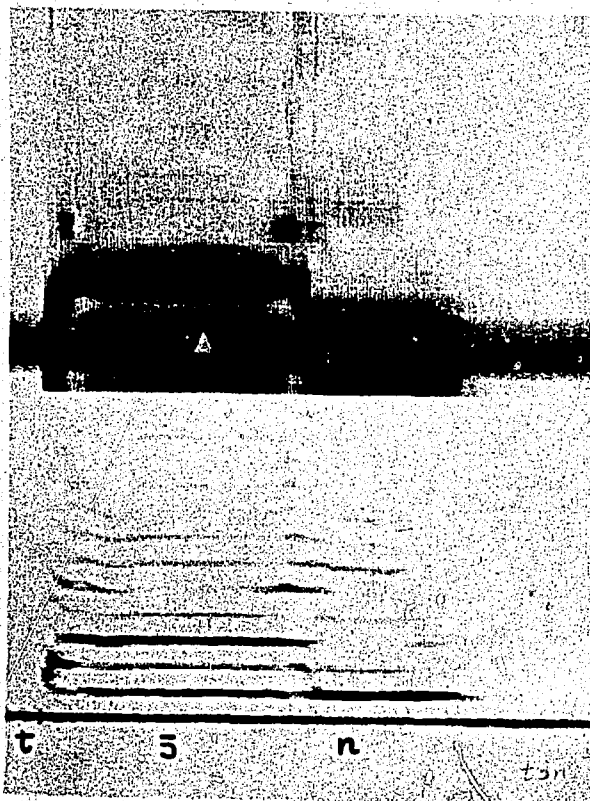


SPECTROGRAM NO. 7b

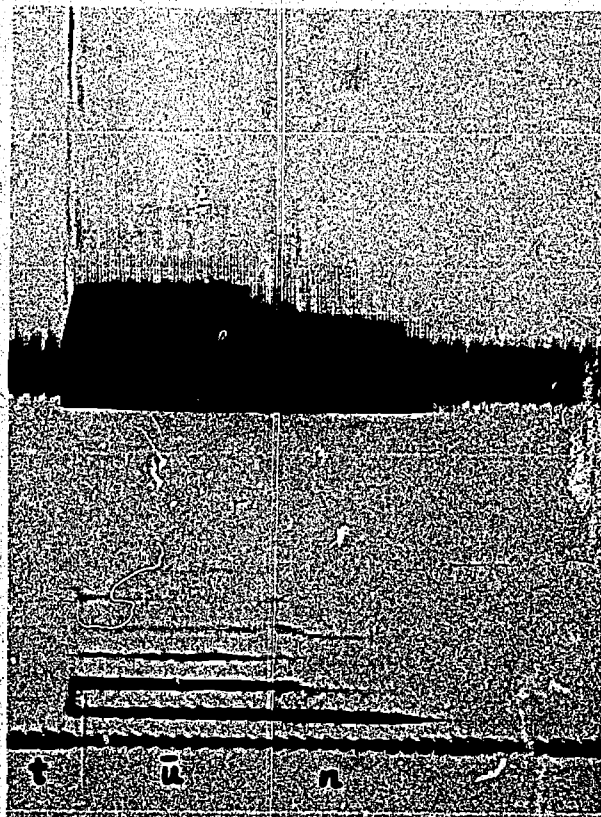
SPECTROGRAM NO. 8b



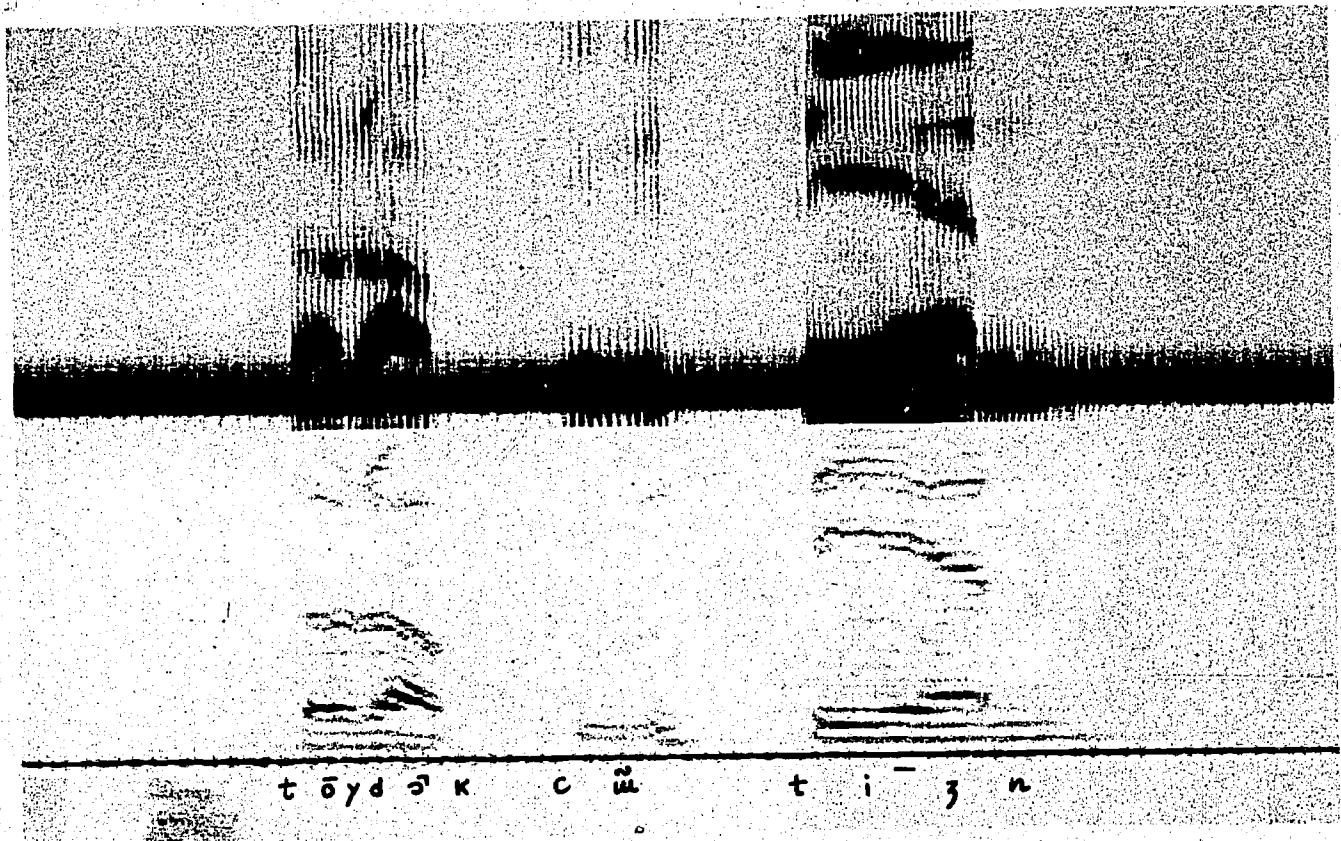
Informant 3



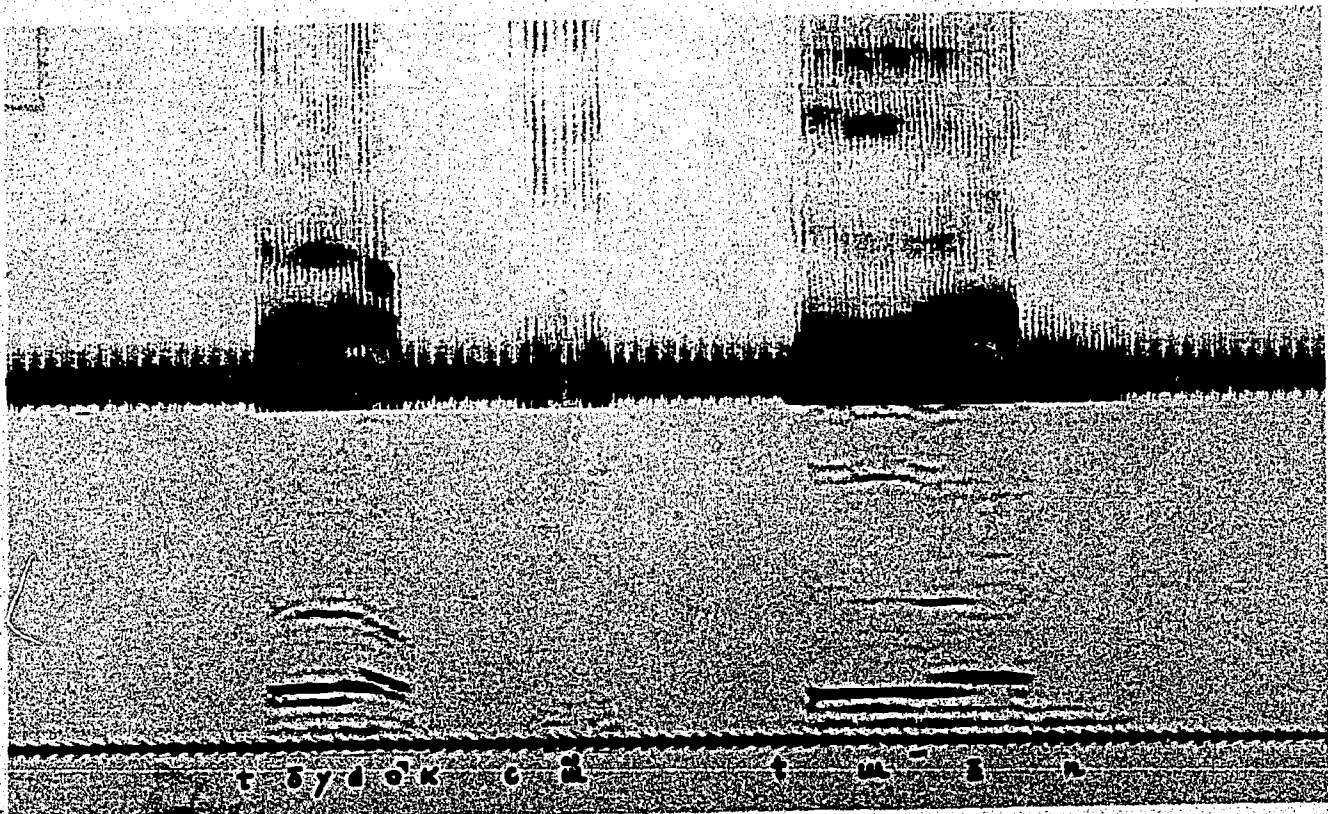
SPECTROGRAM NO. 11b

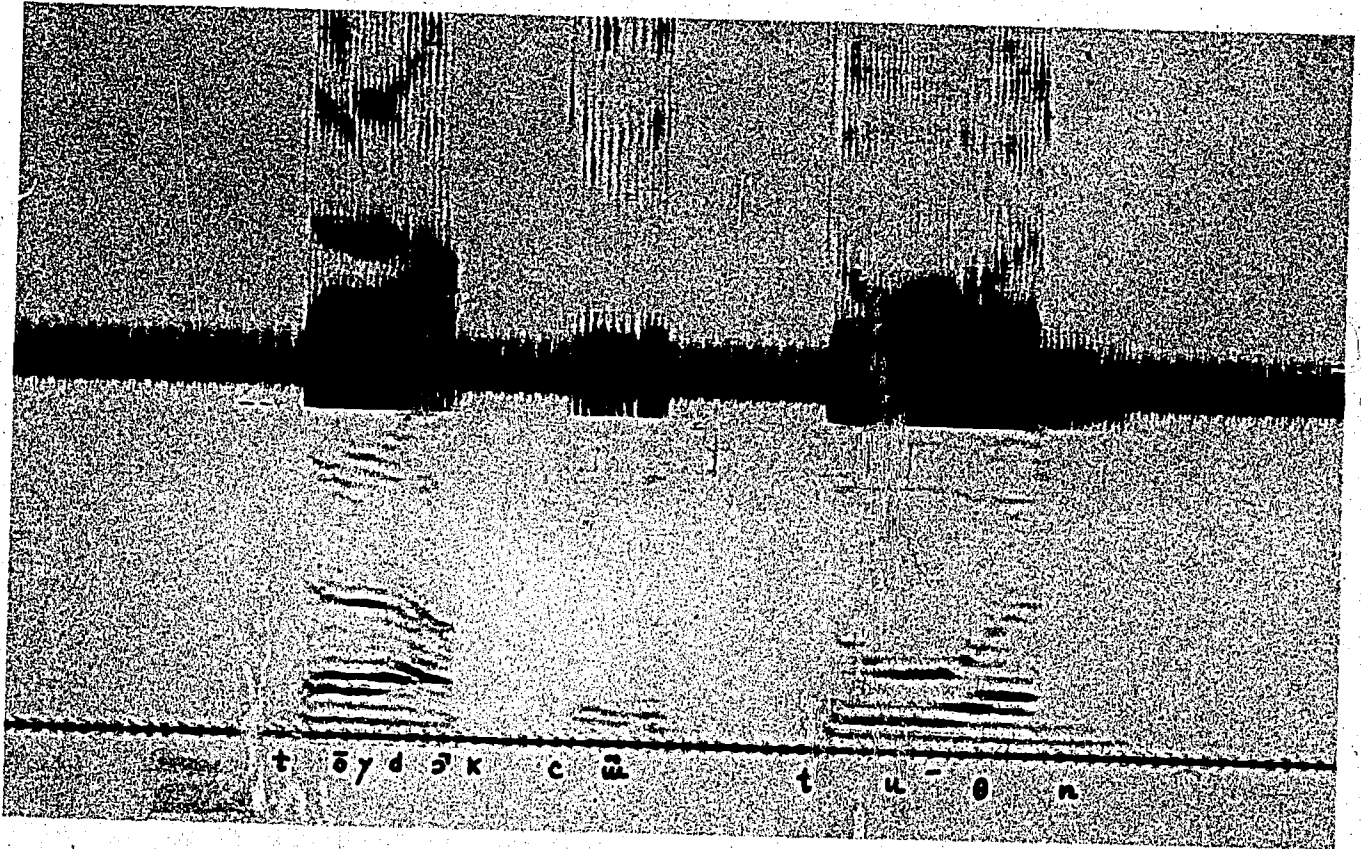


SPECTROGRAM NO. 12a Informant 4

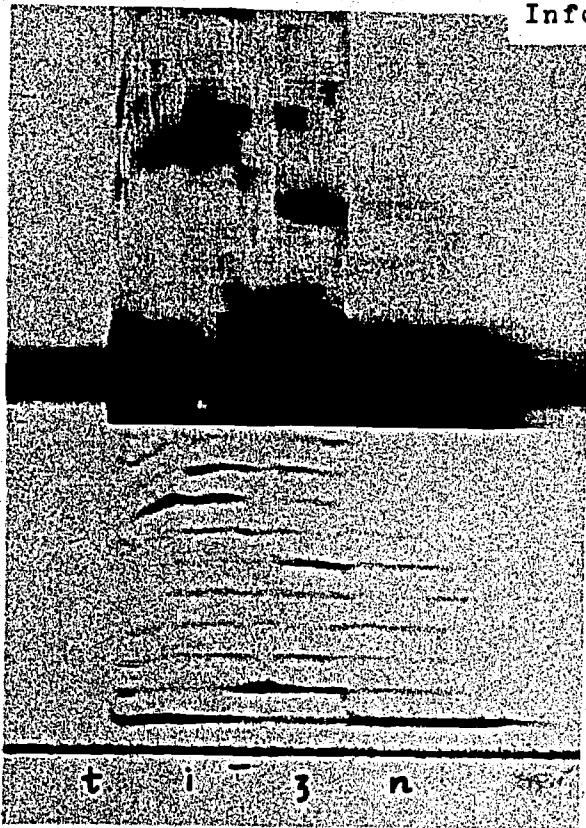


SPECTROGRAM NO. 13a

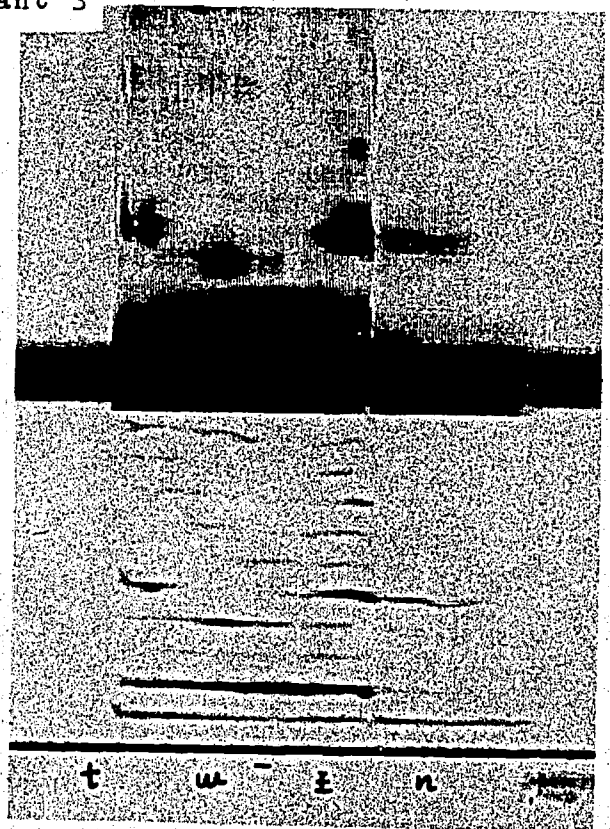




SPECTROGRAM NO. 12b

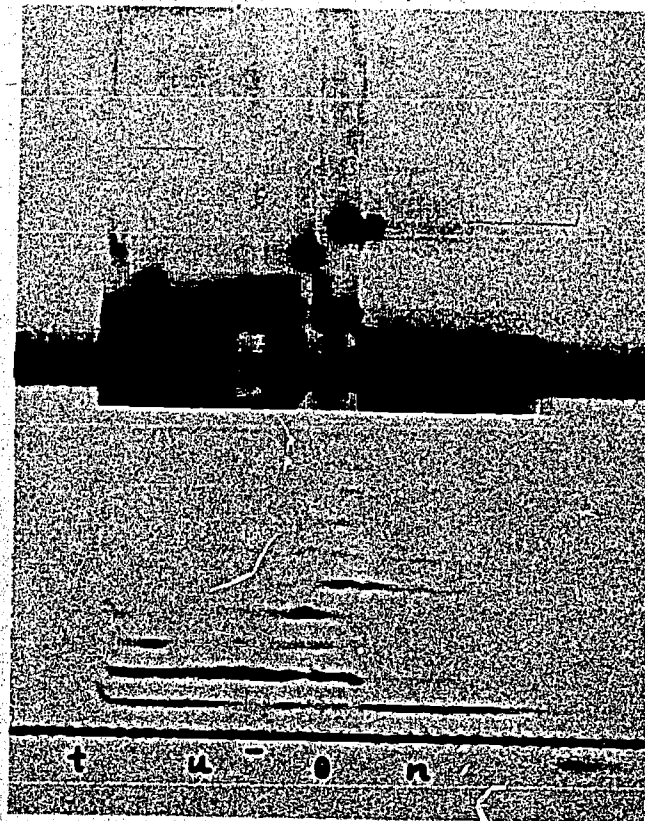


SPECTROGRAM NO. 13b



Informant 3

SPECTROGRAM NO. 14b



a boundary between the 2 segments. The mid-way point between the beginning of the formant and this boundary was then taken as the target quality of the first segment of the nucleus, [I]; and, the mid-way point between the boundary and the end of the formant was considered as the target of the second segment, [ʒ].

Recordings of [Iʒ], [uɪ], and [Uθ] in the environment /t - n/ were made using the same frame sentence /t̄ōy d̄ōk cū t̄-n; t̄-n, t̄-n, t̄-n./

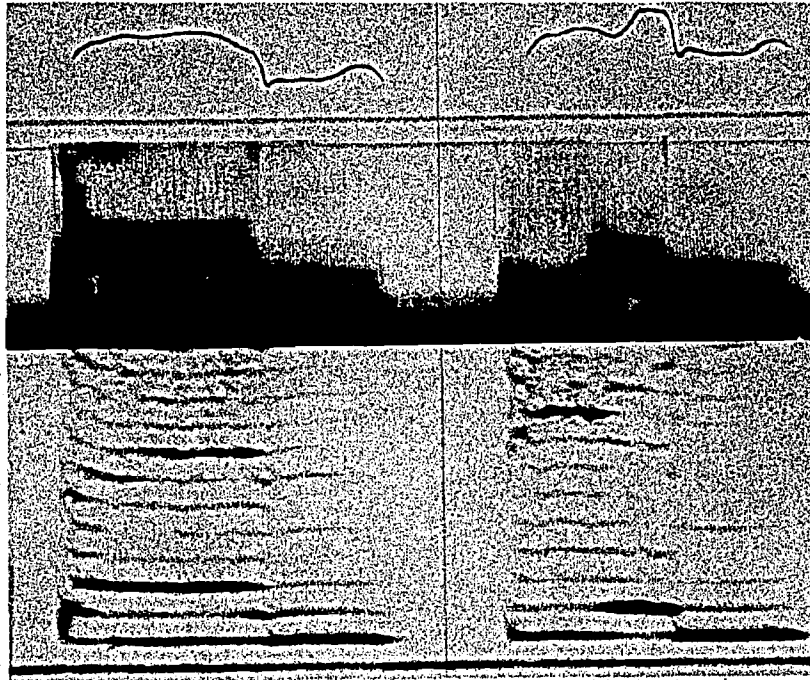
Informant 4's speech was examined first because it is easier to work with the formant measurements of a male voice. On listening carefully to the initial vowel qualities of the complex nuclei, it was found that they sound very much like /i/, /u/, and /u/ respectively. To confirm this auditory impression with acoustic data, we measured F1 and F2 of [I] and [ʒ] in the word [t̄Iʒn], of [u] and [ɪ] in the word [t̄uɪn] and of [U] and [θ] in the word [t̄Uθn]. These measurements are presented in Table 6.

Figure 6 is a composite graphic representation of the domains of the complex nuclei [Iʒ], [uɪ], [Uθ] and the domains of the simple vowels. The dots and the solid line circles represent the measurements of Table 6, while the broken line circles represent the domains of the simple vowels of the same speaker as obtained earlier and recorded in Table 1 and Figure 1.

SPECTROGRAM NO. 15

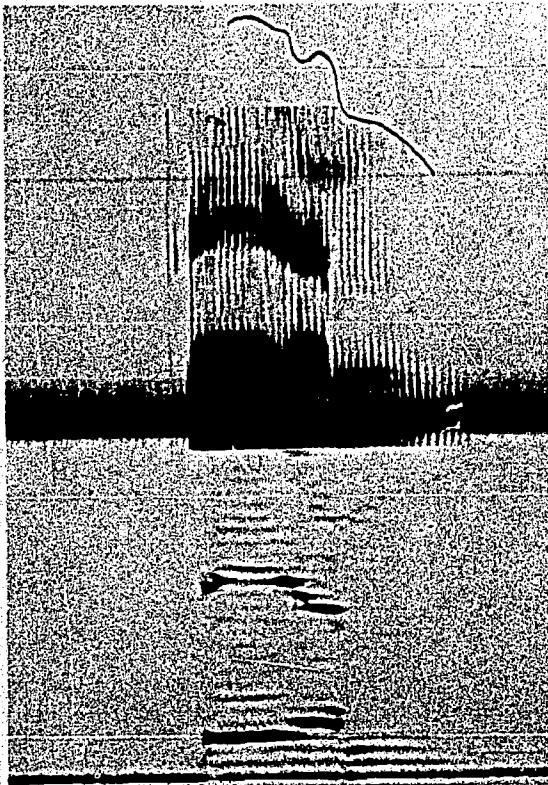
Amplitude contours of [e] and [ɪ]

Informant 3



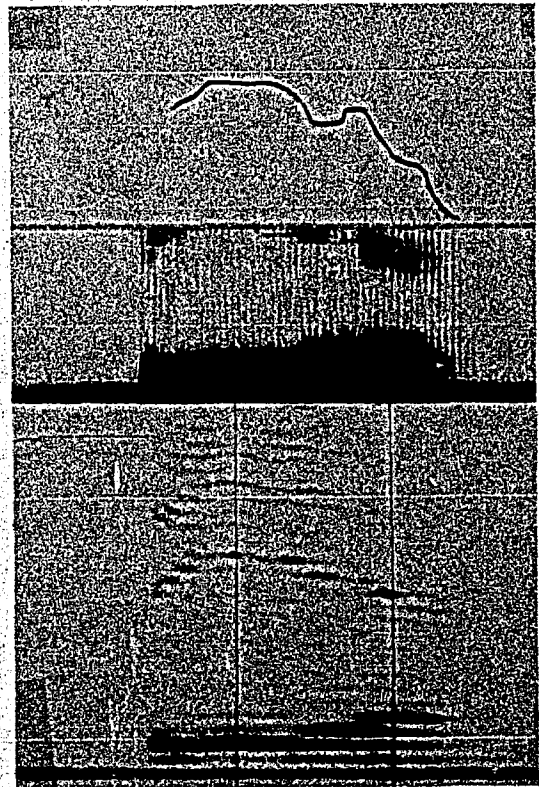
t e n t i ɜ n

Informant 1



t i ɜ n

Informant 4



t i ɜ

TABLE 6

Formant measurements of complex nuclei in the environment /t - n/: Informant 4 cycles/second

Segment [i] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tīn	300	2300	2950	300	2200	2950	350	2250	2900	350	2150	2950
	300	2350	2850	300	2300	3050	350	2250	2800	350	2200	2800
	300	2300	2850	300	2300	3000	300	2250	2900	350	2100	2900
	300	2300	2800	300	2300	3000	300	2250	2950	300	2400	2950
	300	2350	2950	300	2350	3000	300	2250	2900	300	2400	3000

Segment [u] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tūn	300	800		300	800		300	800		350	750	
	325	750		325	800		350	750		325	750	
	300	800		350	800		350	800		400	800	
	350	800		400	850		350	850		350	800	
	300	800		350	800		400	800		300	800	

Segment [ɔ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tīn	600	1950	2800	600	1950	2850	550	1950	2800	550	2000	2800
	550	2000	2800	550	2050	2850	575	1950	2800	550	2000	2800
	625	2000	2800	625	2000	2850	600	1950	2850	600	1900	2800
	600	1950	2750	600	1950	2750	600	2000	2800	600	2000	2850
	650	2000	2950	650	2000	2800	650	2000	2850	650	2000	2800

Segment [ə] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tūn	550	1150		550	1250		500	1100		500	1100	
	500	1100		500	1050		500	1100		500	1050	
	550	1100		550	1100		550	1200		550	1150	
	550	1150		550	1150		500	1100		550	1150	
	550	1200		550	1100		550	1150		550	1100	

Segment [w] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tūn	450	1450		450	1400		450	1400		450	1400	
	450	1400		450	1450		425	1350		450	1400	
	450	1450		450	1350		450	1350		500	1400	
	400	1350		450	1450		450	1400		400	1450	
	450	1450		500	1500		450	1350		500	1300	

Segment [ɪ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tūn	550	1500		550	1450		550	1450		600	1450	
	600	1400		600	1400		600	1400		600	1400	
	600	1400		600	1450		600	1400		600	1400	
	650	1450		625	1450		600	1450		600	1450	
	650	1450		600	1400		625	1450		650	1450	

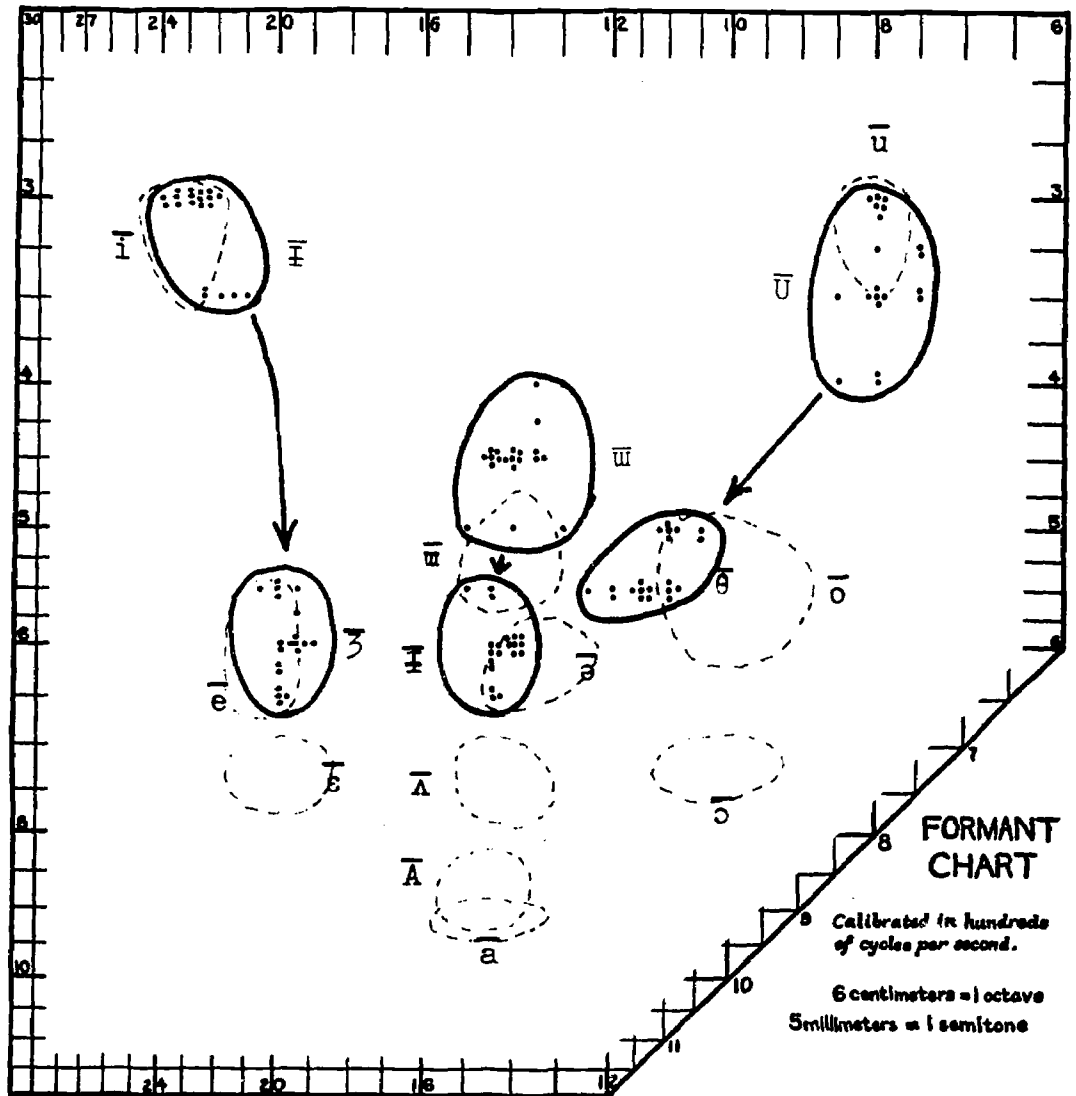
Blank spaces indicate where precise measurements were not obtainable.

FIGURE 6

Complex nuclei compared with simple vowels in the environment /t - n/

Level tone

Informant 4



As can be seen in Figure 6, the first segments of the complex nuclei [Iʒ], [uɛ], and [Uθ] are phonetically similar to [i], [u], and [u]. The acoustic data confirms the auditory impression shared by all analysts that the first segments of the complex nuclei [Iʒ], [uɛ], and [Uθ] are phonetically the same as [i], [u], and [u] respectively. They are so phonetically similar, in fact, that we will hereafter transcribe them as [i], [u], and [u] in our data.

In Figure 6, it is clearly observed that the formant measurements of [ʒ], [ɛ], and [θ] form three distinct areas. The domain of [ʒ] corresponds closely to that of /e/, [ɛ] corresponds roughly to that of /e/, and the domain of [θ] is closer to that of /o/ than to any other vowel.

Having confirmed that the qualities of [I u U] are the same as /i u u/ of the simple vowels, we then focused our attention on the second elements only, in the formant analysis of the other informants. Using the same procedures, we measured F1 and F2 of [ʒ], [ɛ], and [θ] as spoken by Informant 3.

Table 7 represents F1 and F2 of [ʒ], [ɛ], and [θ] in [tiʒn], [tuɛn], and [tuθn] as spoken by Informant 3. Figure 7 is the corresponding composite graphic representation of the domains of the second segment of the complex nuclei and the domains of the simple vowels. Solid lines circle the domains of [ʒ], [ɛ], and [θ] as presented in Table 7, while broken lines circle the simple vowel qualities presented in Table 2 and Figure 2.

In Figure 7 the analysis of [ɜ], [ɪ], and [θ] as being three phonetically different sounds is further supported. In Informant 3's speech, also, the domain of [ɜ] overlaps with /e/, [ɪ] overlaps with /ə/, and [θ] overlaps with /o/. Since /e/, /ə/, and /o/ are three distinct phonemes, it is reasonable to consider [ɜ], [ɪ], and [θ] as three different vocalic qualities of 3 different vowels rather than as a single phoneme, such as /ə/, with three allophones. The reason some English speakers hear all three sounds as /ə/ may be attributed to the linguistic habit of the native speakers of English to classify a rather wide range of mid-central vowel sounds as the phoneme /ə/.

Informant 1 had made a few recordings of complex nuclei before leaving us. In the limited amount of data available, we found a recording of the words, [tɪɜ̃n], [tʷɪ̃n], and [tʷθ̃n] spoken in our standard frame sentence. Spectrograms and measurements were made as presented in Table 8. Using the same techniques as those used in the experiments with Informants 4 and 3, the figures were converted into the graphic representation shown in Figure 8. Although no conclusion can be drawn from such small statistical data as that of Informant 1, it also seems to support the analysis of /ɜ/, /ɪ/, and /θ/ as three different sounds rather than one.

Through the acoustic phonetic analysis of the complex nuclei [ɪɜ], [ʷɪ], and [ʷθ] in the environment /t - n/, we

TABLE 7

Formant measurements of
second segments of the complex nuclei in the environment /t - n/: Informant 3
cycles/second

Segment [ɔ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tiɔn	600	1850		600	1900		600	1850		600	1850	
	625	1850		575	1800		600	1850		600	1900	
	600	1850		600	1850		600	1800		500	1950	
	600	2000		600	2100		600	1850		600	1950	
	575	2050		550	2000		600	1950		600	2100	
	625	1950		650	1950		600	1900		600	1900	
	600	1900		600	1900		600	1850		600	1850	
	600	1900		600	1850		600	1850		600	1850	
	600	1850		600	1850		600	1850		600	1850	
	600	2000		600	1900		600	1850		625	1900	

Segment [ɛ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tiɛn	600	1550		600	1550		600	1550		600	1550	
	600	1550		600	1550		600	1550		600	1550	
	600	1550		600	1550		625	1500		600	1550	
	600	1550		550	1500		575	1500		600	1500	
	600	1550		575	1500		600	1550		600	1500	
	625	1600		650	1600		600	1600		625	1600	
	625	1600		625	1450		600	1550		600	1550	
	650	1600		600	1400		625	1550		600	1550	
	650	1600		600	1600		600	1550		600	1550	
	550	1500		600	1550		600	1550		600	1550	

Segment [ə] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tuən	600	1250		600	1250		600	1250		600	1250	
	600	1250		600	1250		600	1250		600	1250	
	600	1250		600	1250		600	1200		575	1200	
	600	1350		600	1200		550	1200		600	1200	
	600	1250		575	1200		575	1300		550	1200	
	600	1300		600	1300		600	1250		600	1300	
	625	1300		625	1300		625	1300		600	1300	
	600	1300		600	1300		600	1300		600	1250	
	625	1300		600	1250		600	1300		600	1400	
	575	1250		600	1250		600	1250		600	1250	

Blank spaces indicate where precise measurements were not obtainable.

FIGURE 7

Second element of the complex nuclei compared with simple vowels in
the environment /t - n/ Level tone Informant 3

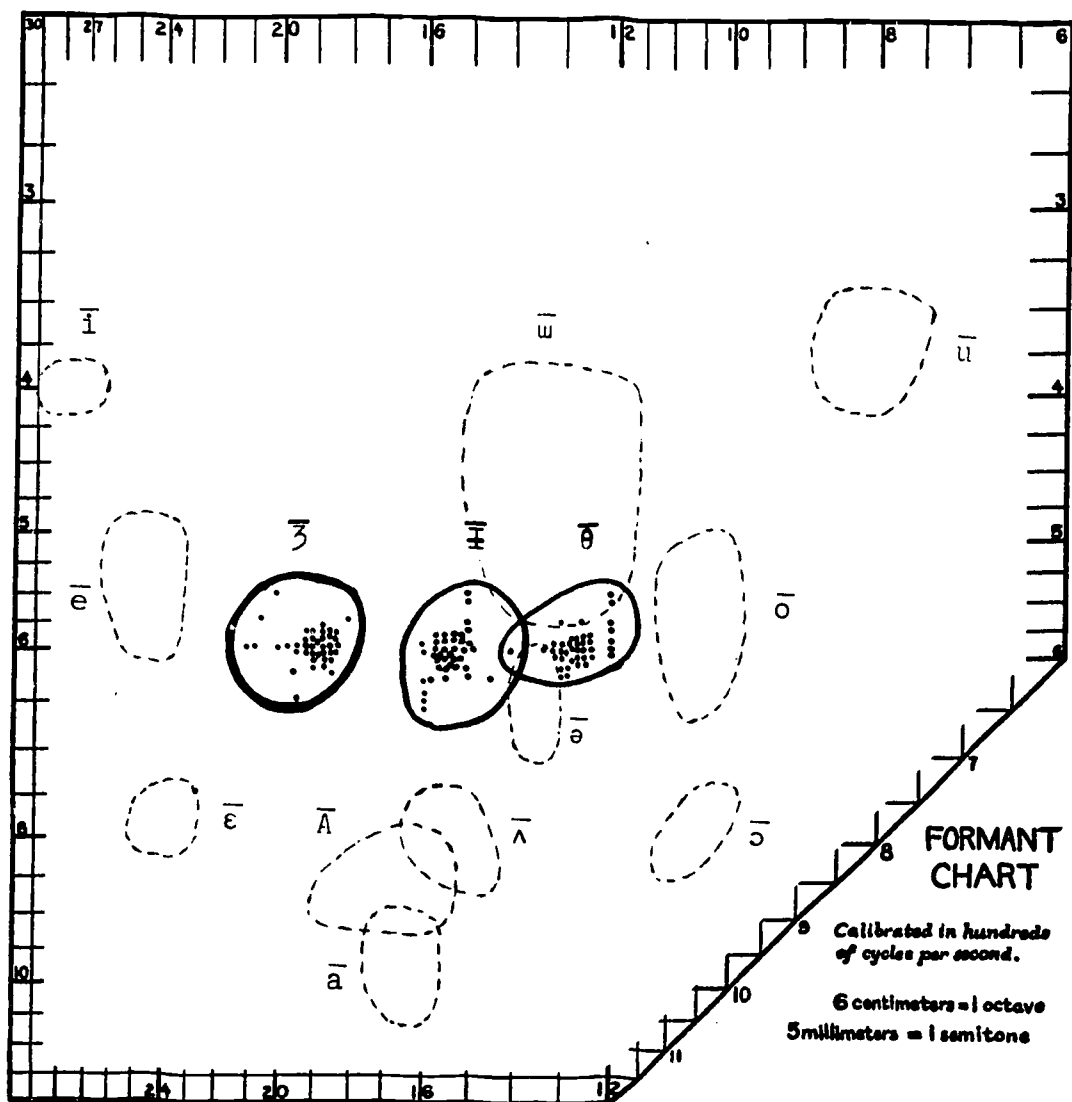


TABLE 8

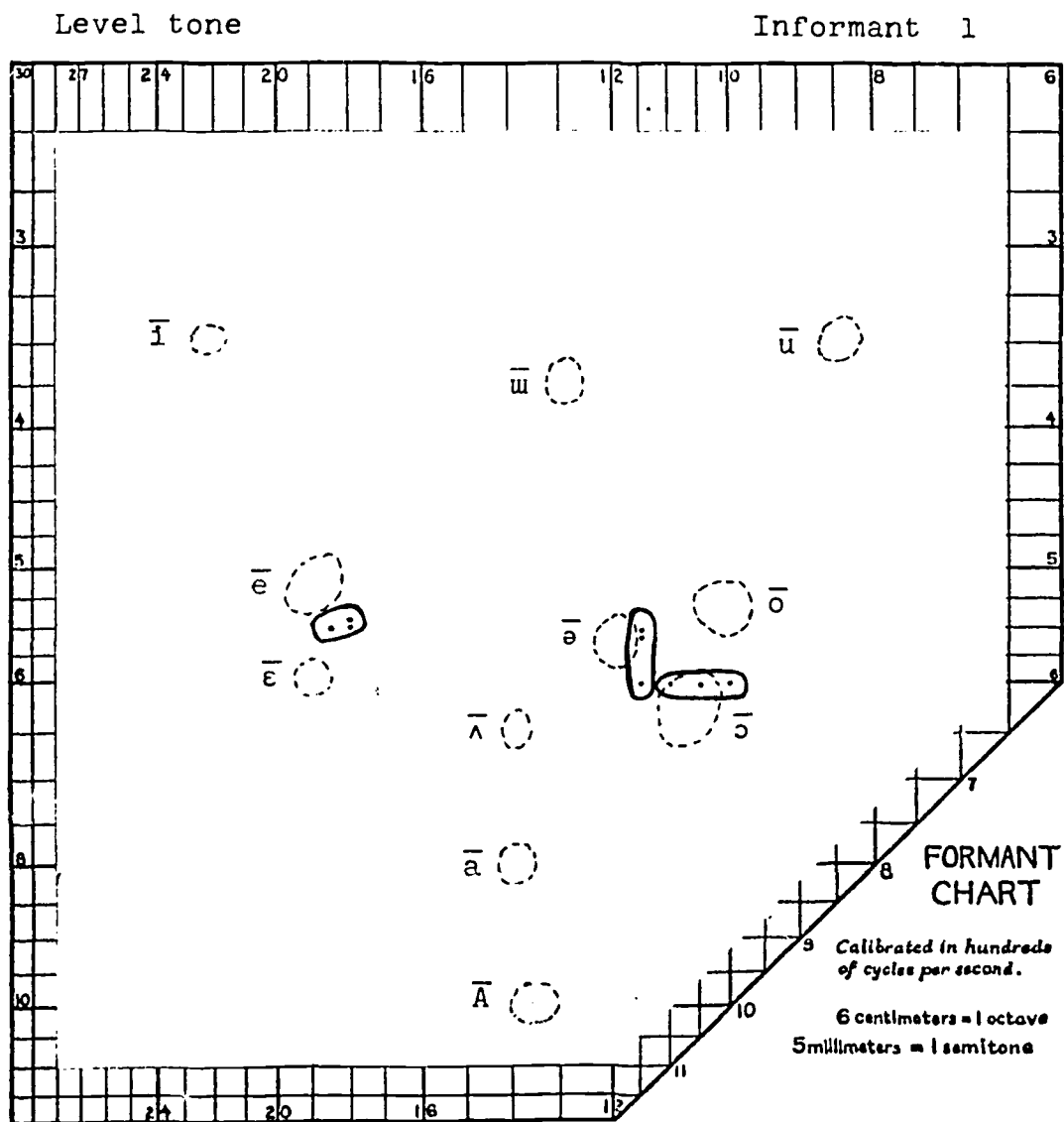
Second segments of the complex nuclei: Informant 1

Word	1		2		3		4	
	F1	F2	F1	F2	F1	F2	F1	F2
tī̄zn			550	1800	550	1800	550	1850
tū̄m			600	1150	550	1150	550	1150
tū̄θn			600	1050	600	1000	600	1100

Blank spaces indicate where precise measurements were not obtainable.

FIGURE 8

Second element of the complex nuclei compared with simple vowels



are led to the following conclusions:

- 1) The first segments, tentatively transcribed as [ɪ], [ʊ], and [ʊ] are phonetically similar enough to [i], [w], and [u] to be regarded as the same vowel qualities. The acoustic phonetic data confirms the auditory impression. The first segments of the complex nuclei are best analysed as /i/, /w/, and /u/ respectively.
- 2) The second segments of [ɪʒ], [wɪ], and [uθ] in the environment /t - n/ with level tone occupy three distinctive domains on the formant chart. [ɪ] is more similar to /e/, [ɪ] is more similar to /ə/, and [θ] is more similar to /o/ than [ɪ], [ɪ], and [θ] are to each other or to the domain of any one phoneme.

It might be possible to analyse [ɪ], [ɪ], and [θ] as one single phoneme on the basis of their distribution, since [ɪ] occurs only after /i/, [ɪ] only after /w/, and [θ] only after /u/. On a distributional basis they could be assigned as allophones in complementary distribution. Such a phonemic analysis, however, lacks phonetic basis and is close to becoming merely a mentalistic game. After careful observation of the phonetic phenomena, we analyse [ɪ], [ɪ], and [θ] phonemically as /e/, /ə/, and /o/, making the complex nuclei phonemically: /ie/ /wə/ and /uo/.

Chapter 4

COMPLEX NUCLEI IN VARIED ENVIRONMENTS

As presented in the previous chapter, the acoustic-phonetic study of complex syllable nuclei led us to the analysis of the segments spelled "tiên", "tubh", and "tuôn" as / \overline{ti} en/, / \overline{tu} ən/, and / \overline{tu} on/.

The purpose of the present chapter is to test our analysis of [ʒ], [ɸ], and [θ] as the three separate phonemes /e/, /ə/, and /o/ in more varied phonetic environments. Also, we will try to answer the question of whether the second segments of each of the following pairs are phonetically similar enough to be considered the same:

Open syllables	Closed syllables
"-ia"	"-iê-"
"-uâ"	"-ubɛ"
"-ua"	"-uô-"

As noted earlier, Thompson analysed the second segments [ʒ], [ɸ], and [θ] in open syllables as all being the same phoneme /ʌ/, and those in closed syllables as being three separate phonemes /e/, /ə/, and /o/. Other analysts have interpreted the second segments of the pairs spelled "-ia" and "-iê-", "-uâ" and "-uôɛ", and "-ua" and "-uô-" as being

phonemically the same. To arrive at a conclusive answer to this problem, it is necessary to study phonetic differences between the complex nuclei in open syllables and those in closed syllables.

For this study, the recording material was arranged according to syllable types and tones. Six tones, level /-/, rising / \nearrow /, broken / \sim /, falling / \searrow /, curve / \vee /, and drop / \neg /, are contrastive in the Hanoi dialect of Vietnamese. A syllable in Vietnamese can be open or closed. The final consonants that occur following the three complex nuclei are summarized as follows:

	p	t	k	m	n	ŋ	w	y
[iɜ]	+	+	+	+	+	+	+	-
[wɪ]	+	+	+	+	+	+	+	+
[uθ]	-	+	+	+	+	+	+	+

The distribution of final /y/ and /w/ with complex nuclei is noteworthy. /y/ in Vietnamese follows only the central and back vowels and does not occur after /i/, /e/, /ɛ/, and [iɜ]. /w/ follows only the central and front vowels and does not occur after /u/, /o/, /ɔ/, and [uθ]. This distributional characteristic seems to suggest that [ɜ] is structurally parallel to the front vowel /e/, and [θ] is structurally parallel to the back vowel /o/. However, the phonemic status of /w/ and /y/ as consonants needs further study to confirm this interpretation. We, therefore, decided not to include /w/ and /y/ as consonants in our spectrographic analyses. Our analysis included: 1) open

syllable words grouped according to the six different tones and 2) closed syllable words with final consonants /p t k m n ŋ/, also grouped according to the six tones.

Table 9 represents F1 and F2 measurements of the second segment [ɜ] of [iɜ] in open syllable words as spoken by Informant 4. Figure 9 is the corresponding graphic representation. The [x] represents the measurements of [ɜ] with drop tone, while the dot [.] represents [ɜ] with all other tones. The occurrences of phones having an F1 measurement between 550-600 cps are identified as being either those with drop tone /↘/ or with broken tone /↙/. In our previous study, it was observed that drop tone consistently raised F1 measurements of simple vowels 50-100 cps, making the phones with drop tone appear much lower on the formant chart. In Figure 9, the same effect is observed on the formant measurements of [ɜ].

Table 10 summarizes the data obtained from the formant measurements of [ɪ] of [uɪ] in open syllables spoken by Informant 4. When converting the figures into the graphic representation on the formant chart as shown in Figure 10, it became apparent that on this vowel, also, the effect of the drop tone is clearly observable. It is interesting to note that the effect of drop tone on the segments [ɜ] and [ɪ] is very much like that observed on the simple vowels /e/ and /ə/.

It was noted in our previous study that drop tone has slightly less effect on back vowels than on front and central vowels. The extent of the drop tone effect on F1 measurements

TABLE 2
 Formant measurements of complex nuclei segment [ɜ] Open syllable cycles/second
 All tones Informant 4

Formant [ɜ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tɜ̃	450	2050		450	2000		450	2000		450	2050	
tɜ̃ˀ	500	1900		450	1900		450	1950		450	1950	
sɜ̃	400	2100		450	2150		450	2100		450	2000	
ɛɜ̃	450	2050		450	2000		450	2050		450	2050	
ɪɜ̃	450	2050		450	2000		450	2050		450	1950	
ɪɜ̃ˀ	450	1900		450	1850		450	1900		450	1850	
nɜ̃	450	2050		450	2000		450	2100		450	2050	
ɲɜ̃	450	2000		450	2000		450	2000		450	2000	
wɜ̃	450	2000		450	1850		450	1950		450	1850	
ɔɜ̃	450	1900		450	1850		450	1900		450	1550	
ʌɜ̃	450	2000		450	1900		450	1900		450	1900	

Segment [ɜ] with tone [ˀ]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tɜ̃ˀ	500	2000		500	1850		450	1900		450	1950	
mɜ̃ˀ	500	2000		450	1900		450	2050		450	2050	
ɾɜ̃ˀ	500	1850		500	1950		450	2000		450	1950	
xɜ̃ˀ	450	2050		450	2000		450	2000		450	2050	

Formant [ɜ] with tone [ˁ]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tɜ̃ˁ	450	2050		500	2000		450	2050		450	2100	
ɛɜ̃ˁ	450	2150		500	2000		500	1950		450	2100	
kɜ̃ˁ	500	2000		500	1900		500	1950		450	2000	
bɜ̃ˁ	450	2000		450	1900		450	2000		450	2000	
dɜ̃ˁ	450	1850		450	2000		450	1900		500	1850	
lɜ̃ˁ	450	2000		450	1950		450	2000		450	2000	

Segment [ɜ] with tone [˂]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ɛɜ̃˂	650	1950		550	1850		600	1850		600	1850	
dɜ̃˂	600	1850		550	1800		550	1800		600	1850	
nɜ̃˂	650	1900		550	1800		550	1900		600	1850	
ŋɜ̃˂	600	1800		550	1900		600	1850		600	1850	

Segment [ɜ] with tone [˃]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ɪɜ̃˃	450	2000		550	1900		500	2000		400	2050	
tɪɜ̃˃	500	2050		450	2050		400	2000		400	2000	
dɪɜ̃˃	500	1900		450	1950		500	1950		500	2000	
mɪɜ̃˃	550	2000		500	1950		500	2000		500	1950	

Segment [ɜ] with tone [˄]

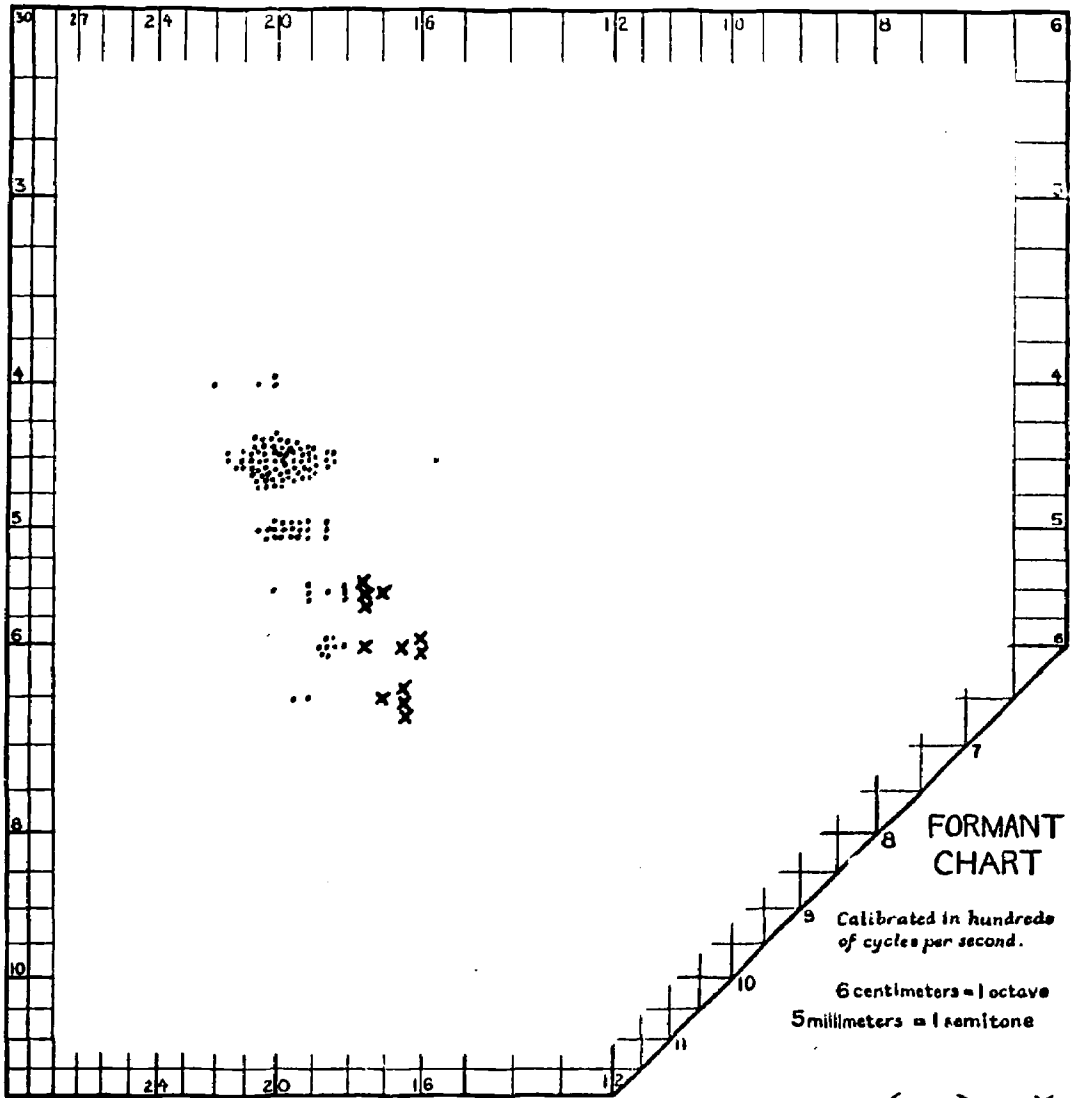
Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
bɪɜ̃˄	650	1650		650	1650		550	1750		550	1750	
dɪɜ̃˄	650	1700		550	1750		550	1700		600	1750	
lɪɜ̃˄	650	1650		600	1600		600	1600		600	1650	

Blank spaces indicate where precise measurements were not obtainable.

FIGURE 9

[ʒ] in open syllables

All tones Informant 4



• = [ʒ̄] [ʒ̂] [ʒ̃] [ʒ̄̃] [ʒ̃̄]

x = [ʒ̄]

TABLE 10
Formant measurements of complex nuclei segment [ɛ̃] Open syllable cycles/second
All tones Informant 4

Segment [ɛ̃] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ũ	550	1450		550	1400		550	1400		550	1450	
tʰũ	550	1450		450	1450		450	1350		550	1350	
cw̃	450	1500		500	1600		450	1650		500	1450	
kw̃	450	1400		450	1400		450	1400		500	1450	
ɬw̃	550	1350		450	1500		450	1500		500	1350	
mw̃	500	1450		500	1450		450	1450		450	1450	
ɲw̃	450	1450		450	1450		450	1400		450	1400	
hw̃	500	1500		500	1500		450	1550		450	1500	

Segment [ɛ̃] with tone [ʔ]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
cw̃	550	1500		450	1500		450	1500		450	1500	
kw̃	600	1350		450	1350		500	1450		450	1450	
bw̃	450	1400		450	1400		450	1350		450	1400	
ɬw̃	500	1450		500	1600		500	1450		500	1500	
lw̃	500	1500		500	1450		550	1400		500	1500	
mw̃	500	1450		500	1450		500	1450		450	1400	
ɲw̃	550	1350		500	1450		500	1450		450	1450	
ɳw̃	600	1400		500	1500		500	1500		500	1350	
hw̃	500	1450		500	1350		500	1350		500	1450	

Segment [ɛ̃] with tone [˨]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tʰw̃	550	1350		500	1350		500	1350		500	1350	
cw̃	500	1450		450	1400		500	1300		500	1400	
bw̃	600	1350		500	1500		500	1550		450	1500	
lw̃	500	1450		550	1450		550	1400		550	1450	
ɳw̃	550	1450		500	1350		500	1350		550	1350	

Segment [ɛ̃] with tone [˨˨]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
cw̃	550	1500		550	1550		550	1500		550	1450	
bw̃	600	1400		550	1450		550	1400		600	1450	
ɳw̃	600	1450		550	1350		600	1350		550	1400	

Segment [ɛ̃] with tone [˨˨˨]

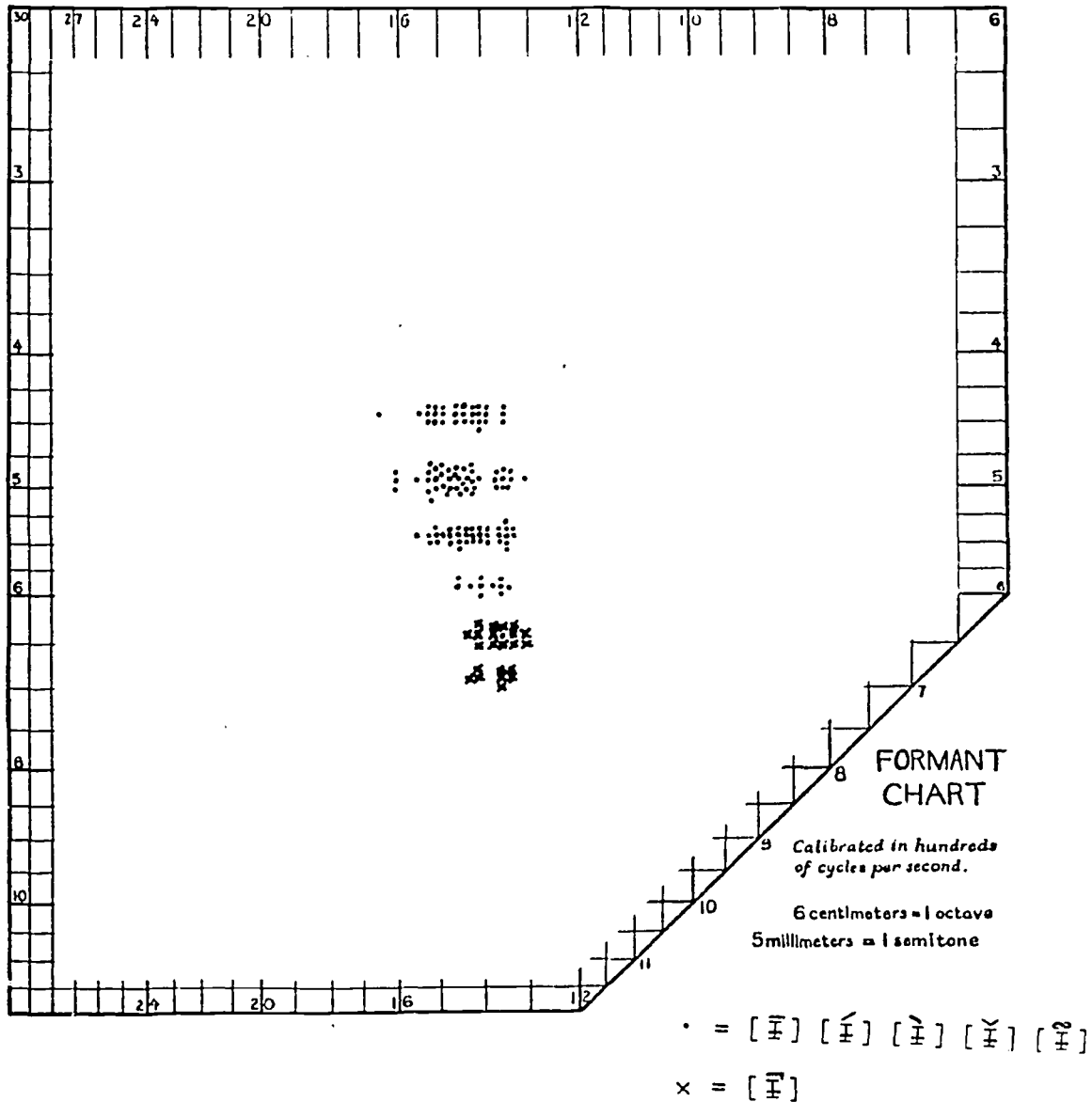
Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
cw̃	600	1400		550	1500		500	1450		500	1450	
kw̃	600	1350		550	1400		550	1350		550	1400	
bw̃	650	1350		550	1400		500	1450		550	1350	
mw̃	550	1350		550	1350		550	1500		550	1400	
ɲw̃	600	1350		550	1450		500	1500		500	1500	
ɳw̃	600	1400		500	1500		550	1400		550	1450	

Segment [ɛ̃] with tone [˨˨˨˨]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
w̃	650	1300		700	1350		700	1350		700	1350	
tw̃	650	1300		650	1400		650	1400		650	1350	
kw̃	700	1350		650	1350		650	1300		700	1400	
bw̃	700	1400		650	1400		650	1350		650	1350	
lw̃	700	1400		700	1350		650	1350		650	1350	
ɳw̃	700	1350		650	1350		650	1350		650	1400	

Blank spaces indicate where precise measurements were not obtainable.

FIGURE 10
 [ɪ] in open syllables
 All tones Informant 4



of back vowels is approximately 50 cps. Table 11 summarizes the measurements of F1 and F2 of the segment [θ] of [uθ] in open syllables. Figure 11 is the graphic representation of the same measurements. The effect of drop tone on the segment [θ] is seen to be very similar to that observed on the simple vowel /o/.

The domains occupied by [ɜ], [ɛ], and [θ] in open syllables are placed together on one formant chart as shown in Figure 11a. This chart shows that the three sounds do occupy three distinct areas even when the environments of the complex nuclei are enlarged to include all six tones and various initial consonants. This result gives further support to our analysis of [ɜ], [ɛ], and [θ] as three separate phonemes rather than one single phoneme.

TABLE 11
Formant measurements of complex nuclei segment [ə] Open syllable
All tones Informant 4 cycles/second

Segment [ə] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
uə	550	1150		500	1150		500	1150		500	1100	
tuə	500	1000		450	1000		450	1000		450	950	
cuə	500	1000		450	1050		450	1050		500	1000	
buə	450	950		500	1050		450	1050		450	950	
luə	500	1000		550	1100		550	1100		500	1000	
muə	450	900		450	1000		450	900		450	950	
nuə	450	950		450	950		450	1000		450	1000	
vuə	450	1000		500	1000		550	1100		550	1100	
vuə	500	1050		500	1000		500	1050		450	1050	
vuə	500	1100		450	1100		450	1000		450	1000	
vuə	450	1050		500	1050		500	1100		450	1100	
vuə	450	1100		450	1050		450	1050		450	1050	
xuə	450	1000		500	1100		500	1050		500	1100	

Segment [ə] with tone [ˊ]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
uə	600	1100		550	1100		500	1100		550	1000	
tuə	500	1150		500	1150		550	1100		500	1000	
cuə	550	1150		500	1150		450	1100		500	1150	
buə	500	1050		450	1050		450	1100		450	1000	
luə	450	1100		500	1100		450	1000		450	1000	
muə	450	1050		450	1000		450	1000		450	900	

Segment [ə] with tone [ˋ]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
uə	550	1150		550	1050		550	1150		500	1100	
tuə	500	1150		600	1150		550	1100		600	1100	
cuə	500	1100		550	1100		550	1200		500	1100	
buə	550	1100		500	1100		500	1000		500	1000	
luə	500	1100		450	1000		450	1000		500	1100	
muə	550	1150		550	1100		550	1100		550	1100	
nuə	500	1000		500	1100		500	1000		500	1000	

Segment [ə] with tone [ˌ]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
duə	550	1100		600	1050		600	1100		600	1150	
luə	600	1150		550	1150		500	1000		550	1150	
zuə	550	1150		550	1100		550	1150		600	1150	

Segment [ə] with tone [ˍ]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
uə	600	1050		600	1100		550	1050		600	1050	
kuə	550	1050		500	1050		550	1000		500	1000	
suə	600	1150		550	1100		550	1050		550	1050	
zuə	550	1150		500	1100		550	1100		500	1000	

Segment [ə] with tone [ˎ]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
uə	650	1150		650	1150		650	1200		650	1200	
buə	650	1150		650	1150		650	1150		650	1200	
luə	700	1150		650	1150		600	1150		600	1150	

Blank spaces indicate where precise measurements were not obtainable.

FIGURE 11

[θ] in open syllables

All tones Informant 4

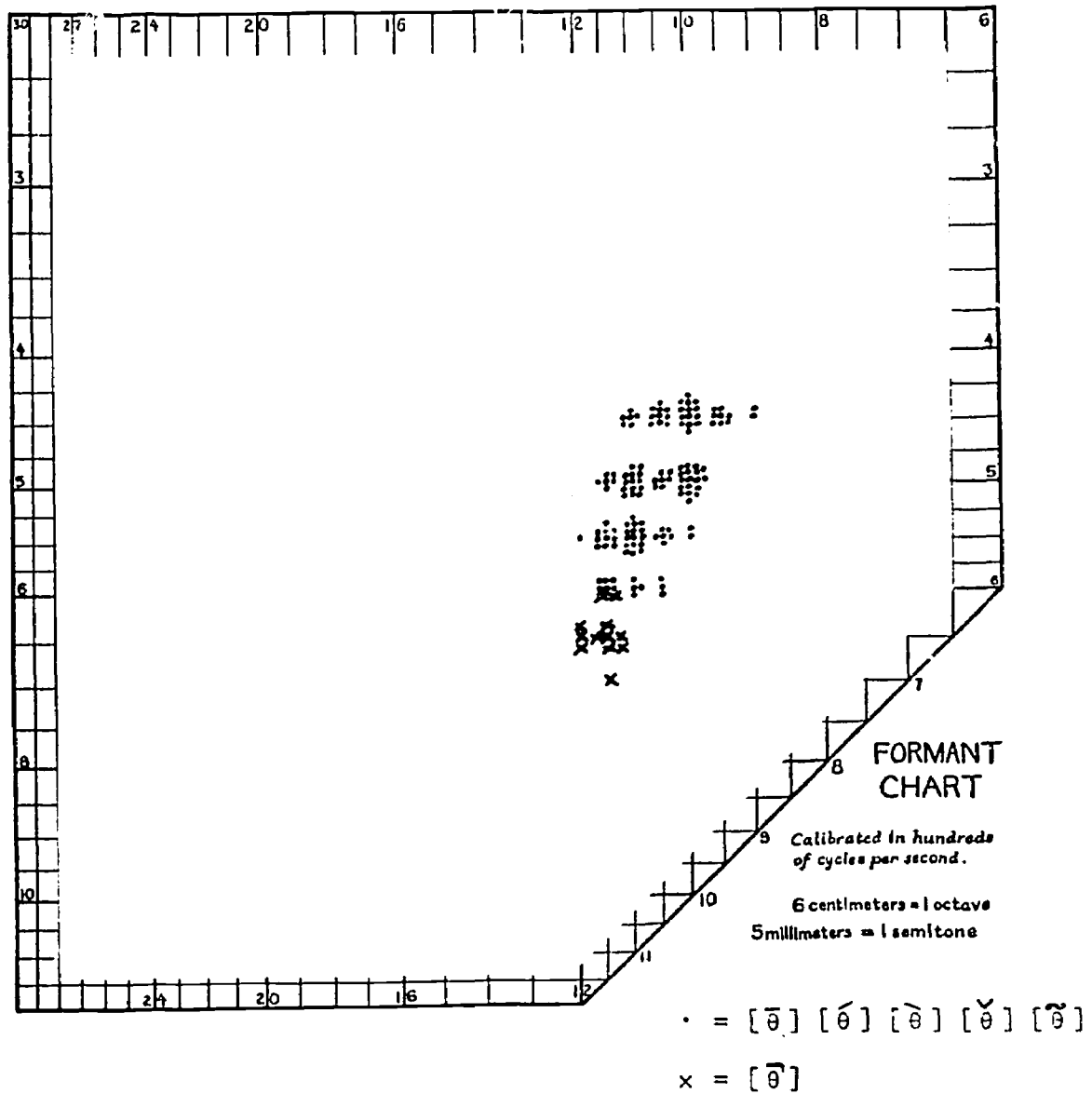
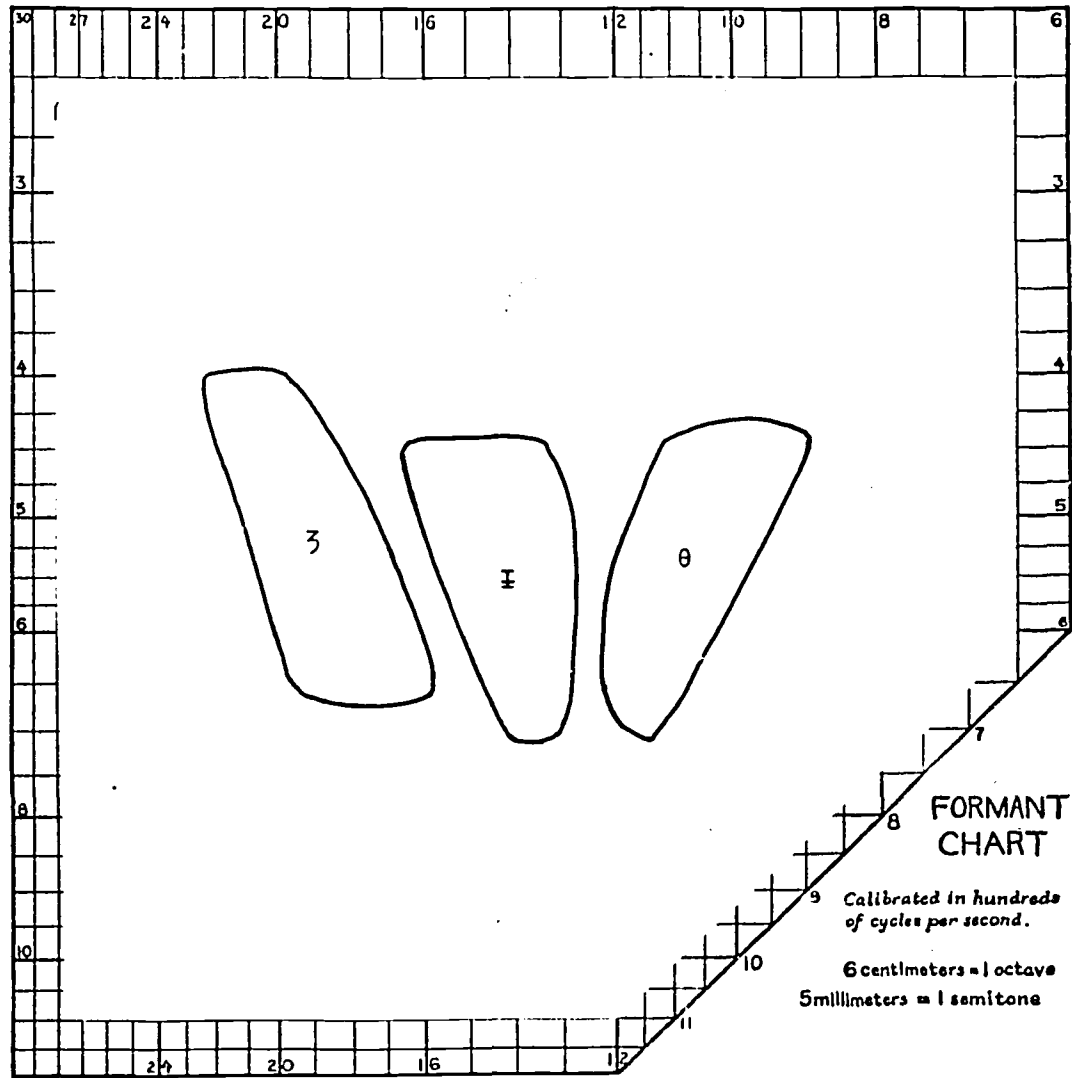


FIGURE 11a

Domains of [-ɜ] [-ɛ] [-θ] in open syllables

All tones

Informant 4

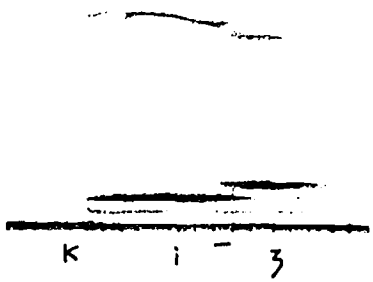
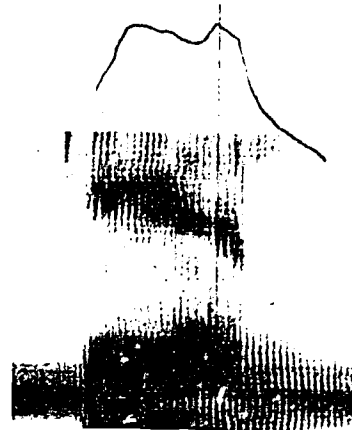
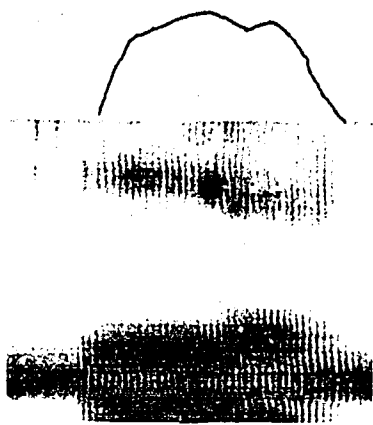


Different final consonants have varying effects on the quality of the syllable nuclei. These differences are observable in the frequency and shapes of formants. Spectrograms 16-19 illustrate the differences in formant shapes of [iɜ] in an open syllable, such as [kiɜ], and in closed syllables with the final consonants [-n], [-m], and [-ŋ], as in [kiɜ̄n], [kiɜ̄m], and [kiɜ̄ŋ]. As is easily seen on these spectrograms, the complex nuclei [iɜ] in the open syllable has a steady state of [i] and a steady state of [ɜ]. When there is such a steady state on the spectrogram of a vocalic quality, this point is taken as the most reasonable place to measure the formant. In the case of closed syllables, as seen on the spectrograms of [kiɜ̄n], [kiɜ̄m], and [kiɜ̄ŋ], the second segment [ɜ] is usually shorter than the first segment [i] and usually has no observable steady state. In the case of continually changing formants such as these, it is difficult to determine where the formant measurements should be taken, because a small difference in time may result in a large difference in F1 and F2 measurements. For this reason, we applied the use of an amplitude display unit in determining the point where F1 and F2 measurements should be taken. Table 12 shows F1 and F2 measurements taken at intervals of two centiseconds along the relatively steady states of the formants of [i] and of [ɜ] in [kiɜ] and, also, those measurements taken along the continually changing formants of [i] and [ɜ] of [kiɜ̄n], [kiɜ̄m], and [kiɜ̄ŋ]. Figure 12a shows a diagrammed interpretation of the formant

SPECTROGRAM NO. 16

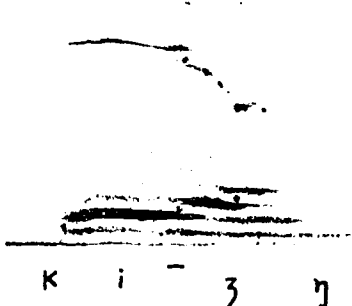
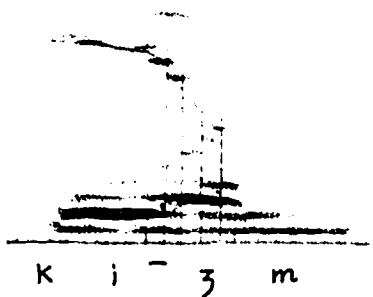
SPECTROGRAM NO. 17

Informant 4



SPECTROGRAM NO. 18

SPECTROGRAM NO. 19



k i - 3 m

k i - 3 n

TABLE 12

Formant measurements at intervals of 2 centiseconds

Complex nuclei [i:]		Informant 4				cycles/second			
Word	[ki:]		[ki:]n		[ki:]m		[ki:]n		
csec.	F1	F2	F1	F2	F1	F2	F1	F2	
0	300	2250	300	2350	300	2200	300	2200	
2	300	2250	300	2350	350	2200	350	2200	
4	300	2250	300	2350	350	2200	350	2200	
6	300	2250	300	2300	350	2150	350	2200	
8	300	2250	350	2250	350	2100	350	2150	
10	300	2250	400	2100	350	2050	350	2150	
12	300	2200	450	2050	400	1950	400	2000	
14	300	2150	500	1950	500	1800	500	1950	
16	350	2050	500	1900	500	1400	500	1750	
18	450	2000	500	1850	550	1250	550	1550	
20	450	2000					600	1500	
22	450	2000							
24	450	2000							
26	450	2000							

Blank spaces indicate where precise measurements were not obtainable.

measurements, with an x marking the point of the amplitude peak of the segment [ʒ]. Figure 12b shows how these measurements would be interpreted on formant charts. Table 12 and Figure 12a and 12b show the varying effects of different final consonants on the complex nuclei.

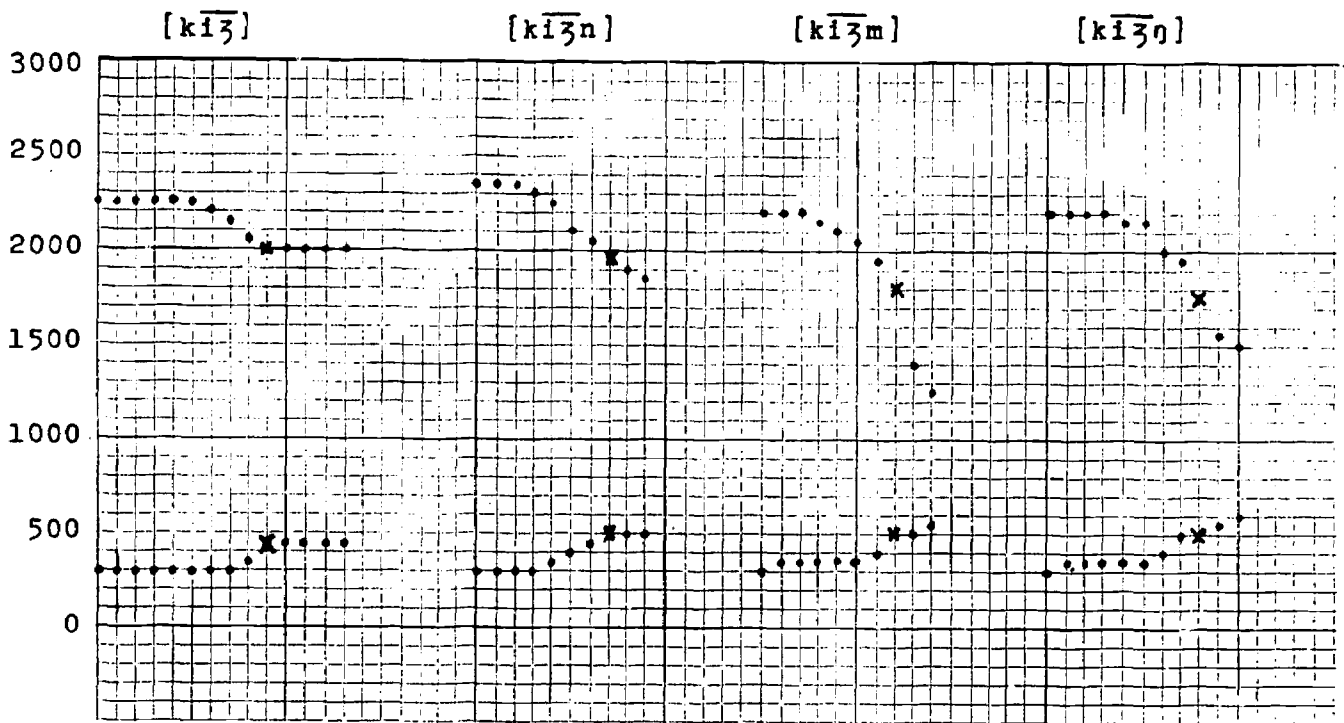
In a complex nucleus, there usually are two amplitude peaks; whereas, in a simple vowel nucleus, there is only one amplitude peak. The two amplitude peaks of a complex nucleus normally coincide in time with the mid-points of the first and the second segments of the nucleus. The mid-point and amplitude peak of the first segment also coincide with the steady state of that segment. This suggests that the point where the second amplitude peak occurs is the target point or near it, and therefore is the most logical place to measure F1 and F2 of the second segment. Using this reasoning, the measurements presented in the following tables were obtained at the point of the second amplitude peak.

Table 13 presents the F1 and F2 measurements of the segment [ʒ] of [iʒ] in closed syllables with /-m, -n, -ŋ, -p, -t, -k/ as the final consonants. All tones are represented here in the utterances spoken by Informant 4. Figure 13 is the graphic representation of the figures presented in Table 13. It may be noted that the domain of [ʒ] is slightly larger and more centralized in these examples than is the domain of [ʒ] in open syllables.

FIGURE 12a

F1 and F2 of complex nucleus [i:]
in different environments

Informant 4

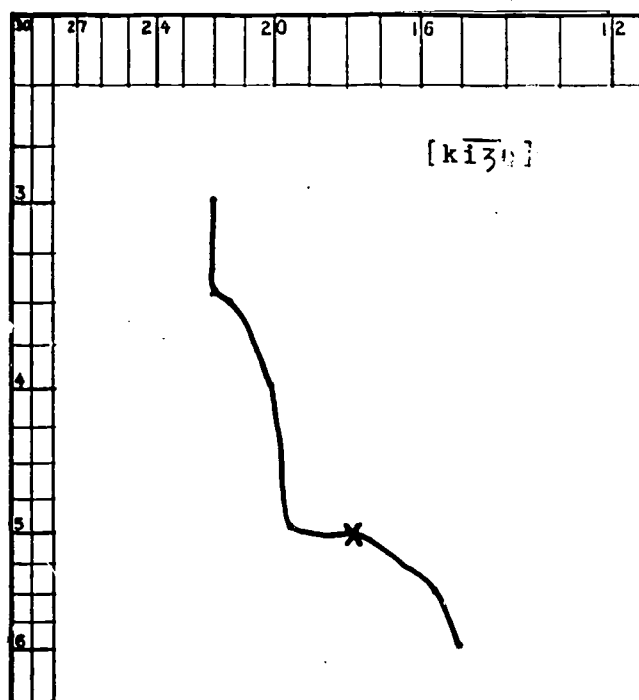
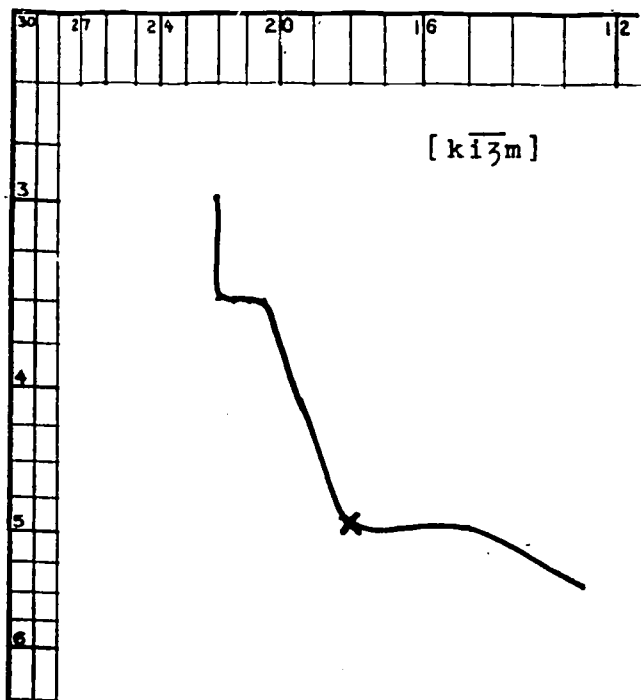
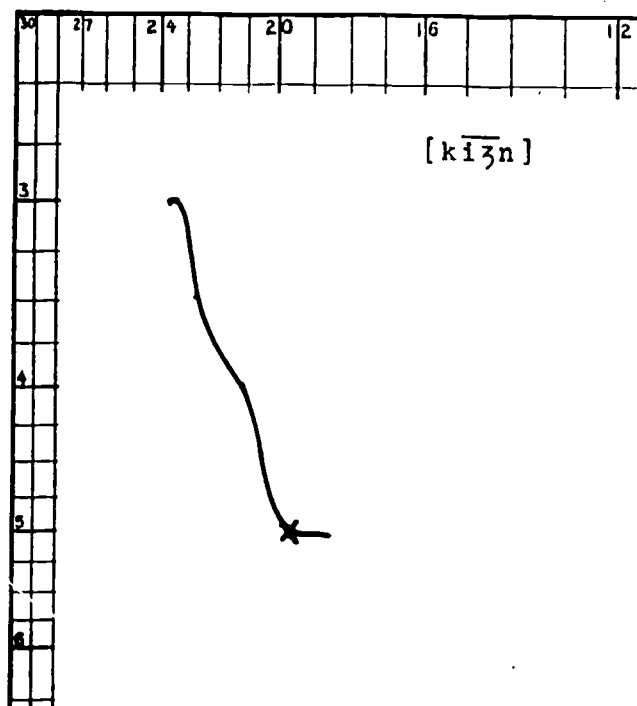
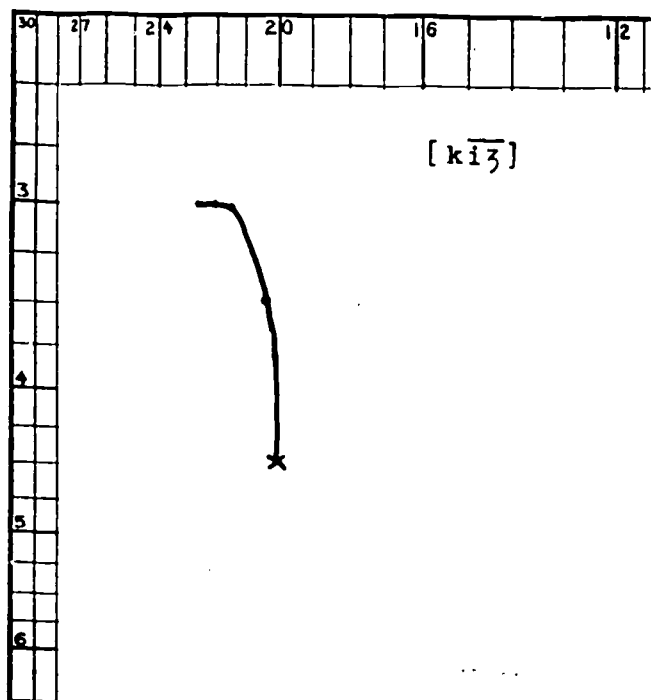


x marks the amplitude peak of segment [-ɜ]

FIGURE 12b

Formant movements in complex nucleus [iɜ]

Informant 4



x marks the amplitude peak of segment [-ɜ]

TABLE 13

Formant measurements of complex nuclei segment [ɜ] Closed syllable
All tones Informant 4 cycles/second

Segment [ɜ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tɜ̃	600	1700		600	1500		600	1500		600	1500	
tɜ̃n	600	1500		600	1500		550	1500		550	1500	
tɜ̃m				600	1500		550	1500		500	1550	
tɜ̃n	600	1550		600	1500		600	1500		600	1500	
tɜ̃m				600	1600		550	1600		550	1600	
tɜ̃n				550	1550		550	1600		500	1650	
tɜ̃n	550	1900		600	1900		550	1950		600	1900	
tɜ̃m	550	1900		550	1900		550	1950		600	1850	
tɜ̃n	550	1950		500	1950		450	1950		450	1950	
tɜ̃m	550	1950		550	1900		500	1950		600	1850	
tɜ̃n	550	1850		500	1900		500	1900		500	1900	
tɜ̃m				550	1950		600	1900		600	1850	
tɜ̃n	550	2000		450	2000		550	2000		450	1950	
tɜ̃m				450	1950		450	1950		450	1950	
tɜ̃n				550	1950		550	1900		550	1900	
tɜ̃n	550	1600		550	1650		500	1600		550	1600	
tɜ̃m				550	1600		550	1700		550	1550	
tɜ̃n				600	1600		550	1650		550	1700	
tɜ̃m				550	1750		550	1750		550	1750	
tɜ̃n				500	1500		450	1500		500	1550	

Segment [ɜ] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tɜ̃m	650	1500		650	1500		600	1500		600	1550	
tɜ̃n	600	1500		600	1500		550	1550		600	1600	
tɜ̃m	600	1400		600	1500		600	1450		600	1500	
tɜ̃n	650	1450		600	1500		600	1500		600	1500	
tɜ̃n	600	1900		600	1850		600	1900		600	1950	
tɜ̃m	550	1850		550	1950		550	1900		600	1900	
tɜ̃n	600	1850		600	1850		600	1900		600	1900	
tɜ̃m	600	1850		600	1900		600	1850		600	1950	
tɜ̃n	550	1550		550	1600		550	1600		550	1600	
tɜ̃m	550	1600		550	1650		550	1750		550	1650	
tɜ̃n	550	1600		500	1700		500	1700		500	1700	
tɜ̃m	500	1600		450	1800		450	1800		450	1850	
tɜ̃n	550	1650		550	1700		550	1700		550	1800	

Segment [ɜ] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tɜ̃m	550	1500		600	1450		600	1400		600	1500	
tɜ̃n	550	1550		550	1500		550	1550		550	1550	
tɜ̃m	550	1900		550	1950		550	1950		500	2000	
tɜ̃n	550	1950		550	1900		550	1950		550	1900	
tɜ̃m	550	1900		550	1950		550	2000		550	1950	
tɜ̃n	600	1600		600	1750		600	1750		600	1800	

Segment [ɜ] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tɜ̃m	600	1500		550	1550		550	1600		550	1600	
tɜ̃n	650	1550		600	1550		650	1500		600	1500	
tɜ̃m	600	1450		550	1450		550	1500		550	1500	
tɜ̃n	600	1500		550	1550		550	1500		600	1500	
tɜ̃m	600	1900		550	1900		600	1900		550	1950	
tɜ̃n	650	1700		600	1800		550	1800		600	1750	

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tɜ̃p	500	1700		550	1700		500	1750		550	1700	
tɜ̃n	500	1650		550	1650		500	1650		550	1700	
tɜ̃m	500	1700		500	1700		500	1700		550	1700	
tɜ̃n	500	1650		500	1700		500	1750		500	1750	
tɜ̃m	550	1750		500	1800		500	1750		500	1750	
tɜ̃n	500	2000		500	2000		500	1950		500	1950	
tɜ̃m	500	1900		550	1950		550	1950		550	1950	
tɜ̃n	550	1900		500	1950		500	1850		500	1950	
tɜ̃m	500	2000		500	1950		500	1950		500	1900	
tɜ̃n	500	2000		500	2000		500	1950		550	1850	
tɜ̃m	500	1700		500	1750		550	1750		500	1800	
tɜ̃n	500	1750		500	1750		500	1800		550	1700	
tɜ̃m	550	1750		550	1750		550	1850		500	1800	
tɜ̃n	550	1700		500	1750		500	1800		500	1800	
tɜ̃m	550	1800		500	1800		500	1750		500	1750	
tɜ̃n	450	1500		550	1600		550	1500		500	1600	
tɜ̃m	550	1500		550	1500		550	1500		500	1500	
tɜ̃n	500	1550		450	1550		450	1550		450	1600	
tɜ̃m	550	1500		550	1500		550	1500		550	1500	
tɜ̃n	500	1550		500	1550		450	1600		550	1500	

Segment [ɜ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tɜ̃p	600	1650		600	1750		600	1650		550	1650	
tɜ̃n	550	1650		600	1550		550	1600		500	1700	
tɜ̃m	600	1700		550	1750		550	1800		500	1750	
tɜ̃n	550	1750		550	1850		550	1800		550	1800	
tɜ̃m	550	1800		550	1700		500	1750		550	1800	
tɜ̃n	550	1850		550	1900		550	1900		550	1900	
tɜ̃m	550	1800		550	1850		550	1800		550	1800	
tɜ̃n	600	1700		550	1700		600	1700		600	1700	
tɜ̃m	600	1650		600	1700		550	1750		550	1700	
tɜ̃n	650	1400		600	1450		600	1450		650	1450	
tɜ̃m	650	1450		600	1500		600	1500		600	1500	
tɜ̃n	650	1450		600	1500		600	1500		600	1500	
tɜ̃m	600	1850		600	1850		600	1800		600	1800	
tɜ̃n	600	1850		600	1800		600	1850		600	1850	

nk spaces indicate where precise measurements were not obtainable. 700 1500 650 1500 700 1500 650 1500

FIGURE 13
 [ʒ] in closed syllables
 All tones Informant 4

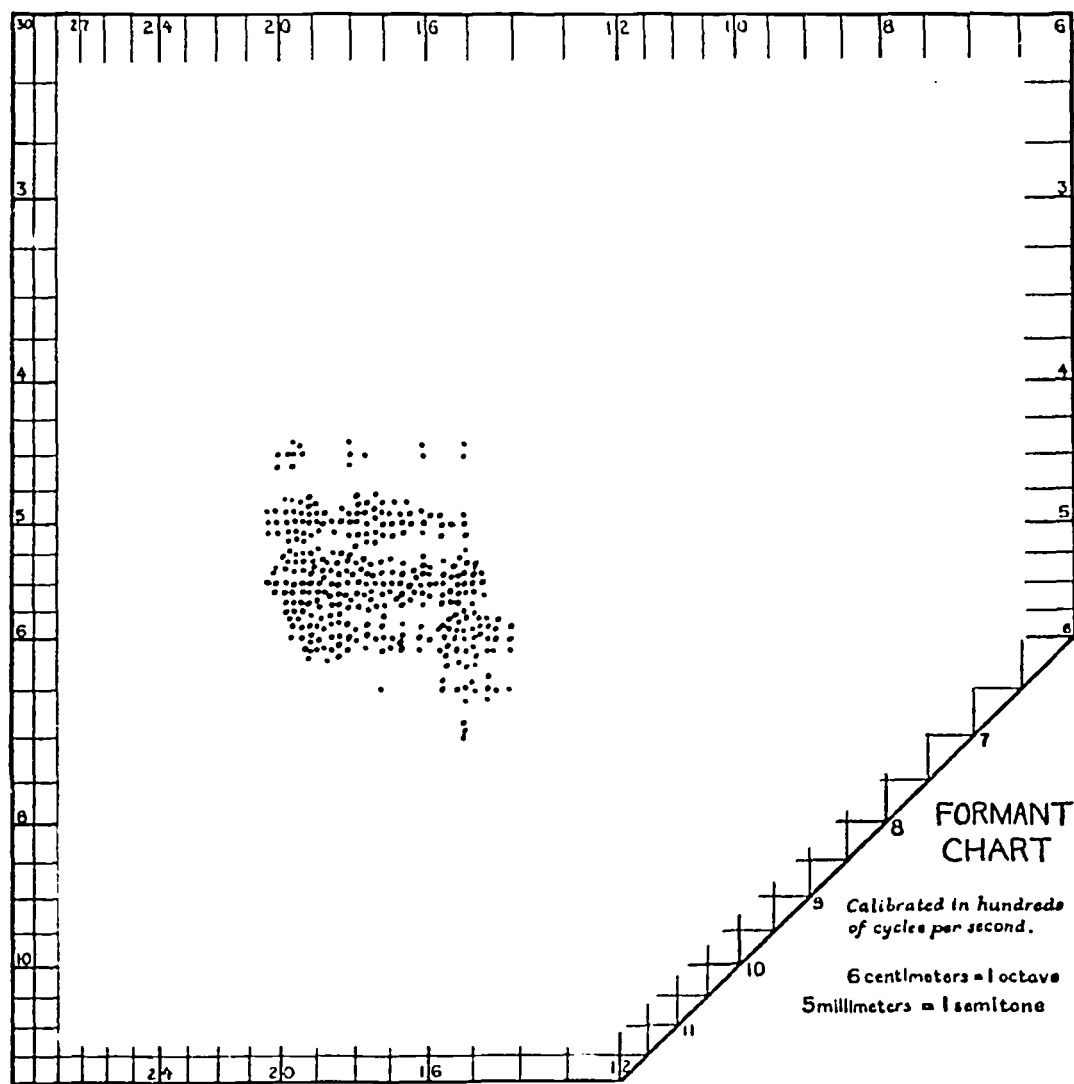


Table 14 presents the F1 and F2 measurements of the segment [ɪ] of [wɪ] in closed syllables with /-m, -n, -ŋ, -p, -t, -k/ as the final consonants. All tones are represented in these utterances by Informant 4. Figure 14 is the corresponding graphic representation of the figures presented in Table 14. It may be noted that the domain of [ɪ] in these examples of the nucleus in closed syllables is slightly larger and extends further back than does the domain of [ɪ] in open syllables.

Table 15 presents the F1 and F2 measurements of [ə] of [uə] in closed syllables with the same final consonants, and with all tones as spoken by Informant 4. Figure 15 is the corresponding graphic representation on the formant chart. It may be noted that, here again, the domain of [ə] covers a slightly larger area and extends further back on the formant chart.

Figure 15a is a composite chart showing all three nuclei segments [ɜ], [ɪ], and [ə] in a variety of environments. Some overlap of the three is seen in this presentation: but on careful examination, it is clear that this overlap is regularly conditioned. Three different environments are included on this chart. The small dark areas indicate the domains of [ɜ], [ɪ], and [ə] in the restricted environment [t-n] with level tone. The larger striped areas indicate the domains of [ɜ], [ɪ], and [ə] in open syllables with all six tones. The very large white areas show the domains of [ɜ], [ɪ], and [ə] in closed syllable

TABLE 14
Formant measurements of complex nuclei segment [ɛ] Closed syllable cycles/second
All tones Informant 4

Segment [ɛ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tɛ̄m	550	1150		500	1200		550	1200		550	1200	
nɛ̄m	550	1150		550	1200		550	1200		550	1150	
ɛ̄m	500	1150		500	1200		500	1200		500	1150	
ɛ̄n	600	1400		600	1400		600	1400		600	1350	
lɛ̄n	550	1450		500	1400		500	1500		550	1450	
tɛ̄ŋ	600	1200		600	1200		600	1200		550	1200	
cɛ̄ŋ	650	1200		650	1250		550	1250		650	1250	
kɛ̄ŋ	600	1150		600	1200		600	1200		600	1250	
bɛ̄ŋ	600	1250		500	1250		500	1250		500	1250	
dɛ̄ŋ	550	1200		500	1200		500	1250		500	1250	
lɛ̄ŋ	550	1200		500	1200		450	1300		500	1200	
mɛ̄ŋ	550	1200		550	1200		500	1300		550	1300	
nɛ̄ŋ	600	1200		600	1250		600	1250		600	1200	
ɛ̄ŋ	600	1200		600	1250		600	1200		550	1200	
hɛ̄ŋ	650	1150		550	1150		500	1150		550	1250	

Segment [ɛ] with tone [✓]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
bɛ̄m	550	1100		550	1150		550	1150		550	1100	
mɛ̄n	600	1550		600	1600		600	1500		550	1450	
bɛ̄ŋ	550	1150		600	1200		600	1200		550	1150	
nɛ̄ŋ	550	1150		600	1200		600	1200		550	1150	
hɛ̄ŋ	550	1200		550	1100		550	1150		600	1200	
ɛ̄p	600	1150		600	1300		500	1200		600	1300	
kɛ̄p	600	1200		550	1250		550	1200		600	1150	
mɛ̄p	550	1200		550	1150		500	1150		550	1100	
ɛ̄t	550	1500		600	1400		550	1400		550	1350	
tɛ̄t	600	1450		550	1450		550	1450		550	1400	
lɛ̄t	550	1450		550	1400		550	1450		550	1500	
mɛ̄t	600	1600		550	1550		550	1500		550	1550	
ɛ̄k	550	1250		600	1300		550	1250		550	1150	
tɛ̄k	600	1200		600	1250		600	1250		600	1300	
kɛ̄k	550	1250		600	1250		600	1300		550	1250	
bɛ̄k	550	1250		500	1250		550	1250		550	1250	

Segment [ɛ] with tone [∞]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
cɛ̄m	550	1100		550	1100		600	1150		600	1150	
kɛ̄m	550	1100		550	1150		550	1100		550	1150	
nɛ̄m	600	1200		600	1150		600	1250		600	1250	
ɛ̄m	600	1150		550	1100		600	1250		550	1200	
cɛ̄n	600	1450		600	1400		550	1350		600	1350	
vɛ̄n	600	1450		600	1450		600	1450		550	1450	
ɛ̄n	600	1400		550	1400		550	1450		600	1450	
tɛ̄ŋ	650	1250		650	1200		600	1250		600	1250	
cɛ̄ŋ	600	1250		600	1250		600	1250		600	1250	
kɛ̄ŋ	650	1200		600	1200		650	1250		650	1250	
dɛ̄ŋ	650	1200		600	1200		600	1200		600	1200	
lɛ̄ŋ	600	1250		650	1200		600	1200		600	1250	
mɛ̄ŋ	650	1200		600	1200		600	1250		600	1250	
nɛ̄ŋ	650	1200		650	1200		650	1200		650	1250	
hɛ̄ŋ	600	1250		550	1150		600	1150		650	1200	

Segment [ɛ] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ɛ̄n	650	1500		600	1450		600	1450		600	1400	
kɛ̄ŋ	650	1200		650	1200		600	1200		600	1200	
lɛ̄ŋ	650	1300		600	1250		650	1200		600	1200	
nɛ̄ŋ	650	1200		600	1250		650	1300		650	1300	
ɛ̄ŋ	650	1250		600	1250		600	1250		600	1200	

Segment [ɛ] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
dɛ̄m	650	1100		650	1150		650	1150		650	1200	
lɛ̄m	600	1150		650	1150		600	1150		600	1150	
lɛ̄n	650	1400		650	1350		650	1400		650	1400	
mɛ̄n	650	1450		650	1450		650	1450		650	1500	
vɛ̄n	650	1400		650	1500		650	1500		600	1500	

Segment [ɛ] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tɛ̄ŋ	600	1200		550	1200		550	1150		550	1150	
tɛ̄ŋ	650	1250		600	1200		550	1150		550	1200	
cɛ̄ŋ	650	1200		600	1200		600	1250		600	1250	
ɛ̄ŋ	550	1150		500	1100		550	1150		500	1100	
hɛ̄ŋ	600	1150		600	1150		600	1150		600	1200	

tɛ̄ŋ	700	1250		700	1250		650	1250		650	1200	
lɛ̄ŋ	650	1250		650	1250		650	1200		650	1250	
nɛ̄ŋ	700	1250		700	1200		700	1300		700	1250	
ɛ̄ŋ	700	1250		700	1250		700	1250		700	1250	
cɛ̄t	600	1350		650	1350		600	1350		600	1350	
mɛ̄t	600	1500		650	1450		600	1450		600	1450	
vɛ̄t	600	1400		600	1500		600	1450		650	1500	
ɛ̄t	600	1350		550	1450		550	1500		550	1400	
dɛ̄k	650	1250		650	1250		600	1250		600	1250	
nɛ̄k	650	1250		600	1200		550	1250		600	1200	
ɛ̄k	700	1250		650	1250		650	1250		650	1200	

Blank spaces indicate where precise measurements were not obtainable.

FIGURE 14

[ɪ] in closed syllables

All tones Informant 4

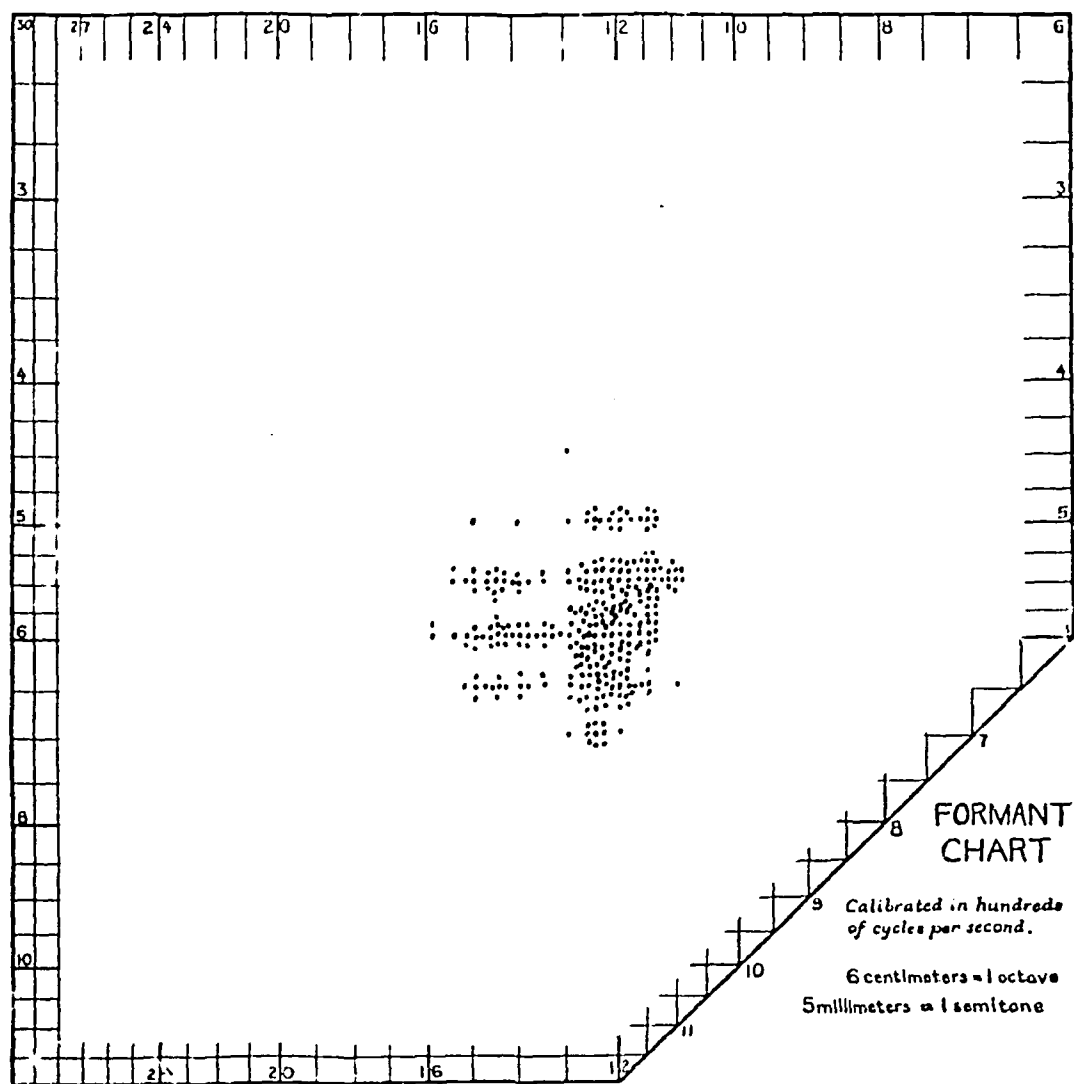


TABLE 15

Formant measurements of complex nuclei segment [ə] Closed syllable cycles/second
 Informant 4

Segment [ə] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
cūəm				450	850		450	1000		450	1000	
ṛūəm				400	1000		400	1000		450	1000	
tūəm				450	1100		450	1150		450	1150	
tʰūəm				450	1100		450	1150		450	1000	
hūəm				450	1150		450	1100		450	1100	
lūəm				500	1150		450	1050		400	1000	
sūəm				450	1100		400	1050		500	1050	
ūəm				550	1000		500	1000		500	950	
cūəm				500	1000		500	1000		450	950	
hūəm				500	1100		450	1000		450	900	
lūəm				450	900		450	1000		450	1000	
sūəm				450	1000		450	1000		450	900	
ūəm				450	900		450	1000		450	1000	

Segment [ə] with tone [✓]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
nūəm				400	750		350	850		350	800	
kūəm				550	1050		500	1100		500	1050	
mūəm				450	950		450	950		550	950	
ūəm				450	850		450	850		500	850	
kūəm				550	950		500	950		500	950	
mūəm				500	950		500	900		450	800	
hūəm				450	900		450	850		450	1000	
tūət				400	1150		400	1100		500	1100	
cūət				400	1150		450	1100		450	1150	
būət				350	1050		350	1000		350	1050	
nūət				450	1150		400	1050		350	1150	
tʰūək				450	900		350	850		450	900	
kūək				400	1150		400	1150		400	1100	
dūək				500	800		500	800		450	900	
ḡūək				450	950		450	1000		450	1050	

Segment [ə] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
būəm				500	1000		500	950		450	850	
tūəm				550	1200		550	1200		500	1150	
cūəm				500	1150		500	1150		550	1150	
lūəm				450	1100		500	1100		500	1100	
ḡūəm				500	1100		500	1100		550	1050	
tūəm				500	1000		500	950		500	950	
kūəm				500	1100		500	1050		500	1050	
lūəm				500	900		500	950		450	1000	
būəm				500	1000		550	1050		500	1050	

Segment [ə] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
kūəm				550	900		500	850		500	850	
mūəm				500	850		500	950		500	800	
mūəm				500	950		500	950		500	850	

Segment [ə] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
nūəm				550	850		500	850		500	850	
kūəm				550	1150		500	1150		550	1100	
mūəm				500	1150		500	1100		550	1150	
ḡūəm				500	1200		550	1200		500	1150	
kūəm				550	950		550	900		550	1000	
zūəm				550	950		500	900		550	1000	
tūət				450	1000		500	1100		450	1150	
cūət				500	1150		500	1200		500	1200	
būət				450	1100		450	1100		450	1050	
zūət				450	1150		500	1150		500	1100	
tʰūək				500	950		450	950		500	1000	
cūək				500	1000		550	1050		550	1050	
kūək				550	1100		500	1050		500	1050	
būək				500	950		450	950		450	900	
lūək				500	1050		550	1000		500	1000	

Segment [ə] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tʰūəm				500	950		450	950		500	950	
sūəm				500	900		500	950		500	1000	

Blank spaces indicate where precise measurements were not obtainable.

FIGURE 15

[θ] in closed syllables

All tones Informant 4

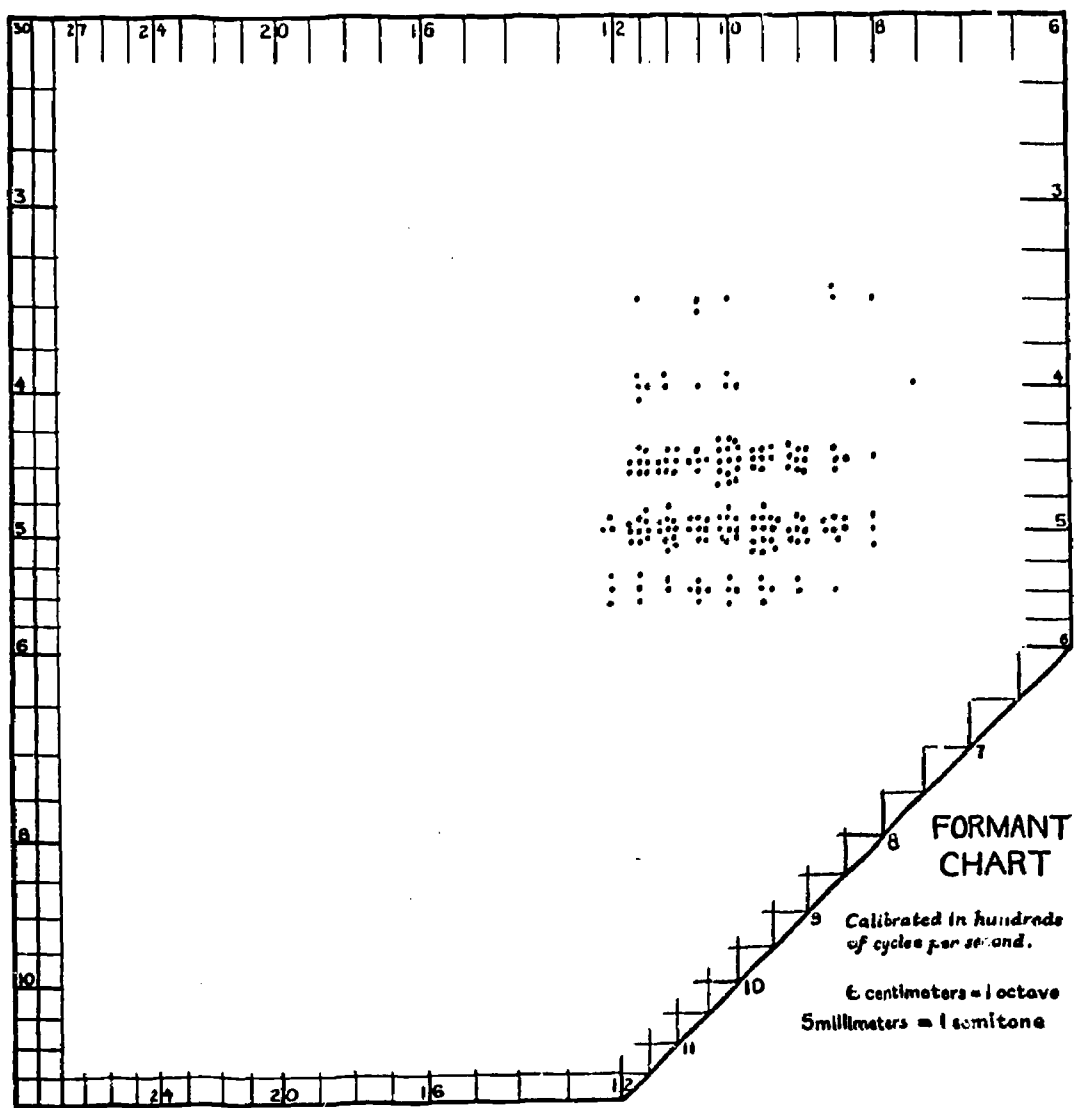
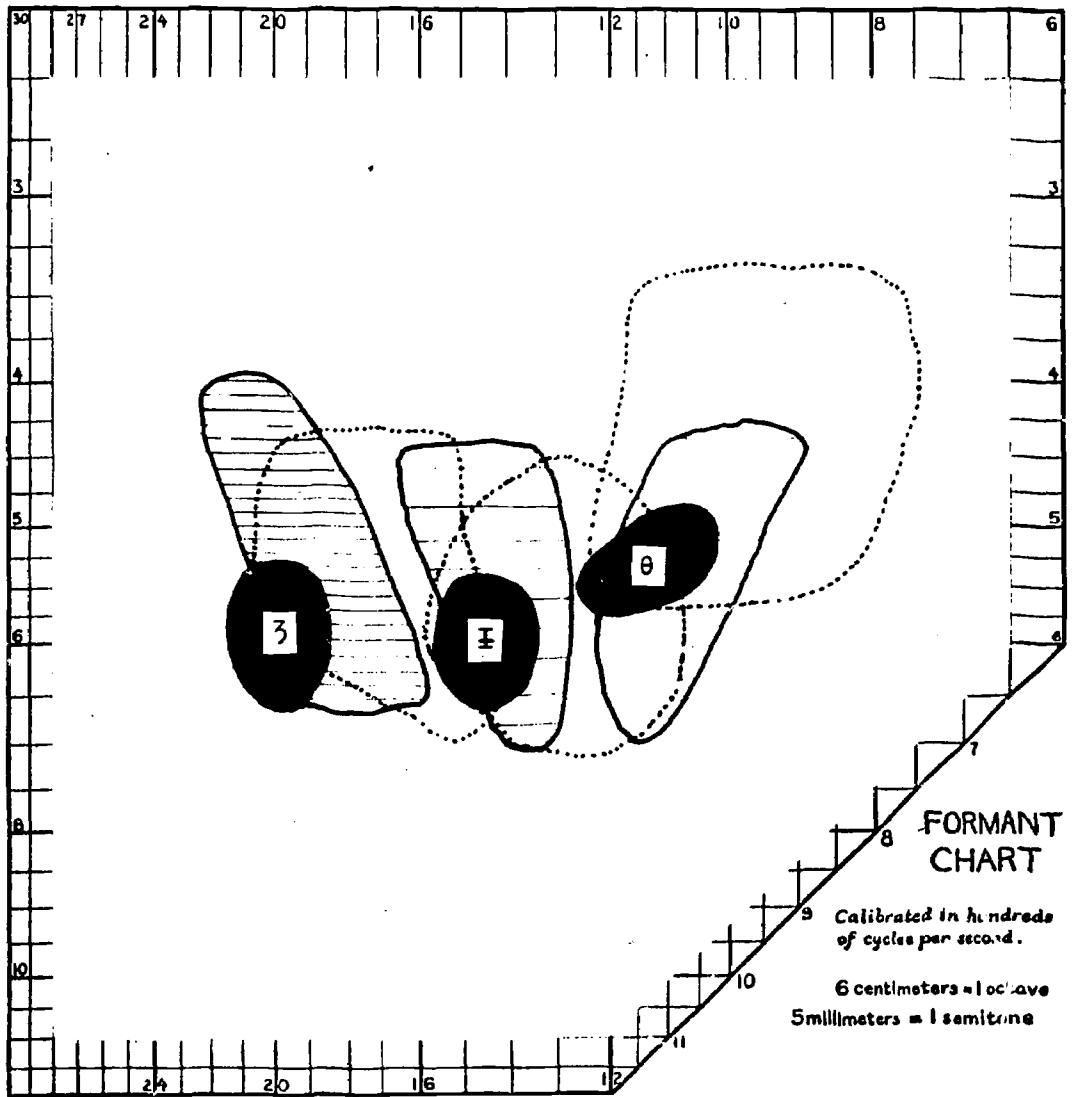


FIGURE 15a

Comparison of [ʒ] [ʒ̥] and [θ]

Various environments

Informant 4



with /-m, -n, -ŋ, -p, -t, -k/ as final consonants, with all six tones.

As was demonstrated in the preceding chapter and as is seen here, the domains of the nuclei segments [ɜ], [ɪ], and [ə] are clearly separated in a restricted environment such as [t-n] with level tone. When the environment is expanded to include all six tones, but restricted to open syllable types, the domains of [ɜ], [ɪ], and [ə] are still clearly distinct from one another. When the environment is expanded to include closed syllables and all tones, overlap of the three domains does occur; but, this overlap is in a regular pattern, i.e., the domains move backward on the formant chart.

To check and augment our data, we examined and analysed the recorded material of Informant 3 according to the same procedures used with that of Informant 4. Tables 16, 17, and 18 are the measurements of Informant 3's [ɜ], [ɪ], and [ə], respectively, in open syllables, including all tones. Figures 16, 17, and 18 are the corresponding graphic representations on formant charts.

Figure 18a presents the domains occupied by [ɜ], [ɪ], and [ə] in open syllables on one formant chart. Although Informant 3's [ɪ] and [ə] show some marginal overlap, [ɜ] is clearly separated and in general, three domains can be identified.

TABLE 16

Formant measurements of complex nuclear segment [ɔ̃] Open syllable cycles/second

All tones Informant 3

Segment [ɔ̃] with tone [-]

Segment [ɔ̃] with tone [~]

Word	1			2			3			4			Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3		F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tɔ̃	750	1800		700	1750		700	1850		700	1700		tɔ̃		750	1950		750	1900		750	1950		750	1950
tʰɔ̃	750	1750		700	1800		700	1700		650	1850		mɔ̃		800	1950		750	1850		750	1850		750	1850
cɔ̃	700	1750		650	1800		700	1800		700	1800		fɔ̃		750	1800		750	1850		750	1850		700	1900
kɔ̃	700	1800		700	1900		700	1900		650	1900		xɔ̃		750	1850		750	1950		750	1950		750	1950
lɔ̃	700	1850		700	1900		650	1850		650	1850														
lɪɔ̃	700	1750		700	1900		700	1900		700	1850														
nɔ̃	700	1900		650	1900		650	1850		650	1850														
nɪɔ̃	700	2000		550	2000		650	1900		550	2100														
vɔ̃	700	1950		700	1950		650	1850		650	2050														
zɔ̃	550	2070		700	1950		650	1950		550	2000														
hɔ̃	600	1800		550	2000		550	2000		550	1900														

Segment [ɔ̃] with tone [~]

Segment [ɔ̃] with tone [~]

Word	1			2			3			4			Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3		F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
cɔ̃				900	1750		800	1800		750	1900		cɔ̃		900	1850		850	1950		850	1900		850	1900
kɔ̃				800	1900		800	1900		750	1850		dɔ̃		850	1900		850	1850		800	1950		800	1950
bɔ̃				800	1750		850	1750		750	1800		nɔ̃		850	1900		850	1850		800	1850		800	1850
dɔ̃				850	1800		800	1800		800	1800		ŋɔ̃		850	1950		850	1850		850	1850		850	1850
lɔ̃				850	1850		850	1750		800	1850														

Segment [ɔ̃] with tone [✓]

Segment [ɔ̃] with tone [~]

Word	1			2			3			4			Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3		F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ɪɔ̃	850	1700		850	1700		850	1700		800	1750		bɪɔ̃	850	1950		850	1900		850	2000		350	1900	
tɪɔ̃	900	1700		900	1700		850	1800		850	1800		dɪɔ̃	850	1900		850	1900		800	1950		800	1950	
dɪɔ̃	900	1650		900	1750		850	1750		800	1800		lɪɔ̃	850	1850		800	1900		850	1850		850	1950	
mɪɔ̃	850	1650		850	1700		800	1750		800	1800														

Blank spaces indicate where precise measurements were not obtainable.

FIGURE 16
 [ʒ] in open syllables
 All tones Informant 3

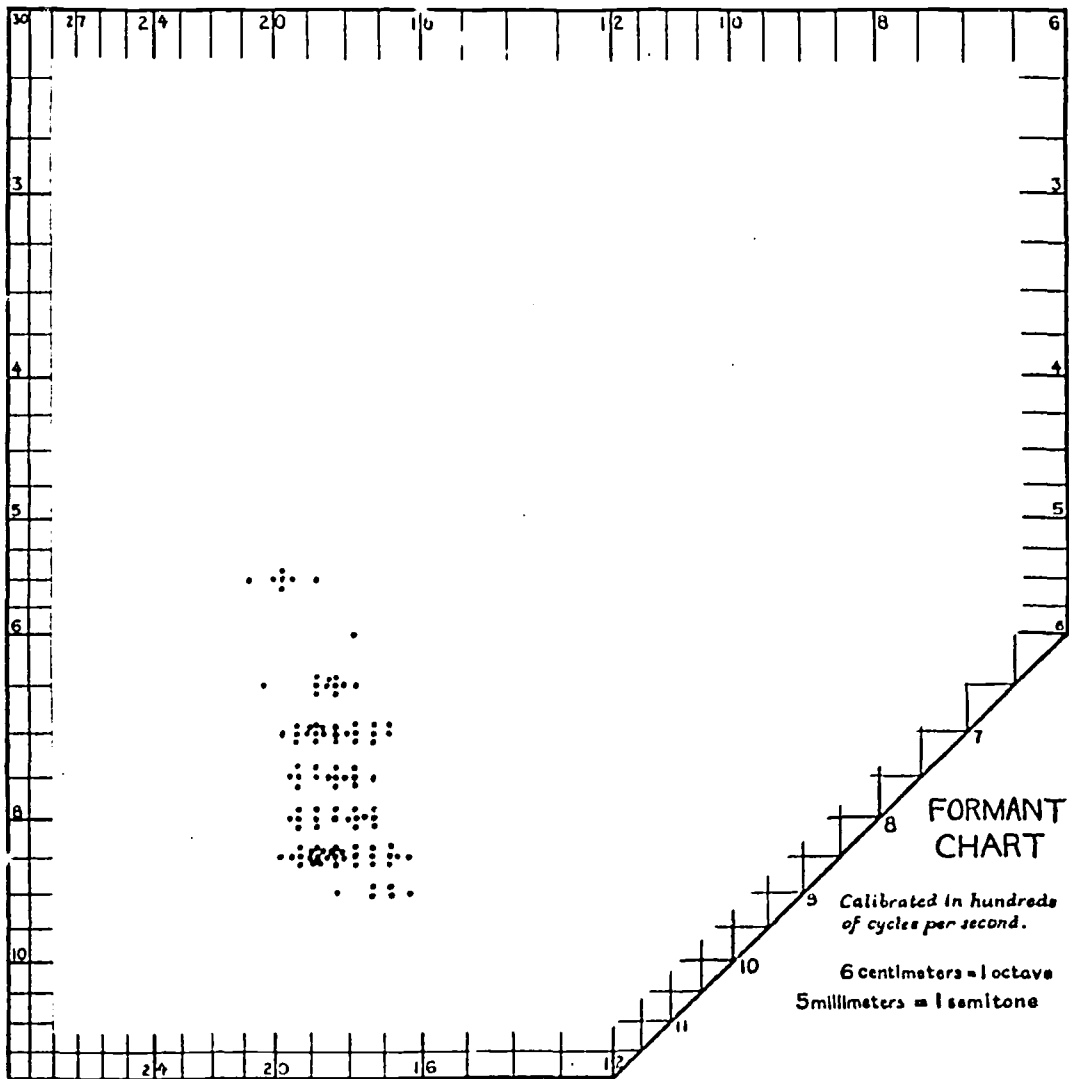


TABLE 17
 Formant measurements of complex nuclei segment [ɛ] Open syllable cycles/second
 All tones Informant 3

Segment [ɛ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
wɛ	500	1350		650	1300		600	1250		600	1250	
tɛwɛ	600	1300		600	1250		600	1250		600	1200	
cwɛ	700	1350		700	1350		650	1350		650	1300	
dwɛ	650	1300		650	1250		600	1250		650	1350	
mwɛ	550	1300		650	1250		650	1250		650	1250	
swɛ	650	1300		650	1250		650	1250		650	1250	
ɛwɛ	650	1300		500	1300		650	1300		650	1250	

Segment [ɛ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
cɛ				650	1300		650	1300		650	1300	
kwɛ				750	1300		650	1300		650	1350	
bwɛ				700	1400		650	1350		650	1350	
dwɛ				650	1350		650	1300		600	1350	
lwɛ				650	1350		650	1250		600	1450	
mwɛ				750	1250		650	1250		500	1250	
nwɛ				650	1300		650	1400		600	1450	
ɛwɛ				600	1350		600	1350		600	1450	
hwɛ				650	1300		650	1300		600	1250	

Segment [ɛ] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
cɛ				800	1400		750	1400		750	1350	
bwɛ				750	1400		750	1350		750	1350	
lwɛ				750	1450		750	1400		750	1400	
mwɛ				750	1350		750	1350		750	1400	

Segment [ɛ] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
cɛ				800	1500		800	1500		750	1500	
bwɛ				800	1400		850	1450		850	1500	
mwɛ				800	1450		800	1450		800	1450	

Segment [ɛ] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
cɛ				850	1350		850	1400		800	1400	
kwɛ				850	1400		800	1450		800	1450	
bwɛ				850	1450		850	1400		850	1400	
mwɛ				900	1450		900	1400		950	1400	
nwɛ				850	1500		800	1500		800	1500	
ɛwɛ				850	1500		850	1450		850	1500	

Segment [ɛ] with tone [-]

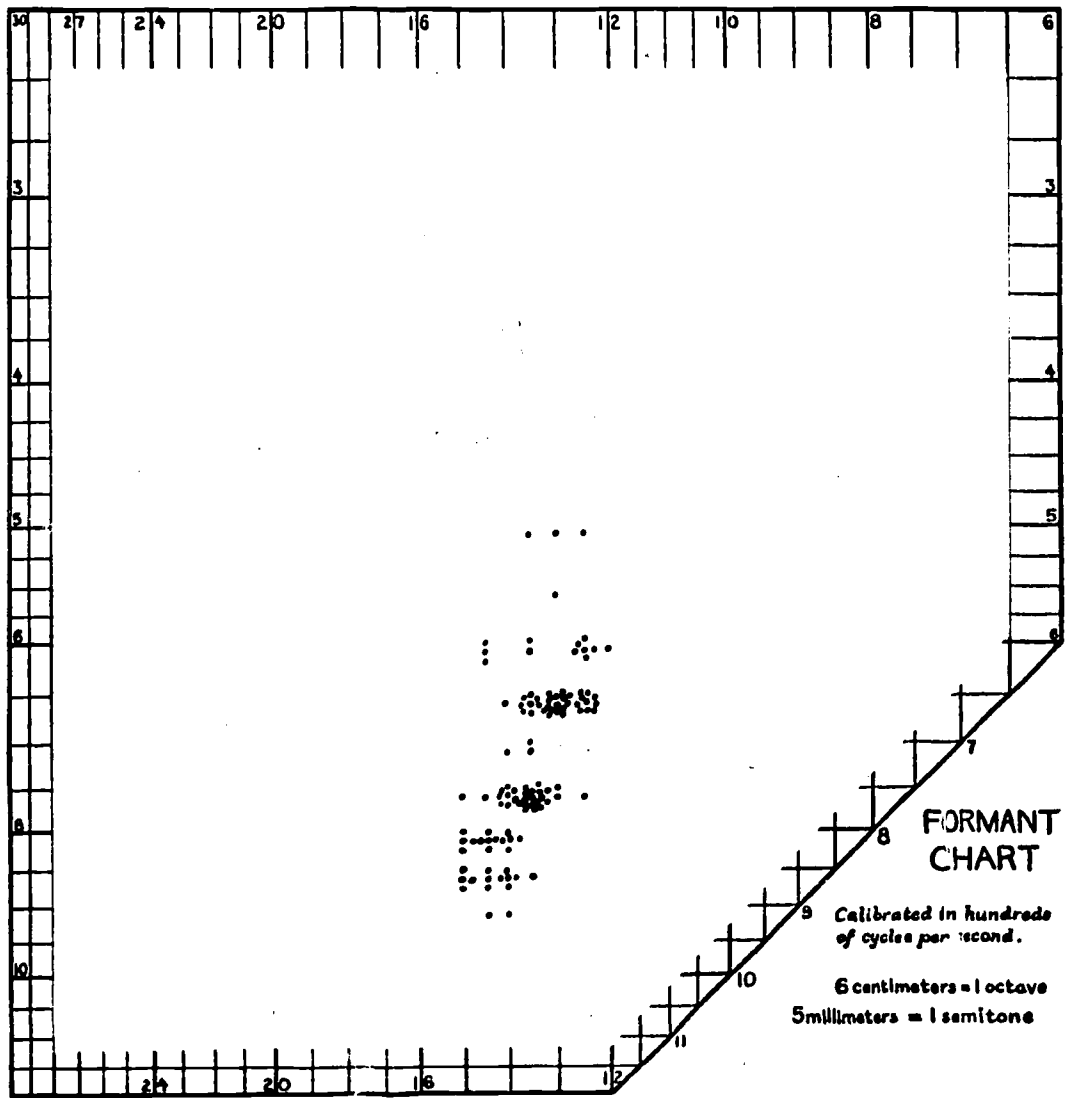
Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
wɛ				750	1350		750	1350		750	1350	
twɛ				750	1400		750	1350		750	1350	
kwɛ				750	1350		750	1350		750	1400	
bwɛ				750	1400		750	1350		750	1350	
lwɛ				800	1400		800	1400		750	1350	
ɛwɛ				750	1350		750	1300		750	1350	

Blank spaces indicate where precise measurements were not obtainable.

FIGURE 17

[ɪ] in open syllables

All tones Informant 3



Formant measurements of complex nuclei segment [ə] Open syllable cycles/second
All tones Informant 3

Segment [ə] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tə̃	700	1150		700	1200		750	1250		700	1200	
tə̄	750	1250		700	1200		700	1200		700	1200	
cə̃	650	1250		700	1200		600	1200		600	1200	
cə̄	650	1050		750	1250		750	1250		700	1200	
nə̃	500	1050		600	1200		600	1200		500	1200	
nə̄	500	1250		500	1000		500	1000		500	1100	
ɸə̃	600	1100		600	1100		600	1200		600	1100	
və̃	700	1150		700	1150		700	1150		700	1150	
ɸə̄	650	1100		600	1100		600	1200		500	1200	
ɸə̄	600	1070		600	1100		600	1150		600	1150	
və̄	600	1000		600	1200		600	1150		600	1200	

Segment [ə] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ũ				550	1050		600	1050		600	1100	
tū̃				650	1000		600	1000		600	1000	
cū̃				600	1000		600	1200		600	1200	
bū̃				500	1000		600	950		450	950	
lū̃				600	1000		600	1200		550	1150	
mū̃				600	1000		600	950		600	1100	

Segment [ə] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ū				650	1050		650	1100		650	1100	
cū̄				750	1200		650	1200		650	1200	
bū̄				650	1100		650	1100		650	1100	
dū̄				650	1150		750	1200		650	1150	
lū̄				750	1200		700	1150		700	1200	
mū̄				650	1100		600	1050		600	1150	

Segment [ə] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
dū̃	700	1250		750	1200		750	1250		750	1250	
lū̃	750	1300		750	1200		750	1250		750	1250	
zū̃				700	1200		750	1300		750	1250	

Segment [ə] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ū̃	850	1200		800	1250		750	1150		800	1150	
kū̃				850	1200		750	1200		800	1150	
zū̃				800	1200		850	1300		850	1250	

Segment [ə] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ū̄	750	1200		750	1250		750	1150		750	1150	
bū̄	750	1200		750	1150		700	1200		700	1150	
lū̄	750	1200		750	1250		750	1250		700	1200	

FIGURE 18

[ə] in open syllables

All tones Informant 3

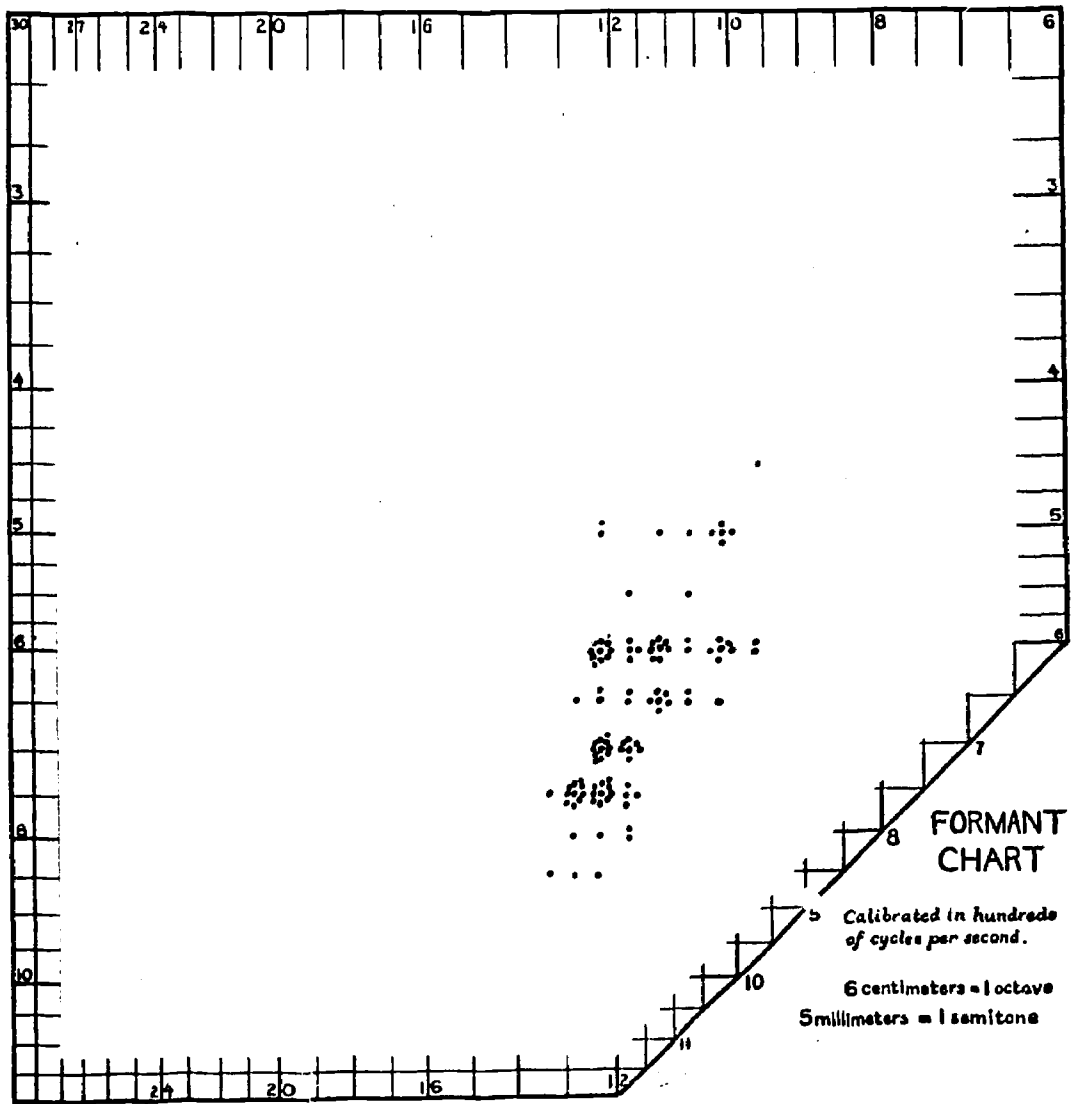
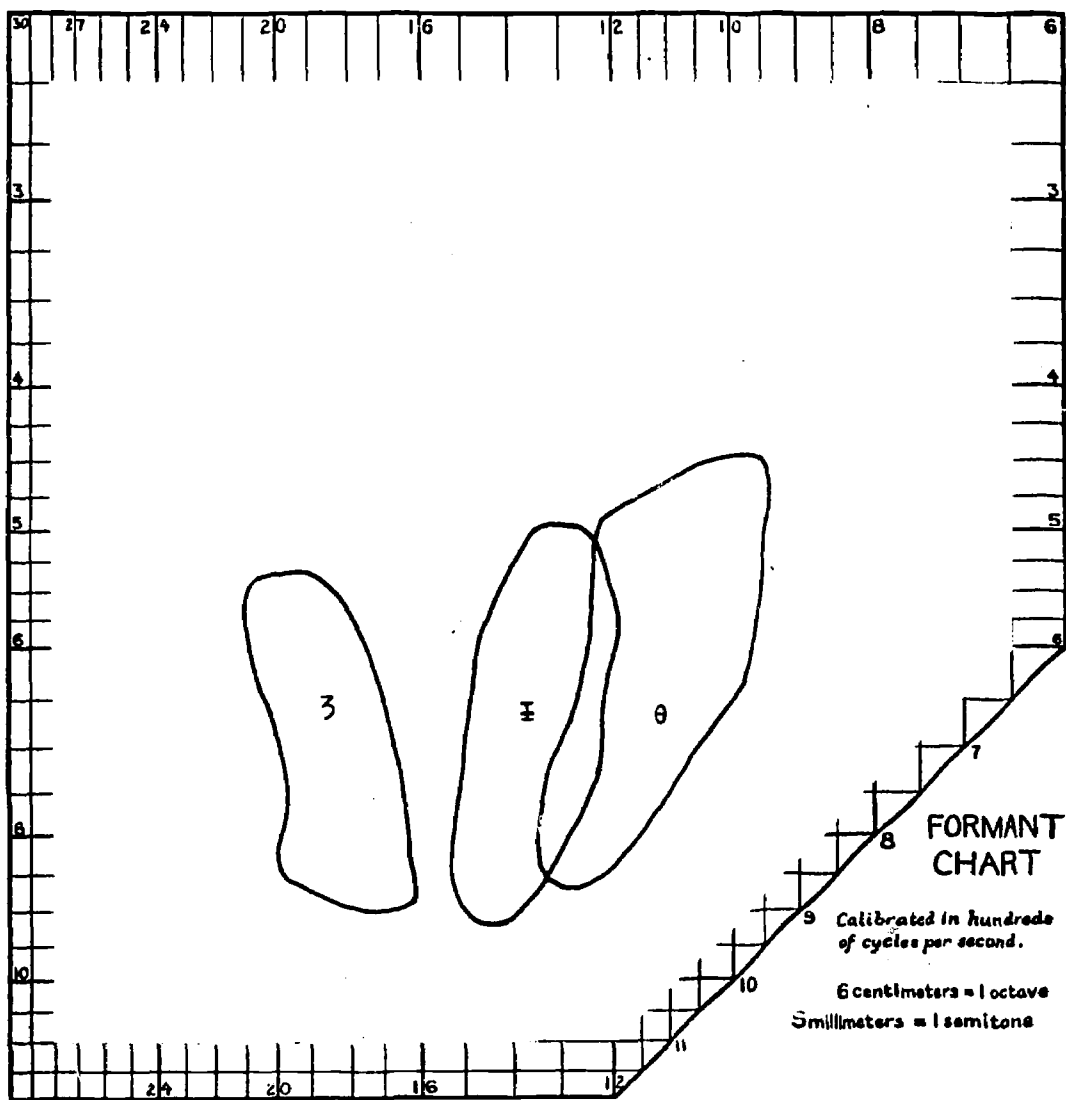


FIGURE 18a

Domains of [-ʒ] [-ɪ] [-θ] in open syllables

All tones

Informant 3



Tables 19, 20, and 21 are the measurements of the three segments [ʒ], [ɪ], and [θ] of Informant 3 in closed syllables with the final consonants /-m, -n, -ŋ, -p, -t, -k/, including all six tones. Figures 19, 20, and 21 are the corresponding charts.

Figure 21a is the composite chart showing all three nuclei segments in the three environments examined: [t-n] with level tone; open syllable with all tones; and closed syllables with all tones. As with Informant 4, the overlap which is apparent is regularly conditioned with the domains becoming larger and moving further back on the formant chart.

TABLE 19

Formant measurements of complex nuclei segment [ɜ] Closed syllable cycles/second
All tones Informant 3

Segment [ɜ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
lɜ̄m				550	1900		550	1850		550	1900	
tɜ̄m				550	1950		550	1950		550	1850	
kɜ̄m				550	1900		550	2150		550	2000	
lɜ̄m				550	1900		550	1850		550	2100	
ɬɜ̄m				550	1950		550	1950		550	2050	
ɟɜ̄m				550	1900		550	1850		550	1850	
lɜ̄n				550	2250		550	2150		550	2150	
tɜ̄n				550	2050		550	1900		550	1950	
kɜ̄n				550	2200		550	2100		550	2150	
lɜ̄n				550	2150		550	2100		550	2100	
ɬɜ̄n				550	2150		550	2150		550	2150	
ɟɜ̄n				550	2250		550	2150		550	2250	
lɜ̄n				550	2150		550	2250		550	2150	
ɬɜ̄n				550	2200		550	2100		550	2050	
ɟɜ̄n				500	2250		500	2100		500	2100	
lɜ̄ŋ				500	1950		500	1950		500	1900	
kɜ̄ŋ				550	1900		550	1850		550	2000	
ɟɜ̄ŋ				550	1850		550	1900		550	1900	
lɜ̄p				800	1750		800	1750		800	1750	
ɟɜ̄p				800	1850		800	1850		800	1800	
tɜ̄t				750	1950		750	2000		750	1900	
tʰɜ̄t				800	1900		750	1900		750	2000	
nɜ̄t				750	1950		750	1950		750	2000	
ɟɜ̄t				750	2050		800	2100		750	2000	
tɜ̄k				750	1750		800	1750		900	1750	
vɜ̄k				800	1750		800	1800		800	1750	

Segment [ɜ] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
lɜ̄m				650	2100		650	2100		650	2050	
tɜ̄m				650	2100		650	2100		600	2000	
kɜ̄m				600	1950		650	2050		600	2000	
lɜ̄n				700	2150		700	2100		700	2100	
tɜ̄n				750	2200		750	2000		750	2150	
lɜ̄n				500	2050		500	2050		500	2000	
bɜ̄n				600	1950		600	1950		600	1950	
dɜ̄n				500	1950		500	1900		500	1950	
tɜ̄p				650	1850		600	1900		600	1800	
kɜ̄p				650	2000		650	1800		650	1800	
ɜ̄t				650			650	2050		650	2200	
tɜ̄t				700	1950		650	1950		650	1950	
kɜ̄t				650	1950		650	2000		650	2000	
tɜ̄k				700	1750		700	1750		700	1800	
pɜ̄k				700	1850		700	1800		700	1800	
dɜ̄k				750	1850		700	1750		650	1800	
lɜ̄ŋ				750	1900		750	1900		750	1950	
nɜ̄ŋ				850	1850		850	1800		800	1950	
nɜ̄m				800	1900		750	1750		750	1850	
tɜ̄n				850	2050		800	2050		800	2000	
lɜ̄n				800	2100		850	2000		800	2100	
nɜ̄n				800	2100		800	2100		800	2100	
nɜ̄ŋ				750	1900		750	1900		750	1950	

Segment [ɜ] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tɜ̄m				800	1850		800	1800		800	1850	
kɜ̄m				800	1850		800	1850		750	1800	
lɜ̄m				800	1750		750	1800		800	1800	
nɜ̄m				800	1800		750	1750		750	1750	
tɜ̄n				800	2000		800	1950		800	2000	
lɜ̄n				800	2000		750	1950		750	1900	
nɜ̄n				800	2150		800	2000		750	2100	

Segment [ɜ] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tɜ̄m				800	1800		800	1900		800	1900	
nɜ̄m				800	1900		800	1950		800	1900	
ɟɜ̄m				750	1900		800	1950		750	1950	
tɜ̄n				800	1950		800	1950		800	1900	
tʰɜ̄n				850	1950		850	1900		850	1950	
lɜ̄ŋ				800	1850		800	1900		800	1900	

Segment [ɜ] with tone [✓]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ɬɜ̄m				850	1800		800	1700		850	1800	
tʰɜ̄m				850	1750		850	1700		850	1800	
kɜ̄m				800	1800		850	1700		750	1950	
tʰɜ̄n				850	1950		750	1900		700	2000	
ɟɜ̄m				900	1800		850	1700		850	1650	

Blank spaces indicate where precise measurements were not obtainable.

FIGURE 19

[ʒ] in closed syllables

All tones

Informant 3

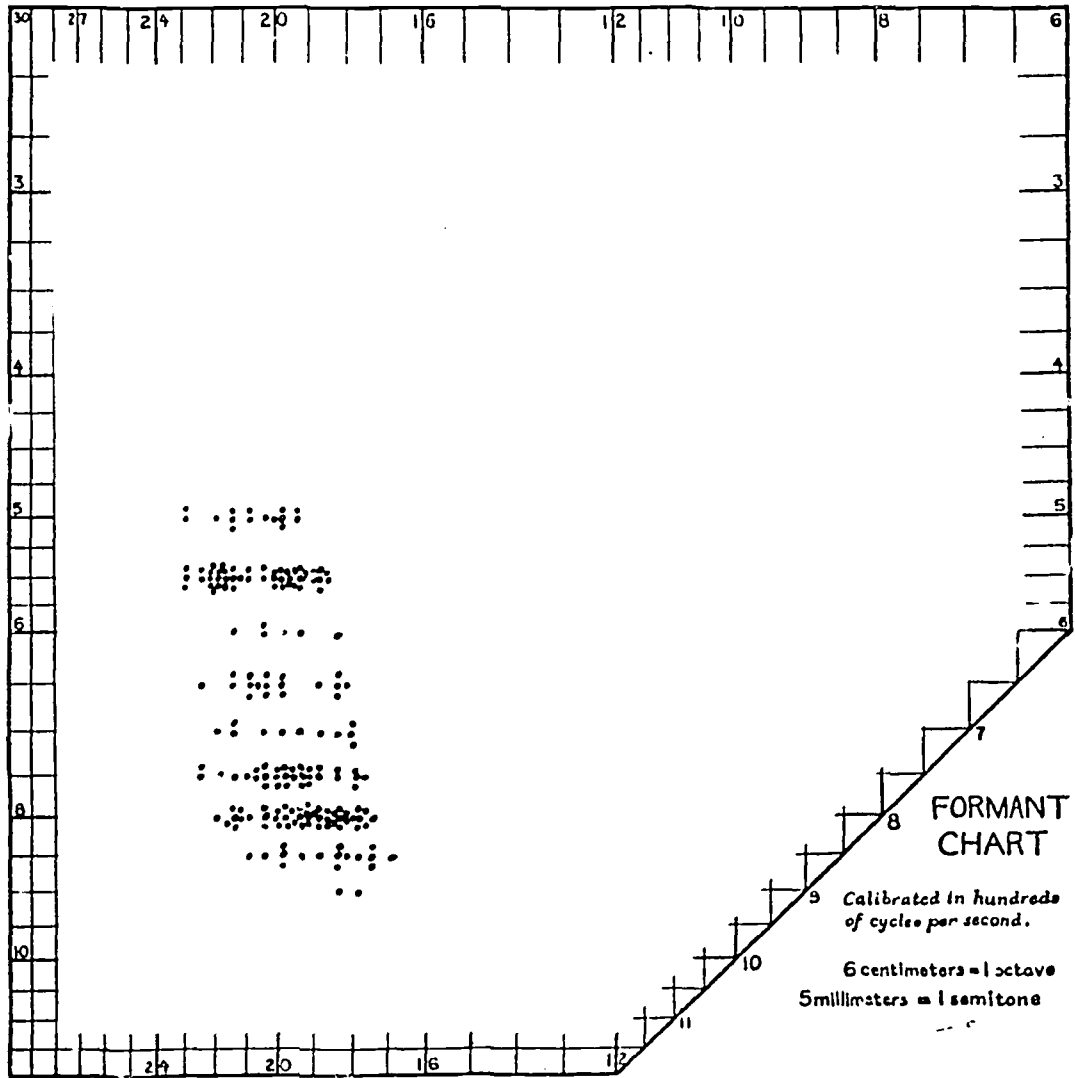


TABLE 20

Formant measurements of complex nuclei segment [ɪ] Closed syllable cycles/second

All tones Informant 3

Segment [ɪ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ɬwɪm				600	1200		600	1200		600	1200	
nɪm				550	1350		550	1350		550	1350	
ɲɪm				600	1200		550	1250		550	1250	
ɟɪm				500	1300		500	1400		500	1400	
lɪm				500	1400		500	1450		550	1350	
ɬwɪɲ				550	1450		550	1400		550	1350	
ɬwɪɲ				550	1350		550	1350		550	1350	
ɬwɪɲ				550	1400		550	1400		550	1400	
ɬwɪɲ				550	1400		550	1350		500	1350	
ɬwɪɲ				550	1350		500	1300		500	1300	
ɬwɪɲ				550	1400		550	1400		550	1350	
ɬwɪɲ				550	1350		550	1350		550	1350	

Segment [ɪ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ɬwɪm				500	1250		500	1250		500	1250	
ɲwɪn				500	1400		600	1500		600	1500	
ɬwɪɲ				450	1200		450	1200		450	1200	
ɲwɪɲ				500	1250		500	1250		450	1200	
hwɪɲ				500	1300		500	1300		500	1250	
ɬwɪp				700	1350		650	1350		650	1350	
kwɪp				700	1350		700	1400		650	1350	
wɪt				650	1400		650	1450		650	1450	
ɬwɪt				650	1350		650	1300		650	1350	
ɬwɪt				650	1400		600	1500		600	1500	
wɪk				700	1300		700	1300		700	1350	
ɬwɪk				650	1300		650	1300		650	1300	
hɬwɪk				650	1300		650	1300		650	1300	
kwɪk				650	1250		650	1250		650	1250	
ɬwɪk				650	1250		650	1250		650	1250	

Segment [ɪ] with tone [ʌ]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ɬwɪm				750	1350		750	1450		700	1400	
kwɪm				700	1350		700	1400		750	1400	
ɲwɪm				800	1450		750	1350		750	1350	
zwɪm				700	1400		700	1350		750	1300	
ɬwɪn				650	1500		700	1500		700	1550	
vɬwɪn				750	1550		750	1500		750	1600	
swɪn				750	1550		750	1550		750	1550	
ɬwɪɲ				700	1400		650	1300		650	1350	
ɬwɪɲ				700	1400		650	1350		750	1300	
ɬwɪɲ				650	1350		650	1350		750	1350	
hwɪɲ				650	1350		700	1400		700	1350	

Segment [ɪ] with tone [~]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ɬwɪn				700	1650		700	1650		700	1600	
ɬwɪɲ				750	1350		750	1350		750	1300	
kwɪɲ				750	1200		750	1300		700	1250	
ɲwɪɲ				750	1250		750	1300		700	1350	

Segment [ɪ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ɬwɪm				700	1450		750	1400		750	1350	
ɬwɪm				750	1400		750	1400		750	1350	
ɬwɪn				700	1350		750	1400		800	1400	
ɲwɪn				800	1450		800	1450		800	1450	
vɬwɪn				750	1400		750	1350		750	1400	
ɬwɪɲ				750	1350		700	1350		750	1350	
ɬwɪɲ				700	1300		700	1300		700	1350	
ɲwɪɲ				700	1400		750	1350		700	1400	
ɬwɪt				800	1400		750	1350		700	1400	
ɬwɪt				700	1400		700	1450		700	1400	
vɬwɪt				750	1350		750	1350		750	1350	
zwɪt				750	1400		750	1400		750	1350	
ɬwɪk				700	1250		700	1200		700	1200	
ɬwɪk				700	1400		700	1400		700	1400	
ɬwɪk				700	1200		700	1200		650	1150	

Segment [ɪ] with tone [V]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
ɬwɪɲ				700	1250		700	1250		700	1200	
ɬwɪɲ				700	1250		750	1250		750	1250	
hwɪɲ				800	1250		750	1300		750	1300	

FIGURE 20

[ɛ] in closed syllables

All tones

Informant 3

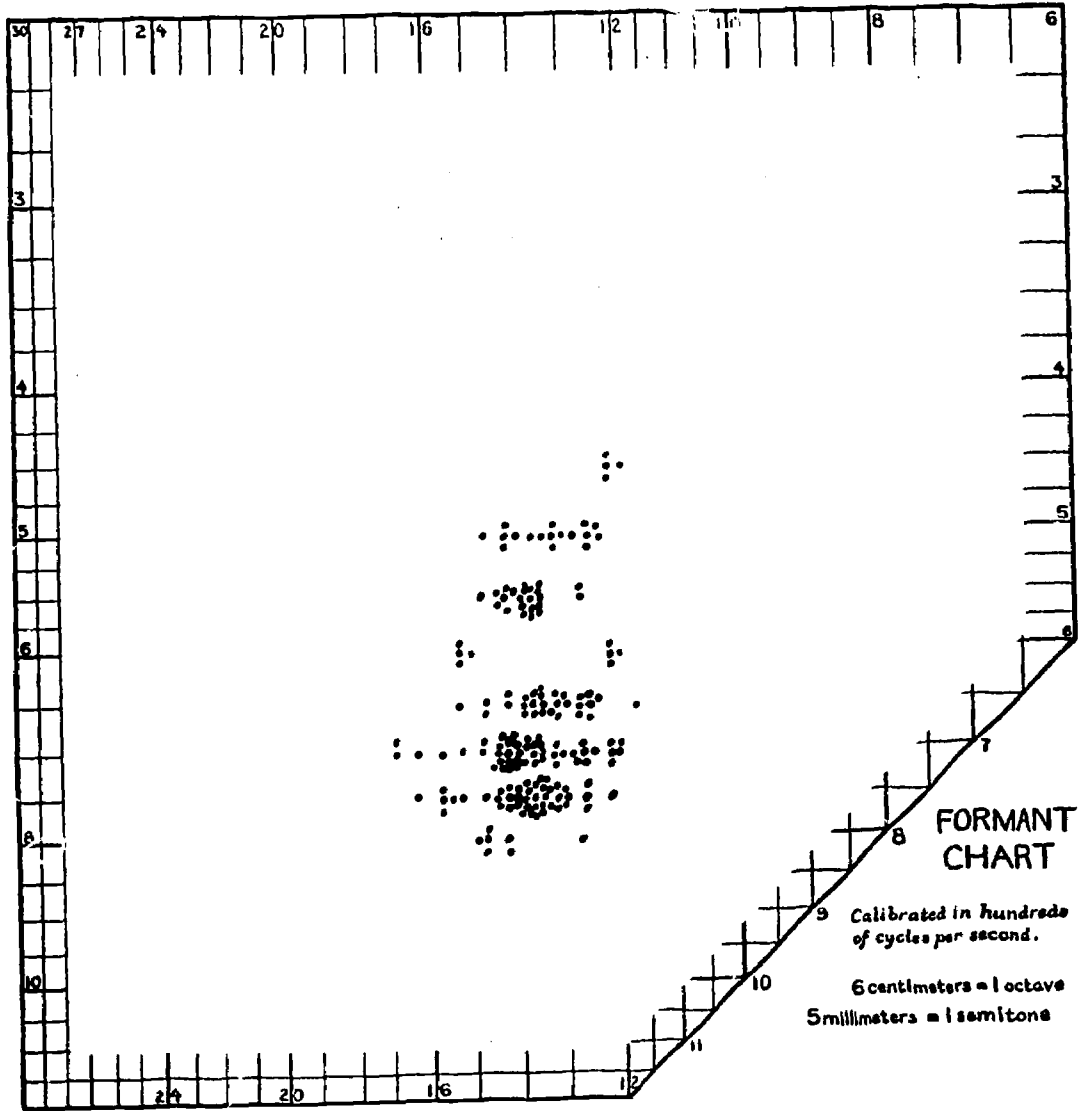


TABLE 21

Formant measurements of complex nuclei segment [ə] Closed syllable cycles/second
All tones Informant 3

Segment [ɔ] with tone [-]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
cūŋ				500	1100		500	1050		500	1050	
mūŋ				550	1050		500	1050		500	1050	
tuŋ				500	1300		500	1300		500	1250	
tūŋ				500	1300		500	1300		500	1300	
būŋ				500	1300		500	1300		500	1300	
lūŋ				500	1300		500	1300		500	1300	
mūŋ				500	1350		500	1350		500	1300	
nūŋ				500	1050		500	1000		500	1000	
cūŋ				500	1050		500	1000		500	1000	
būŋ				450	950		500	1000		500	1050	
lūŋ				500	1050		500	1000		500	1050	
mūŋ				500	1050		500	1000		500	1000	

Segment [ə] with tone [✓]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
mūŋ				450	950		450	950		450	950	
kūŋ				450	1250		450	1250		450	1250	
mūŋ				500	1250		500	1200		450	1200	
ūŋ				450	950		450	950		450	950	
cūŋ				450	1000		450	1000		500	1000	
mūŋ				450	950		450	950		450	1000	
hūŋ				450	950		450	950		450	950	
tūŋ				600	1250		600	1250		600	1250	
cūŋ				650	1300		650	1250		600	1200	
būŋ				600	1250		600	1200		600	1250	
nūŋ				600	1250		550	1250		600	1250	
tūŋ				600	1000		650	950		700	1050	
kūŋ				650	1050		650	1000		650	1000	
dūŋ				650	1000		650	950		650	950	
gūŋ				700	1000		700	1050		650	1000	

Segment [ə] with tone [✓]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
būŋ				600	1000		600	1000		550	1050	
tuŋ				600	1300		600	1300		600	1350	
cūŋ				650	1500		650	1350		650	1300	
lūŋ				600	1350		650	1300		650	1350	
tuŋ				600	1000		650	950		650	1000	
būŋ				600	1000		650	1000		650	1050	
lūŋ				600	1000		650	1000		650	1050	

Segment [ə] with tone [✓]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
kūŋ				650	1200		650	1150		650	1200	
mūŋ				700	1200		700	1250		700	1250	
nūŋ				650	1000		650	1050		700	1100	

Segment [ə] with tone [✓]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
mūŋ				700	1250		750	1250		700	1200	
kūŋ				700	1350		700	1350		700	1350	
mūŋ				750	1350		750	1300		750	1300	
gūŋ				650	1300		700	1400		700	1400	

Segment [ə] with tone [✓]

Word	1			2			3			4		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
tūŋ				700	1100		700	1150		700	1100	
sūŋ				700	1050		700	1050		650	1050	

kūŋ				700	1100		650	1150		600	1100	
zūŋ				700	1200		700	1250		700	1200	
tuŋ				700	1300		700	1300		700	1350	
cūŋ				700	1300		750	1350		750	1350	
būŋ				600	1250		700	1300		700	1250	
zūŋ				650	1300		650	1250		600	1250	
tūŋ				700	1000		650	1050		650	1100	
cūŋ				700	1100		750	1150		650	1050	
kūŋ				650	1050		700	1100		700	1200	
būŋ				700	1100		700	1100		650	1050	
lūŋ				700	1100		650	1150		700	1150	

Blank spaces indicate where precise measurements were not obtainable.

FIGURE 21

[3] in closed syllables

All tones

Informant 3

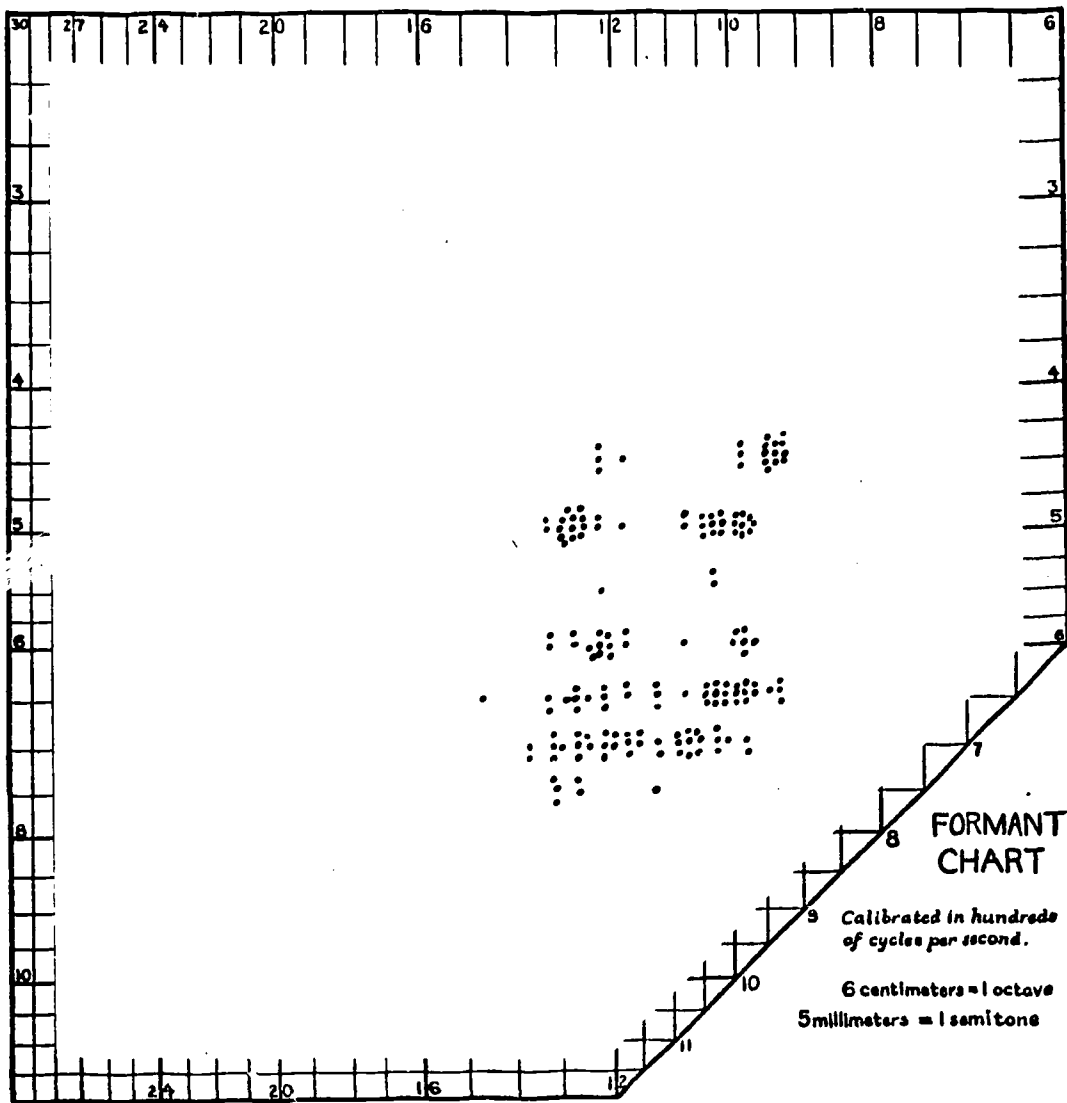
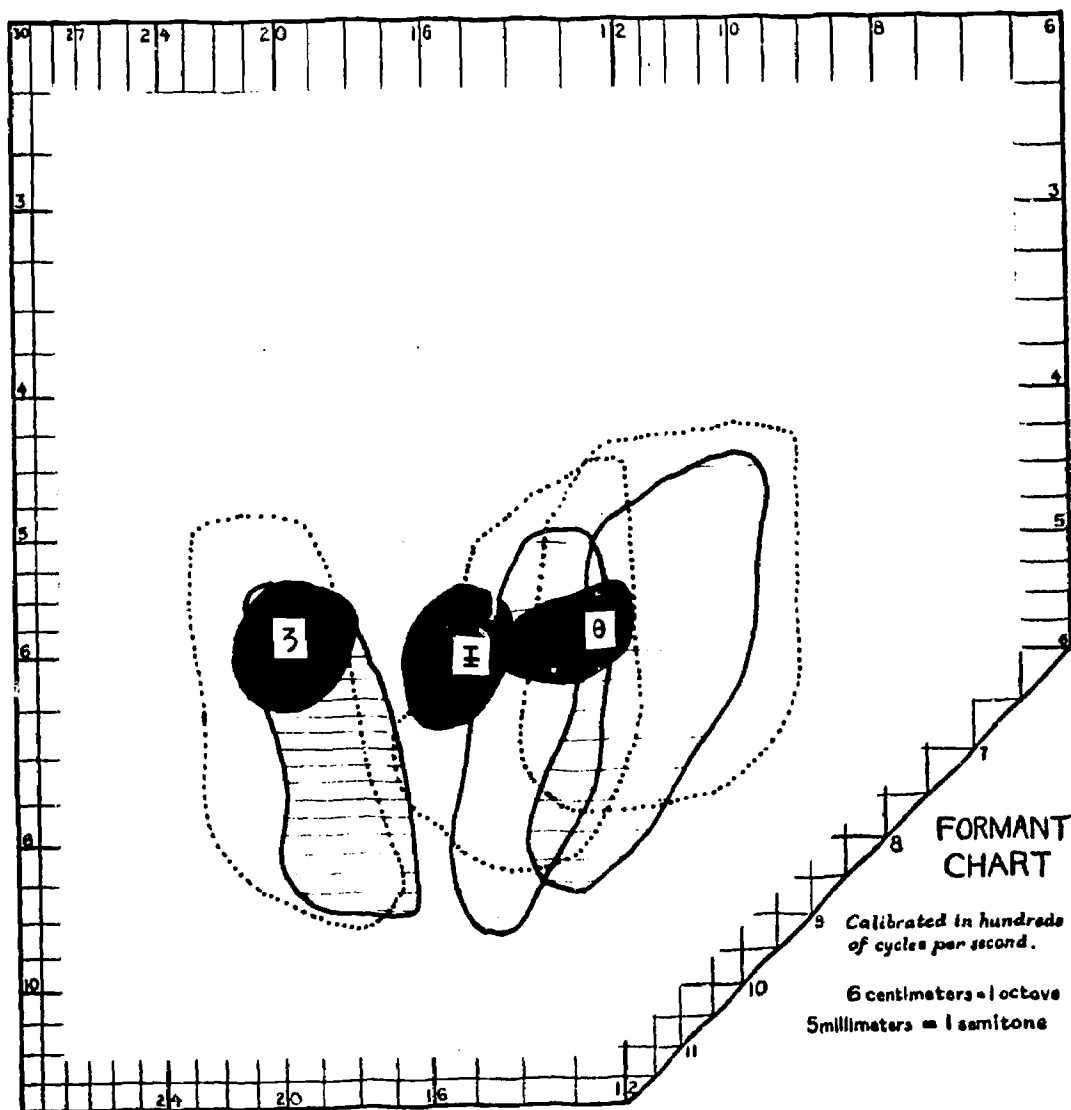


FIGURE 21a

Comparison of [ʒ] [ɛ] and [ə]

Various environments

Informant 3



CONCLUSIONS

After carefully considering all the data presented, we came to several conclusions regarding Vietnamese complex nuclei.

1) In Chapter 3, it was established that the first segments of the complex nuclei [Iʒ], [wɿ], and [Uθ] could be clearly assigned to the phonemes /i/, /w/, and /u/. It was then demonstrated that the analysis of [ʒ], [ɿ], and [θ] as the three separate phonemes /e/, /ə/, and /o/ was that most consistent with the phonetic phenomena. Experiments with the complex nuclei in more varied environments as delineated in Chapter 4 support this analysis as a valid one.

2) With regard to the question of whether the difference between the sequences spelled "-ia", "-uà", "-ua" in final position and "-iê-", "-ub²", "-uô-" in medial position are so great that they should be considered as two different phonemes, we can say that our preliminary phonetic transcription of [Iʒ], [wɿ], and [Uθ] for both sequences is supported. Although the location of the domains are shifted slightly backward in closed syllables, they maintain a relative distinctiveness, and the differences among the domains in closed syllables are comparable to those in open syllables. If [ʒ], [ɿ], and [θ] are demonstrated as being three different vocalic qualities in

open syllables, they should be so analysed in closed syllables. In closed syllables or open, spelled "-ia", "-uà", "-ua", or "-iê-", "-ub'", "-uô-", our phonetic interpretation of these complex nuclei as [iɜ], [wɛ], [uθ] is adequately supported by the acoustic data.

3) We also noted that tone and consonant influence on the complex nuclei is very similar to that observed on the simple vowels /e/, /ɔ/, and /o/. As was mentioned earlier, there are also distributional characteristics associated with /y/ and /w/ that make [ɜ] similar to /e/, [θ] similar to /o/, and [ɛ] different from /e/ and /o/ and more similar to /ə/.

Therefore, it is our conclusion that the complex syllable nuclei are best analysed with [ɜ] as an allophone of /e/, [ɛ] as an allophone of /ə/, and [θ] as an allophone of /o/, making the complex nuclei phonemically /ie/, /wə/, and /uo/.

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<p>A phonetic and phonemic analysis of the three complex nuclei of Vietnamese (Hanoi dialect) spelled (1) yê-, -iê-, -ia, (2) -uô-, -uâ, (3) -uô-, -ua, was carried out, using the sound spectrograph. The relative domains of the target qualities of the complex nuclei were established and then compared with those of the eleven simple vowels. The first segments of the complex nuclei were easily established as being the same as /i/, /w/, and /u/. The second segments, which have been variously analysed, were found to occupy three distinct domains which led to our analysis of them as phonemically /e/, /ə/, and /o/. Further analysis was done, varying the environment with regard to type of syllable, tone, initial and final consonants. Regardless of environment, a relative distinctiveness of domain seems to be maintained and this, together with distributional characteristics, supports our final phonemic analysis of the complex nuclei as /ie/, /ue/, and /uo/.</p>			

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Acoustic Phonetics						
Vietnamese						
Syllable Nucleus						
Sound Spectrograph						

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