AN ACOUSTIC STUDY OF THE REGISTER COMPLEX IN KUI (SUAI)*

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0. *Language data*

Kui (Suai) is a Mon-Khmer language spoken in many Northeastern provinces: Surin, Srisaket, Buriram, Ubonratchathani, Mahasarakham, and Nakhonratchasima. This language comprises several dialects.[1] The dialect studied is that spoken in Ban Sangkae, Tambon Tael, Amphoe Sikhoraphum, Surin Province. The phonological description and lexicon of this dialect can be found in the Kui (Suai)-Thai-English Dictionary compiled by Prasert Sriwises (1978), who is a native speaker of Kui Ban Sangkae. The following is a brief sketch of Kui phonology:[2]

Consonant system

Initial consonants:	p	t	c	k	ʔ	ph	th	ch	kh
	b	d	ɟ	m	n	ɲ	ŋ	(f)[3]	s
	h	w	r	l	j				
Consonant clusters:	pr	tr	kr	pl	kl	phr	thr	khr	phl
	khl	br	bl						
Final consonants:	p	t	c	k	ʔ	m	n	ɲ	ŋ
	h	w	r	l	j				

Vowel system

Monophthongs:	i	e	ɛ	a	ɯ	ɤ	ʌ	ɑ	u	o	ɔ
	ii	ee	ɛɛ	aa	ɯɯ	ɤɤ	ʌʌ	ɑɑ	uu	oo	ɔɔ
Diphthongs:	ia	ɯa[4]	ua								

Register system: R1 (clear voice + high pitch), R2 (breathy voice[5] + low pitch)

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The data for instrumental studies were recorded in the recording studio of the Linguistics Research Unit at the Faculty of Arts, Chulalongkorn University. Prasert Sriwises, the compiler of the Kui (Suai)-Thai-English Dictionary, kindly acted as subject.

1. *Phonetic correlates of Kui registers*

The term "register" has been used by linguists in many different ways; however, I will follow Henderson (1952). Thus, "register" is regarded as a phonological concept. It is a cover term not only for laryngeal activity but also for a constellation of activities in the vocal tract. Register phenomena are then described in terms of multi-dimensional features or a set of phonetic parameters.[6] The phonetic realization of Kui registers may be summed up as in Chart 1.

2. *Acoustic measurements*

In this section, an acoustic description of Kui vowels in respect to formant frequency, fundamental frequency, duration and overall intensity will be given. Wide band spectrograms (see Figure 1) and narrow band spectrograms (see Figure 2) were used for measuring formant frequencies and fundamental frequencies, respectively. Duration and intensity were measured from mingograms (see Figure 3).

Register	Initial consonants[7]	Vowel quality	Vowel length	Phonation type	Pitch
R1	obstruents (asp. stop, vl.stop,vd. stop) continuants (nasal, fricative, liquid, semi vowel)	somewhat different, depending upon each pair of vowels	somewhat different, depending upon vowel categories	clear voice	high
R2	obstruents (asp. stop) continuants (nasal, liquid, semi vowel)			breathy voice	low

Chart 1 : Phonetic correlates of registers in Kui.

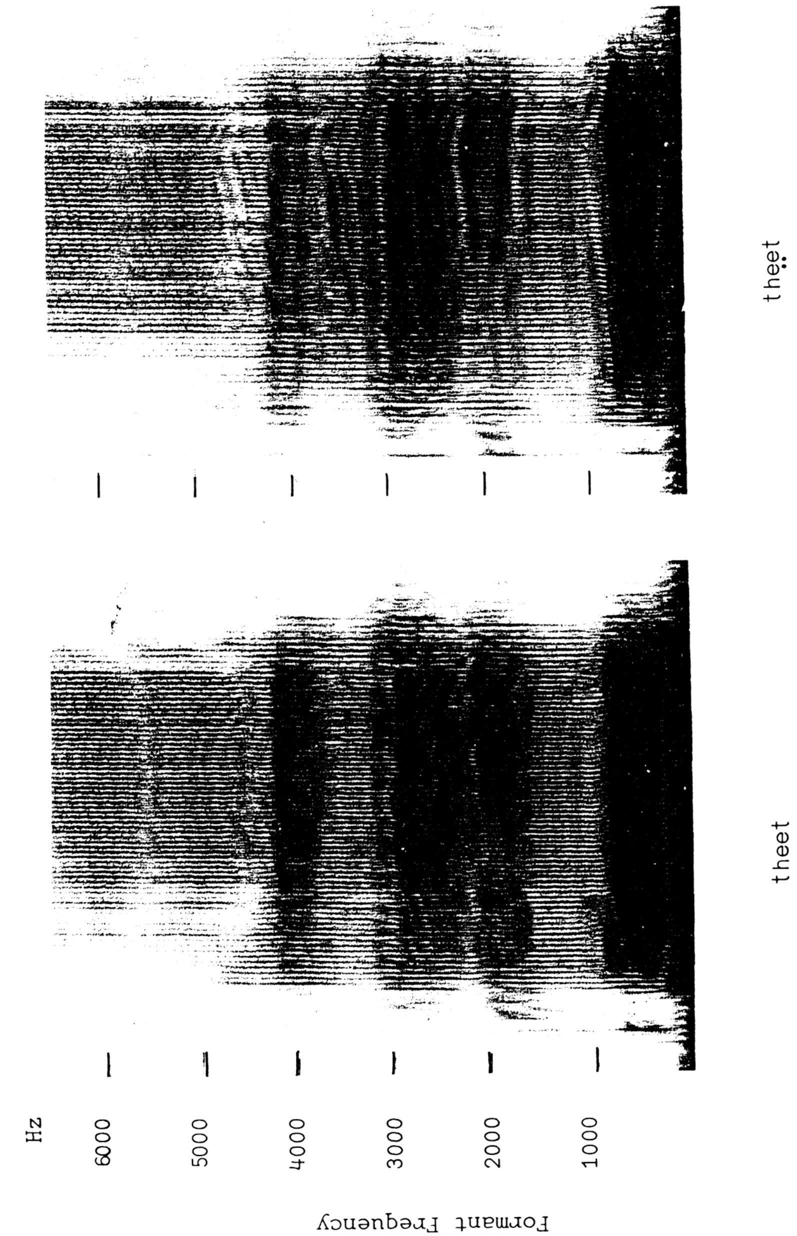

Figure 1: Wide band spectrograms.

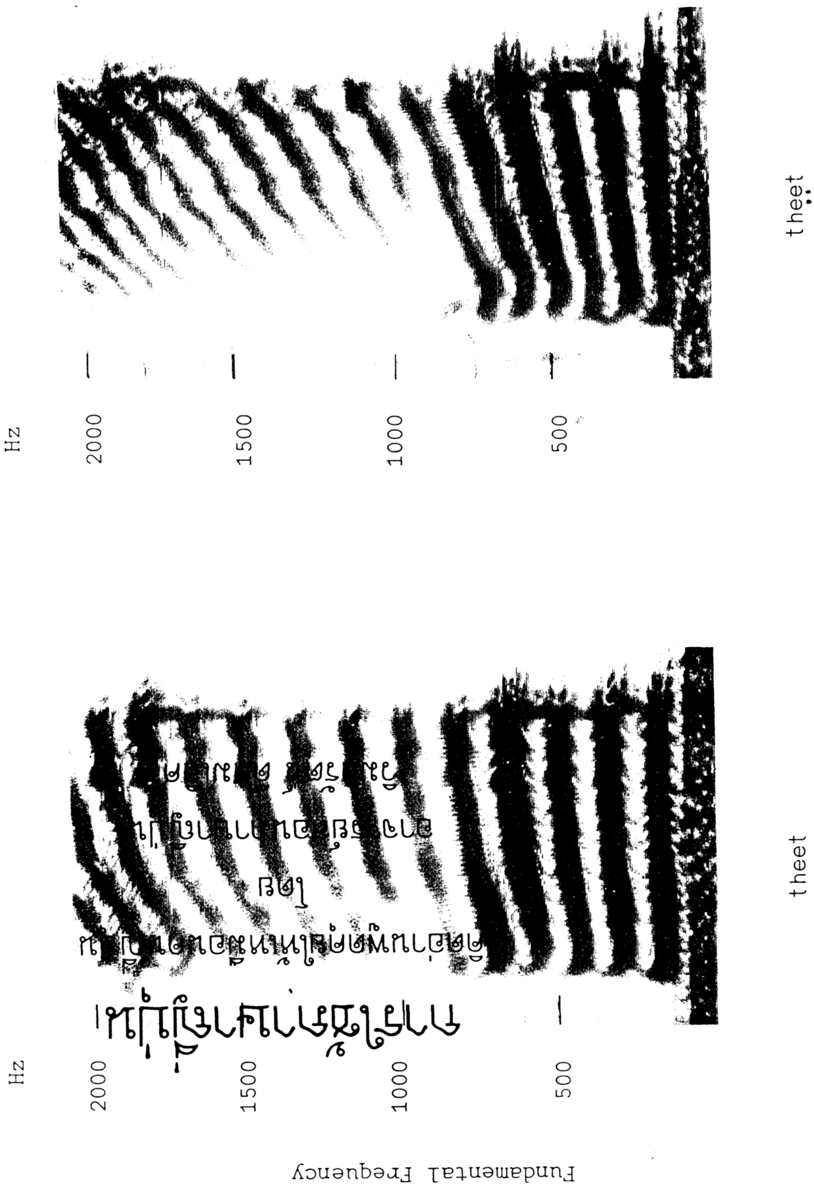

Figure 2: Narrow band spectrograms.

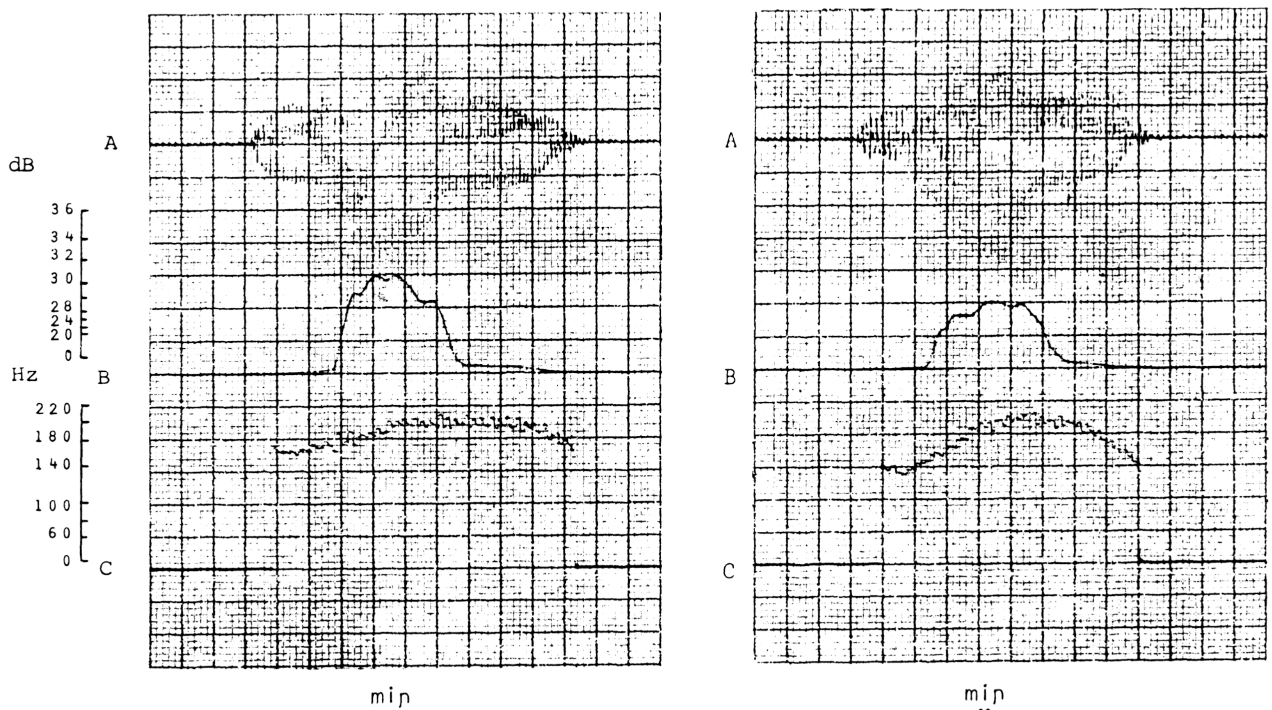

Figure 3: Mingograms of /miɲ/,/mi̤ɲ/.

A. Oscillogram

B. Intensity curve

C. Fundamental frequency curve

2.1 *Formant frequency*

The frequencies of F1, F2 and F3 of eleven pairs of clear and breathy short vowels and eleven pairs of clear and breathy long vowels were measured. Five test words said in isolation were used for each vowel; thus there were altogether 110 (22 x 5) test tokens. The mean values of F1 and F2[8] were plotted on vowel charts (see Figures 4 and 5); the mean values of F3 are to be found in Tables 1 and 2.

The result of the measurements does not seem to validate Gregerson's claim that in Mon-Khmer languages, first register vowels which are produced with retracted tongue-root are always more open than second register vowels which are produced with advanced tongue-root (Gregerson, 1976). The two vowel formant charts do not exhibit any obvious patterns that breathy voiced vowels are always more close or more open than their clear voiced counterparts. The differences, although they do exist, are not systematic. Each pair of vowels seems to behave differently; for example, /uu/ is more open than /ṳṳ/, whereas /u/ is more close than /ṳ/. In Nyah Kur (Chaobon), another Mon-Khmer language of Thailand, the converse is true: /uu/ is more close than /ṳṳ/, whereas /u/ is more open than /ṳ/ (Theraphan, 1982).

2.2 *Fundamental frequency*

The word list used for *Fo* measurement comprised 96 meaningful monosyllabic words which were divided into 16 sets based on different types of syllable structure:

CVN	CVS	CV̤N	CV̤S
CVH	CVʔ	CV̤H	CV̤ʔ
CVV(N)[9]	CVVS[10]	CV̤V̤(N)	CV̤V̤S
CVVH[11]	CVVʔ	CV̤V̤H	CV̤V̤ʔ

The mean values of *Fo* (in *Hz*) can be found in Figure 6. From the data presented in Figure 6, the following points can be drawn:

1. Second register vowels have lower *Fo* than first register vowels in all types of syllable structure.[12]

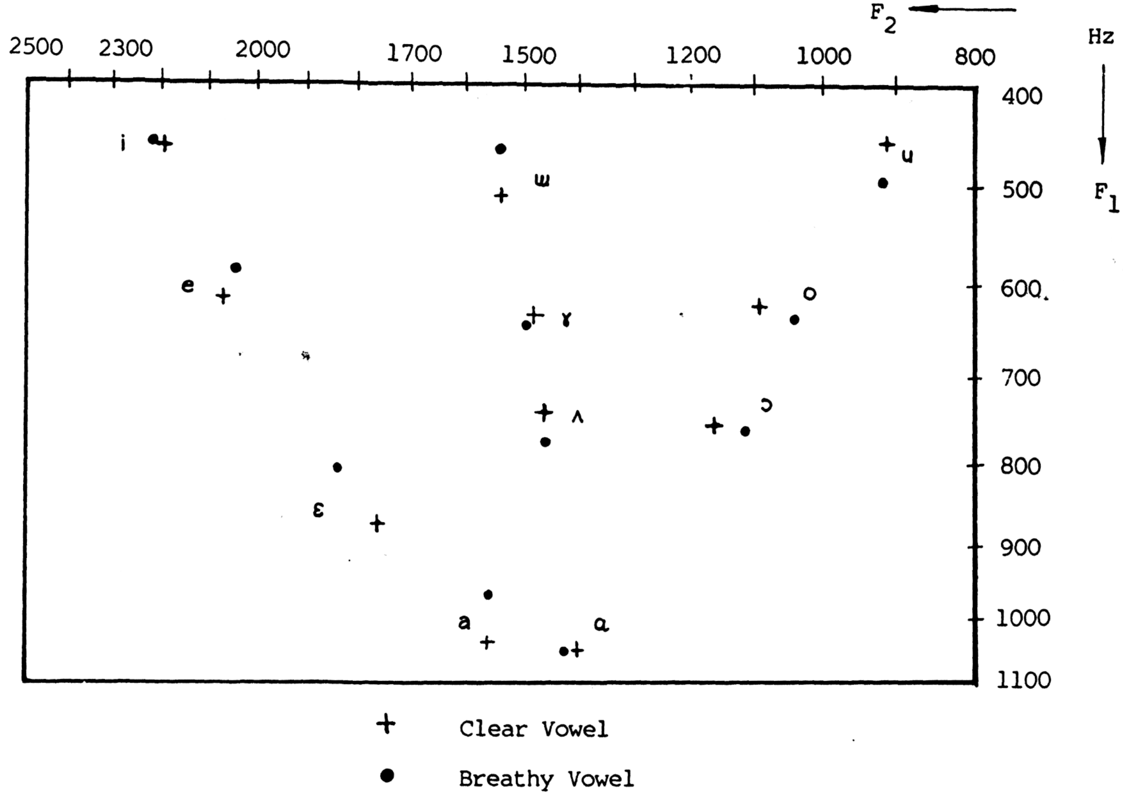

Figure 4: Formant frequencies (F1 and F2) of 1st register and 2nd register short vowels.

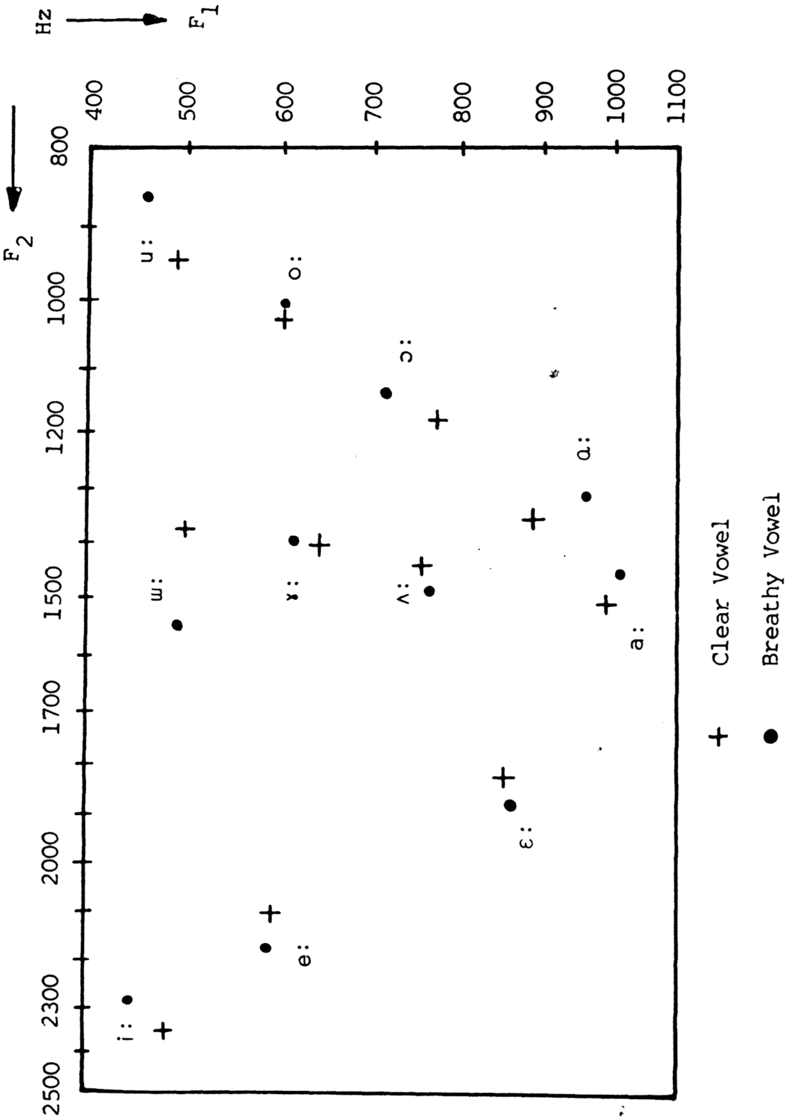

Figure 5: Formant frequencies (F1 and F2) of 1st register and 2nd register long vowels.

Clear Vowel	Mean / Standard Deviation			Breathy Vowel	Mean / Standard Deviation		
	F1	F2	F3		F1	F2	F3
i	465 13.69	2195 57.01	3020 67.08	i̤	455 32.60	2220 103.68	3190 168.26
e	615 48.73	2065 62.75	2985 128.21	e̤	580 20.92	2040 60.21	2745 122.98
ɛ	875 39.53	1765 67.55	2790 181.66	ɛ̤	805 115.11	1845 103.68	2640 82.16
a	1035 57.55	1570 48.09	2945 168.08	a̤	970 54.20	1555 67.08	2940 208.12
ɯ	510 28.50	1530 77.86	2605 109.54	ɯ̤	465 22.36	1530 59.69	2525 103.08
ɤ	635 28.50	1480 48.09	2740 62.75	ɤ̤	645 20.92	1495 11.18	2830 108.11
ʌ	745 27.39	1460 51.84	2865 169.19	ʌ̤	775 17.68	1455 79.84	2790 164.51
ɑ	1050 58.63	1405 20.92	3090 87.68	ɑ̤	1050 53.03	1425 43.30	3105 245.84
u	455 37.08	905 89.09	2985 129.42	ṳ	500 25.00	920 44.72	3060 181.66
o	625 46.77	1095 73.74	3175 196.05	o̤	630 32.60	1045 44.72	3160 89.44
ɔ	755 57.01	1165 48.73	3045 62.25	ɔ̤	760 51.84	1115 62.75	2890 182.52

Table 1: Mean values and standard deviation of F1, F2 and F3 of 1st register and 2nd register short vowels (in Hz)

Clear Vowel	Mean Standard Deviation			Breathy Vowel	Mean Standard Deviation		
	F_1	F_2	F_3		F_1	F_2	F_3
ii	480	2355	3115	i̤i̤	440	2295	3075
	37.08	81.78	67.55		37.91	41.08	88.39
ee	595	2100	2720	e̤e̤	585	2175	2700
	32.60	30.62	20.92		13.69	35.36	68.47
εε	855	1825	2735	ε̤ε̤	860	1885	2625
	20.92	131.10	161.63		51.84	51.84	63.74
aa	990	1515	3095	a̤a̤	1015	1455	3155
	22.36	62.75	145.13		22.36	32.60	422.57
ɯɯ	500	1375	2470	ɯ̤ɯ̤	495	1550	2475
	25.00	81.01	180.62		20.92	84.78	58.63
ɤɤ	640	1390	2690	ɤ̤ɤ̤	615	1400	2615
	28.50	33.54	91.17		13.69	17.68	72.02
ʌʌ	755	1440	2880	ʌ̤ʌ̤	770	1490	2662
	75.83	51.84	69.37		32.60	13.69	93.38
ɑɑ	985	1355	3465	ɑ̤ɑ̤	960	1320	3055
	28.50	20.92	164.51		22.36	32.60	69.37
uu	495	940	2810	ṳṳ	455	860	2830
	20.92	60.21	170.11		37.08	94.54	280.29
oo	605	1020	3145	o̤o̤	605	1010	3330
	32.60	44.72	197.17		20.92	48.73	54.20
ɔɔ	775	1175	2935	ɔ̤ɔ̤	715	1140	3205
	50.00	43.30	182.52		22.36	28.50	32.60

Table 2: Mean values and standard deviation of F1, F2 and F3 of 1st register and 2nd register long vowels (in Hz).

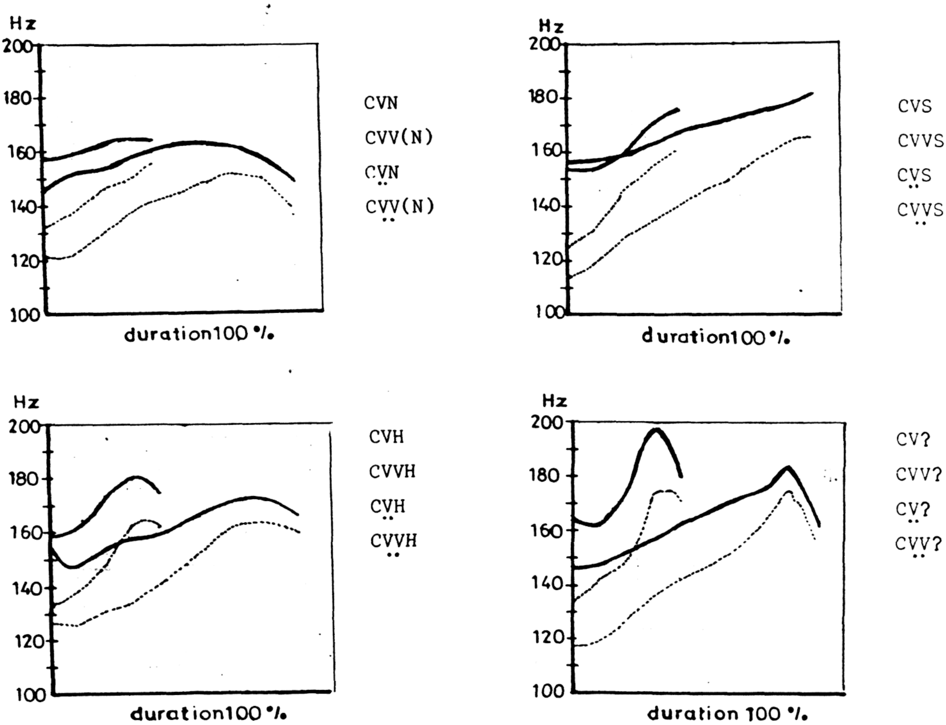

Figure 6: Mean Fo values (in Hz) of vowels in 16 types of syllable structure.

________ = 1st register (clear voice)

.... = 2nd register (breathy vcice)

2. Short vowels of both registers seem to have higher Fo than long vowels.

3. When the Fo of vowels of the same register are compared, vowels in CVH, CVʔ, CV̤H and CV̤ʔ seem to have higher Fo than vowels in the other types of syllable structure.

4. In smooth syllables (CVV(N), CVN), the Fo of first register vowels is rather static,[13] whereas vowels in other types of syllables have rising Fo contour.

2.3 *Duration*

The word list used for the measurement of vowel duration consisted of 26 minimal pairs, 13 pairs of short vowels and 13 pairs of long vowels. For each vowel category, three recordings were made separately; thus there were altogether 78 test tokens. The result of the measurements can be found in Table 3.

	Short vowel	Long vowel
Clear	206 (SD 31.97)	377 (SD 76.27)
Breathy	219 (SD 33.78)	361 (SD 72.99)
	$p < 0.005$	$p < 0.001$

Table 3: Mean duration of 1st and 2nd register vowels (in msec)

Fischer-Jørgensen and Kirk et al, in their studies of Gujarati (1967) and Jalapa Mazatec (1984), respectively, say that breathy vowels in those two languages have longer duration than clear vowels. Is this a universal phonetic characteristic? Perhaps this tendency could be attested only in languages that have no distinctive vowel length. In Kui, although breathy short vowels have longer duration than clear short vowels, it seems to work in the opposite way for long vowels. I suspect that differences in duration caused by differences in phonation types might not be important when the language in question possesses phonological length.

2.4 *Intensity*

The same mingograms were used for the measurements of both vowel duration and intensity. Regarding the overall intensity, clear vowels seem to have higher amplitude than breathy vowels. According to Laver (1980: 135), this is due to the fact that "the acoustic energy is lost by the damping effect of the general relaxation of the muscles of the whole vocal system in LAX VOICE." Consistency is also found in the shape of the curve. On the average, the distance from the beginning of vowel to the peak of the curve in breathy vowels is longer than in clear vowels. This makes the intensity curves of clear vowels look more bell-shaped. (See Table 4 and Figure 7.)

	Short vowel	Long vowel
Clear	43 (SD 3.01)	41 (SD 3.09)
Breathy	41 (SD 4.10)	40 (SD 3.94)
	$p < 0.001$	$p < 0.001$

Table 4: Mean amplitude of 1st register and 2nd register vowels (in dB)

3. *Discussion*

The acoustic analysis presented in this paper is based on the measurements of the formant frequency, fundamental frequency, duration and overall intensity of vowels in citation forms said by only one Kui speaker. The reader might wonder what happens in connected speech. In connected speech, the acoustic correlates of both registers seem to be the same as those in citation forms; for example, breathy vowels still have lower Fo and lower amplitude than clear vowels (see Figure 8).

It would be interesting to see how other native speakers of Kui keep the two registers apart in their speech. In order to reach the same goal, i.e. register distinction, they may or may not exploit the same phonetic parameters as Prasert Sriwises does. A great deal of work also needs to be done on the physiological aspects of register production. Besides, both phonation type and pitch seem equally prominent, but which one is more significant, especially to the native speakers of Kui? Without doing perception testing, this last question cannot be answered satisfactorily.

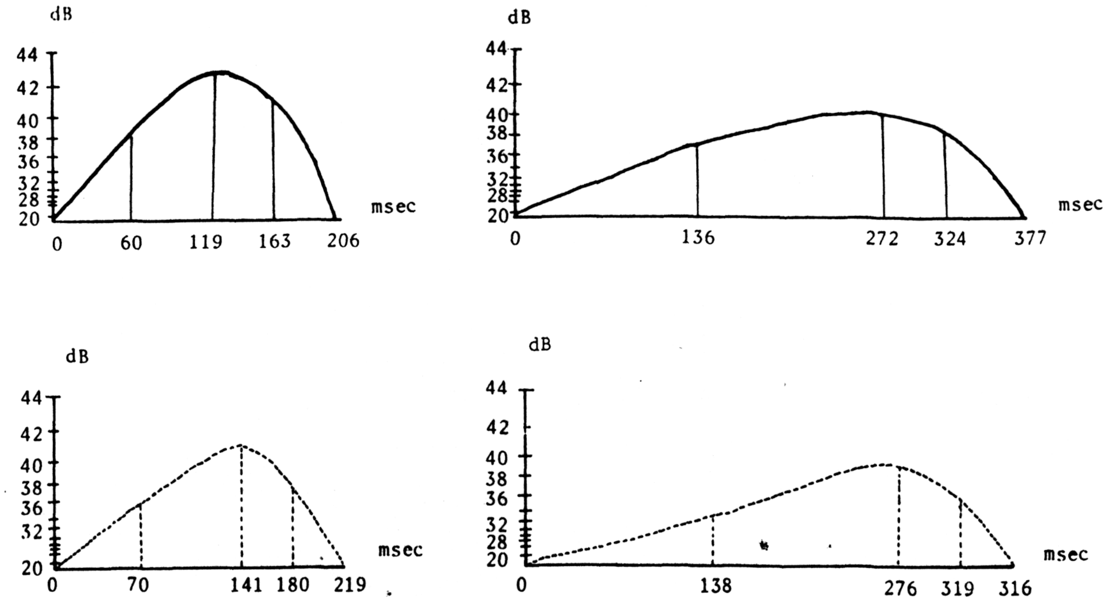

Figure 7: Mean duration (in msec), intensity curves and amplitude (in dB) of 1st register and 2nd register vowels.

______ = 1st register (clear voice)

.... = 2nd register (breathy voice)

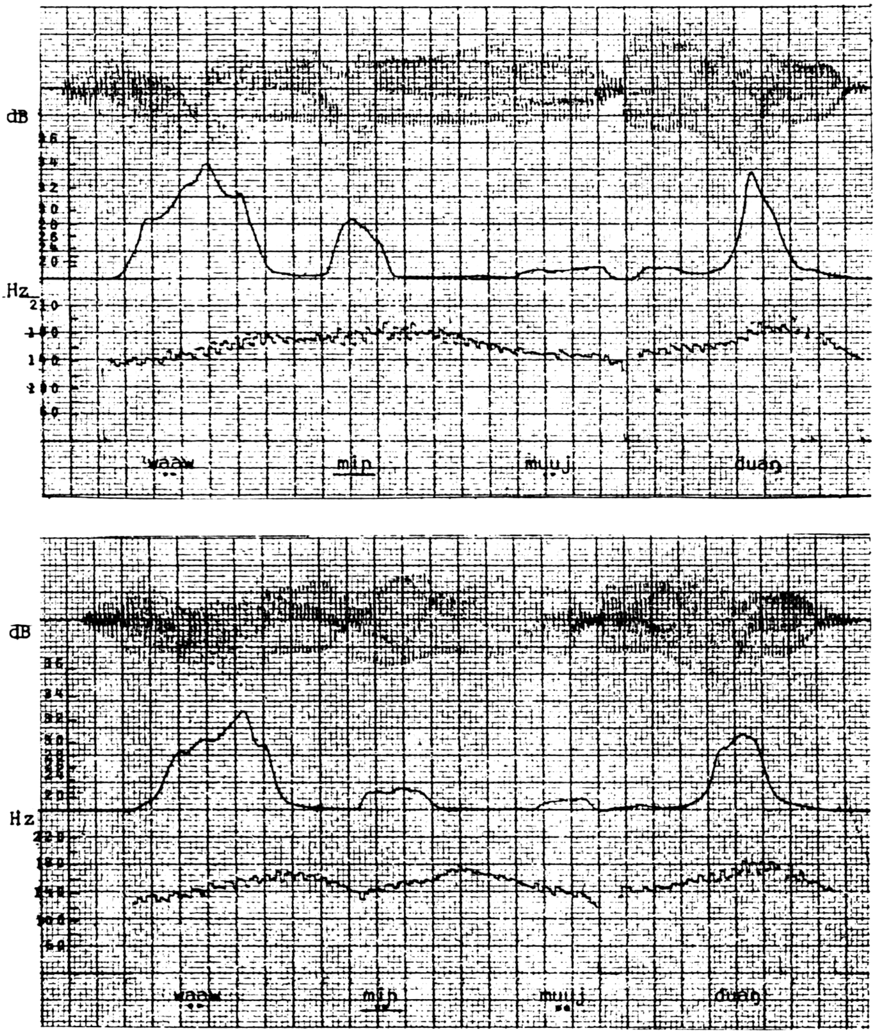

Figure 8: Mingograms of connected speech.

NOTES

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[1] More information can be found in Prasert (1978) and Gainey (1985).

[2] Minor syllables have not been taken into account.

[3] Initial /f-/ is in free variation with /sw-/ except in the word /fraŋ/ "westerner".

[4] The diphthong /ɯa/ occurs only in a few Thai loans.

[5] The wide band spectrograms of some Kui words look more like Laver's spectrogram of whispery voice (Laver, 1980: 115). There is also a close auditory relationship between breathy voice and whispery voice as Laver states, "Both involve the presence of audible friction; to the extent that such friction is concerned, the transition from breathiness to whisperiness is part of an auditory continuum, and the placing of the borderline between the two categories is merely an operational decision." (Laver, 1980: 133)

[6] See details in Henderson (1977), Ladefoged (1971, 1980) and Laver (1980).

[7] Regarding consonant clusters (C_1C_2-), C_1 will be the determiner of register.

[8] The degree of oral and pharyngeal constrictions is indicated by F1, whereas F2 indicates the degree of back tongue constriction (Pickett, 1980: 50-51).

[9] CVV(N) stands for open syllable and closed syllable having final nasal, liquid, or semi-vowel.

[10] H stands for laryngeal fricative /h/.

[11] S stands for final stops /-p, -t, -c, -k/.

12 This phenomenon is common; perhaps it could be regarded as a universal characteristic. See more examples in Fischer-Jørgensen (1967), Theraphan (1982) and Lee (1983).

13 Auditorily, smooth syllables are heard as having mid pitch with a slight fall at the end. In closed syllables (CVN, CVVN), the falling pitch will be on finals.

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