SOME PHONETIC CHARACTERISTICS OF IAAI

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ABSTRACT

Iaai is an Austronesian language with a relatively large vowel inventory as well as some less-common contrasts among consonants. This paper presents the first detailed phonetic description of Iaai, paying particular attention to the formant structure and the lip positions of the vowels, and the articulation and acoustic characteristics of the releases of coronal consonants.

IAAI PHONETICS

Iaai [ja:i], one of the twenty-five or so indigenous languages of New Caledonia, a French "overseas territory" in the South Pacific, is spoken by about two thousand people on Ouvéa, the northernmost of the Loyalty Islands. Its grammar and lexicon have been described by Ozanne-Rivierre [1, 2]. However, there are no studies which have focussed on the phonetics of the language, and in particular no published instrumental phonetic studies.

A number of aspects of this language are of particular phonetic interest. For an Austronesian language, Iaai has a relatively large vowel inventory consisting not only of ten different vowel qualities, but also a phonemic length distinction. In distinguishing these vowels, large differences in lip rounding and spreading are used and these are independent of the front-back distinction. Moreover, there are interesting limitations on the distribution of certain vowels according to the consonant context. The consonant inventory is also quite extensive. The language has three coronal places of articulation, dental, retroflex and pre-palatal, for stops and nasals. In the stops, these three places appear to be acoustically differentiated along lines which differ from most other languages of the world which make use of such distinctions. The Iaai consonant inventory also contains voiced and voiceless sonorants which have phonemic status. What follows will present a general phonetic survey of the language, with emphasis laid on these various aspects of particular interest.

Detailed studies of some of these aspects will be presented, based on analysis of audio and video recordings of five speakers (three female and two male), and palatography for four of them. To characterize the vowels, formant measurements, durations and intrinsic pitch data were obtained from audio recordings. Using videotape, measurements were also made of lip aperture area, the height and width of this aperture, the distance between the outside corners of the lips, and the amount of side contact between them.

IAAI VOWELS

A standard chart of Iaai vowels is given in Figure 1. The vowels can be broadly divided into three height sets, three high vowels, four mid vowels and three low vowels. Front high vowels clearly contrast in rounding, as in /ţii/ 'tea' and /yy/ 'quarrel' (n.) (cf. /uu/ 'fall' (v.)). Mid back vowels /ɤ, o/ also contrast in rounding but the rounding contrast in mid front vowels is not functionally robust since /ø/ occurs in only a very few words. This vowel is always followed by a velar consonant and almost always preceded by a labial. The low vowels /a/ and /æ/ are largely in complementary distribution, with /æ/ restricted to occurrence after the labial consonants /b, m̥, m, p, f, ɥ, ɸ/ and the vowel /y/. This set of sounds also conditions a fronted [œ]-like variant of the lower mid back rounded vowel /ɔ/. Figure 2 shows the first two formants of both long and short variants of 9 of these vowels for the three female speakers. /ø/ is omitted as data is too sparse.

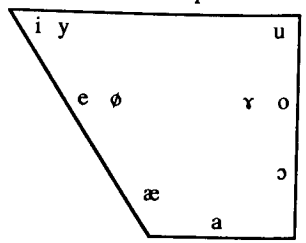

Figure 1. Chart of Iaai vowels.

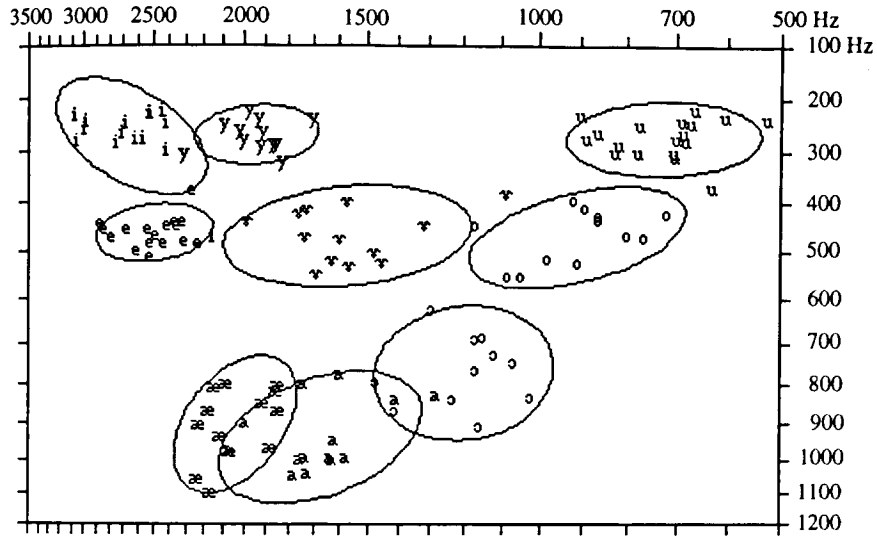

Figure 2. Formants of Iaai vowels (long and short combined) from three female speakers.

There are no consistent effects of length on the formant values; long vowels do not consistently have a higher or lower F1 or F2, nor are they more peripheral or more central in the acoustic vowel space than their short counterparts. Table 1 shows that the ratio of short to long vowel durations approaches 2.0.

Table 1. Long and short vowel durations.

	Short	Long	Difference
Women (9 vowels)	116.1	211.1	95.0
Men (8 vowels)	89.4	175.1	85.6

Lip position

The time-coded videotape was viewed frame-by-frame and the frame in which the lips reached the culminating position of the gesture for the particular vowel determined. This frame was digitized and a number of distances between lip points were measured in the transverse plane. These distances were *Lip Height* (distance between the lower surface of the upper lip and the upper surface of the lower lip at the center); *Lip Width* (the vertical distance between the point of contact of the lips at the left and the point of contact on the right); *Lip Corner* distance (the horizontal distance between the corners of the lip, i.e. the lateral margins of the vermilion border); *Side Contact* distance (the horizontal distance over which the lips are in contact between the corners and the aperture, i.e. *Corner* distance minus *Width*). Also *Lip Area* (the area of the visible opening enclosed by the lips) was measured. Since the video shows a frontal view, there is no quantitative data on lip protrusion. However, some qualitative idea of the degree of protrusion can be obtained. Useful information on the position of the tongue can also be obtained for those vowels with a more open jaw position.

Lip measurement results for three speakers, one male and two female, are shown in Table 2. To normalize across the speakers, all measurements were converted to standardized scores (with a within-speaker mean of zero and standard deviation of 1) before means were calculated and statistical tests performed. This transformation of the data, roughly, sets the value of a neutral lip position to zero. The values in Table 2 are the means of the within-speaker standardized scores. One can see, for example, that the area of the aperture between the lips in pronouncing /ɤ/ is very close to the mean lip area, /y/ and /u/ have the smallest area, indicated by the large negative number, and /a/ the largest.

Table 2. Mean normalized lip measurement values for ten Iaai vowels, from 3 speakers.

Word	*Vowel*	*Lip Height*	*Lip Width*	*Lip Corners*	*Lip Sides*	*Lip Area*
ṭii	i	0.53	0.70	0.89	0.31	0.69
yy	y	-1.41	-1.15	-0.63	0.70	-1.14
eet	e	0.19	1.26	1.27	-0.08	0.51
møøk	ø	-0.45	-0.75	-1.10	0.12	-0.78
vææt	æ	1.22	0.87	0.79	-0.62	1.12
aat	a	1.38	1.03	0.45	-1.18	1.51
θɔɔn	ɔ	0.61	-0.05	-0.61	-0.71	0.14
oṭ	o	-0.75	-1.01	-0.84	0.55	-0.92
ɤṭ	ɤ	-0.15	0.40	0.70	0.12	-0.01
ṭuṭu ~ kaluu	u	-1.17	-1.29	-0.92	0.79	-1.12

The vertical distance between the lips (*Lip Height*) is least for rounded non-low vowels, and greatest for unrounded low vowels. Although a three-way classification of vowels by height (high, mid, low) predicts a significant amount of this variance, the four mid vowels show quite substantial differences, with rounded mid vowels having higher lip position than unrounded ones. Most strikingly, the unrounded high vowel /i/ is more open than /e/ at the lips. The difference between /i/ and /e/ is made by raising the jaw independently of the lips, as the frames in Figure 1 show.

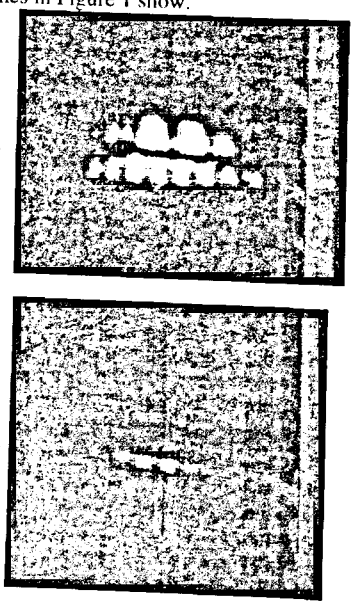

Figure 3. Video frames illustrating lip and jaw position in /i/ and /e/.

Lip Height does not divide rounded from unrounded vowels but *Lip Width* does. The distance between the outside corners of the lips (*Lip Corners*), however, is the best of our measures at effecting such a separation. All five rounded vowels have negative values of at least -0.61; all the unrounded vowels have positive values of 0.45 or greater. Moreover, the *Lip Corner* distance relates well only to the classification of vowels by rounding and not to classification by height as well. This measure seems the best index of lip protrusion when measurements are only taken in a flat plane, transverse to the body. Drawing the corners of the lips closer together is a consequence of protruding them.

Contact at the sides of the lips (*Lip Sides*) was measured following the suggestion of Goldstein [3] that "rounded vowels must be produced with contact along the sides". Although rounded high vowels have the greatest amount of side contact this measure does not separate the Iaai vowels into rounded and unrounded classes, and little of the variance in the *Lip Sides* measure can be predicted from the classification of vowels by rounding ($F(1, 29) = 2.87$, $p = .1011$).

Naturally enough, both *Lip Height* and *Width* measurements are very highly correlated with *Lip Area* (.95 and .92 respectively). Since /y/ and /u/ have the smallest height and width, they have the smallest area of lip opening, having almost identical mean normalized values. In this respect Iaai differs from a number of other languages with a similar pair of vowels, such as French, Swedish, Cantonese and Finnish, where the lip area for /y/ is considerably larger than that for /u/, and is actually comparable to that for /i/ [4]. Iaai also has a larger than expected area for /i/. *Lip Area* broadly separates rounded from unrounded vowels, with vowel height ranking vowels within those groups.

Formants and lip measures

Normalized F1 correlates most highly with *Lip Height*. Acoustic theory predicts a relationship between vowel height and F1; the more open a vowel, is the higher the F1 frequency. Despite the *Lip Height*./vowel height discrepancy with /i/ and /e/, lip height generally goes with openness. F2 and F3 both correlate most highly with the *Lip Corner* measure (.62 and .59 respectively). This measure is associated with rounding and is hypothesized to be related to lip protrusion; low values indicate protruded lips. Since increasing the effective vocal tract length by protruding the lips lowers the frequency of these higher formants, the correlation is attributed to this component of their variation. As these formants are also very sensitive to the location of constrictions inside the oral cavity, the strength of the correlations with this lip measure are quite striking.

IAAI CONSONANTS

The extensive consonant inventory of Iaai includes three coronal places of articulation, voiced and voiceless nasals and lateral and central approximants. Given the strong constraints operating between vowel qualities and labial consonants, it may be the case that all labial consonants include a secondary articulation of palatalization or labialization.

Palatograms of the three coronal series of stops were made of four speakers. Linguagrams were also obtained from one male speaker. For this speaker, the dental in /aṭ/ 'person' has a relatively large contact area entirely covering the upper front teeth and the alveolar ridge. The linguagram confirms that the contact is laminal, or more precisely apico-laminal [5], and includes a considerable extension of the contact laterally back toward the molar teeth on both sides. The post-alveolar ('retroflex') stop in /ḍa/ 'blood' involves a much narrower band of contact entirely behind the teeth toward the back part of the alveolar region. The linguagram shows this contact is strictly apical, with only the narrow anterior-facing surface of the tongue tip and a small area on the upper surface of the tip involved. There is markedly less lateral contact behind the front closure than for the dental, indicating that the mid part of the tongue is lower in this articulation. For the pre-palatal stop in /ca/ 'leg, foot' there is a broad contact area from the back of the alveolar ridge to a point about at the location of the second molars. The linguagram shows that the contact is strictly laminal, with no contact on the frontmost part of the tongue (about the first 1 cm).

The palatograms of the other speakers, who are of a slightly younger generation, tended to show a less clear articulatory distinction in the location of the contacts on the palate and in the tongue contact area. However, all speakers maintain a three-way acoustic distinction. Dental place is characterized by a lack of frication of the release, and if voiceless and prevocalic, by a very short voice onset time. Both the palatal and retroflex places are characterized by a noisy and sustained release. The noise of the release seems to be concentrated in the area of the third formant resonance for the palatal and the fourth formant for the retroflex. Other languages with dental and post-alveolar stops seem more frequently to have a more fricated or noisier release for the dental rather than for the post-alveolar [5], [6]. The Iaai facts show that this is a language-specific property, not a universal.

REFERENCES

[1] Ozanne-Rivierre, F. (1976), *Le Iaai.* SELAF, Paris.

[2] Ozanne-Rivierre, F. (1984), *Dictionnaire Iaai-Français.* SELAF, Paris.

[3] Goldstein, L. (1991), Lip rounding as side contact. *Proc. 12th Int. Congress of Phonetic Sciences, Aix-en-Provence, 1*: 97-101.

[4] Linker, W. (1982), *Articulatory and Acoustic Correlates of Labial Activity in Vowels: A Cross-Linguistic Study.* (= UCLA Working Papers in Phonetics 56.)

[5] Dart, S. (1991), *Articulatory and Acoustic Properties of Apical and Laminal Articulations* (= UCLA Working Papers in Phonetics 79).

[6] Anderson, V. B. and Maddieson, I. (1994), "Acoustic characteristics of Tiwi coronal stops." *UCLA Working Papers in Phonetics* 87: 131-162.