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TABLES OF ARABIC WORDS FOR EXPERIMENTAL PHONETICS

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Introduction

Arabic as well as Hebrew and Aramaic, and even Samaritan Hebrew originate in the same proto type of the Semitic languages. Their linguistic affinity is remarkable and both diachronic and synchronic investigations are of long standing.

These languages are of the synthetic type, tending to express several concepts in a single word and have similar systems of declension and conjugation. Of course assimilation or dissimilation occurs within the word.

The concept of 'root' is common in the Semitic languages. The root, which mostly consists of three letter consonants, represents the morpheme of the word and contains three letters of the language.

First of all verbal forms are based on the root. For instance, 'syrup' is a loan word from an Arabic word whose root contains three consonants, /sh/, /r/, /b/. The verbal form of these consonants basically concerns the meanings of 'to drink'.

In classical Arabic, the verbal form has ten patterns and thirteen personal conjugations for each root. In addition, at least one of the forms of perfect, imperfect, imperative, perticiples (active and passive) and gerund inflects together with a single verb.

Classical Arabic is the proper and standard literary language commonly used in the Arab world today even though modern Arabic with a great many dialects and vernaculars is spoken colloquially there.

It seemed desirable to design some standard and systematic lexical tables of Arabic words for experimental phonetics not only because of the large numbers of inflections and dialects, but also because of the type of Semitic language i.e. 'synthetic'.

For these reasons I have been designing some tables which contain the minimal pairs of actual Arabic words, the roots of which are found in lexicons.

Design

Initially the relationships between Arabic letters and their own consonants as phonemes are shown in Table 1. I.P.A. is adopted here though another phonetic transcription or orthography may be more widespread in the phonology of Semitic languages. I would like to make use of /ʓ/ for the letter ج for convenience. Concerning the letter خ , /χ/ is in use for similar reasons.

Ferguson, having proposed the particular phoneme of /l̩/ as an emphatic consonant of Arabic, I would like to use a single phoneme of /l/ just for the letter ل .

Some characteristic phonemes in the Semitic languages are derived from the sounds articulated in velum, uvula, pharynx and glottis. Even so-called 'emphatic consonants' in phonology are the sounds resulting from pharyngealization. The sounds of /x/, /ɣ/, /q/, /ħ/, /ʕ/, /h/, /ʔ/ and pharyngealized ones have been some

focei of the arguements in etymological, phonological, morphological or phonetic studies of the Semitic languages.

D.H. Obrecht investigated acoustically the velarized consonants of Arabic. Contemporary Standard Arabic in Iraq was investigated by Salman H. al-Ani and he mentioned the features of sound spectrograms quite a lot.

Asher Laufer discussed the pharyngeal sounds of /ħ/ and /ʕ/ in Hebrew language, observing the movement of the epiglottis.

The tables here were designed to exactly reflect my interests in these above sounds. Every word is constructed in simpler patterns using the ten verbal forms, the third person, masculine, imperfect and the imperative. In some cases, the actual words not being found in lexicons, I was obliged to put some words in a part of speech other than the verbal form.

On the whole, simple syllable words are listed in the tables in addition to some essential words composed of different syllables for the purposes of this experiment. The roots containing the letter, phoneme of which is /w/ or /y/ in medial position have been selected.

On the other hand, velar, uvular, pharyngeal, glottal and pharyngealized consonants are always given priority for inclusion in the table within the grammatical framework outlined above wherever they may be found in any position of letter of root.

Then the words selected are arranged according to types of sound (nasal, plosive, fricative, lateral, trill), places of articulation and voiced or voiceless with regard to the initial letter. The words containing pharyngealized consonants in the initial letter are contrasted with non-pharyngealized ones to form some minimal pairs where possible.

As to the final letter, however, one has less freedom of arrangement and order than is the case with the first two letters. So the final letters are arranged in the same way. (Table 2.1)

In cases where one word contrasted with another, whose letters are reversed e.g. letters of one word being XYZ and another having the letters of ZYX, they are treated as minimal pairs of another group. In particular and due to my special interest, some words are separated from the former group when they contain the sounds /ʕ/ and /ħ/. (Table 2.2)

Words containing /x/, /ɣ/, /ʕ/, /ħ/, /h/, /ʔ/ in the initial letter are exclusively grouped in Table 2.3. In order to make a reasonable comparison with pharyngealized consonants in the medial letter, the words consisting of non-pharyngealized consonants in the medial letter are adopted here, too.

Although Table 2.4 contains just five words, the comparison of these words must bring about interesting results.

Whole words mentioned above include vowel /a/ in addition to /laʕu:b/ and /ta:hin/. Unfortunately both two words, /laʕab/ and /ta:h/, which I have expected, are not found in lexicons, so instead of these words the former two words are adopted respectively.

/maḍa:/, /rataqa/, /ḍaha:/, /ɣada:/ and /ɣaḍa:/ are adopted instead of /ma:ḍ/, /rataq/, /ḍa:ħ/, /ɣa:d/ and /ɣa:ḍ/ for similar reasons.

For the purpose of comparing the effects of pharyngealized consonants on vowels /i/ and /u/, the same kind of minimal pairs are grouped in Table 2.5 and

Table 1 *Alphabet & phonemes* in Arabic*

/q/	ق	/z/	ز	/ʔ/	ا
/k/	ك	/s/	س	/b/	ب
/l/	ل	/ʃ/	ش	/t/	ت
/m/	م	/ʂ/	ص	/θ/	ث
/n/	ن	/ɗ/	ض	/ʒ/	ج
/h/	ه	/ʈ/	ط	/ħ/	ح
/w/	و	/ʐ/	ظ	/x/	خ
/y/	ي	/ʕ/	ع	/d/	د
		/ɣ/	غ	/ð/	ذ
		/f/	ف	/r/	ر

* Phonemes according to I.P.A.
Both /ɣ/ for غ and /l/ for ل are for convenience.

Tables of word pairs in Arabic for experiment

Table 2.1 *Minimal pairs of simpler words*

	R*	W*	P*	M*		R*	W*	P*	M*
1.	m w t	ma:t	v.	die	30.	k y l	ka:l	v.	measure
2.	m y ɬ	ma:ɬ	v.	remove	31.	q w l	qa:l	v.	say
3.	m y d	ma:d	v.	be moved	32.	q t r	qatar	v.	be miserly
4.	m ɗ y	maɗa:	v.	go away	33.	q ɬ r	qaɬar	v.	tow,pull
5.	n w b	na:b	v.	substitute	34.	q d m	qadam	v.	arrive
6.	n ð r	naðar	v.	vow	35.	q ɗ m	qaɗam	v.	bite
7.	n s r	nasar	v.	look	36.	ʔ y l	ʔa:l	v.	descend to
8.	b y n	ba:n	v.	come out	37.	ʔ s d	ʔasad	n.	lion
9.	b w b	ba:b	n.	door	38.	ʔ ṣ d	ʔaṣṣad	v.	close
10.	b y t	ba:t	v.	stay at night	39.	f w t	fa:t	v.	pass away
11.	b y d	ba:d	v.	become extinct	40.	θ w r	θa:r	v.	stir,revolt
12.	b y ɗ	ba:ɗ	v.	lay eggs	41.	θ b t	θabat	v.	be firm
13.	b w s	ba:s	v.	kiss	42.	θ b ɬ	θabaɬ	v.	prevent
14.	b w ʃ	ba:ʃ	v.	roar	43.	s w m	sa:m	v.	inflict
15.	b y ʕ	ba:ʕ	v.	sell	44.	ṣ w m	ṣa:m	v.	fast
16.	b ʕ l	baʕʕal	v.	haveas a husband	45.	s y b	sa:b	v.	let free,run
17.	b w ħ	ba:ħ	v.	reveal	46.	ṣ w b	ṣa:b	v.	hit the target
18.	t y m	ta:m	v.	be infatuated	47.	s w d	sa:d	v.	dominate
19.	t w b	ta:b	v.	repent	48.	ṣ y d	ṣa:d	v.	hunt,catch
20.	ɬ w b	ɬa:b	v.	ripen	49.	s y r	sa:r	v.	walk fast
21.	t y h	ta:h	v.	get lost	50.	ṣ y r	ṣa:r	v.	become
22.	ɬ h w	ɬa:hin	n.	a cook	51.	s b ɣ	sabaɣ	v.	bestow
23.	d w s	da:s	v.	crush	52.	ṣ b ɣ	ṣabaɣ	v.	dye
24.	d w r	da:r	v.	circle	53.	ʃ y b	ʃa:b	v.	become old
25.	ɗ y r	ɗa:r	v.	harm	54.	ʃ w b	ʃa:b	v.	vitiate
26.	d ʕ w	da:ʕ	n.	call,appeal	55.	ɣ d w	ɣada:	v.	go out,depart
27.	ɗ y ʕ	ɗa:ʕ	v.	get lost	56.	ɣ ɗ w	ɣaɗa:	v.	overlook
28.	d w ħ	da:ħ	n.	family tree	57.	ħ w b	ħa:b	v.	make a mistake
29.	ɗ ħ w	ɗaħa:	v.	become visible	58.	ħ y d	ħa:d	v.	deviate

* *R*: Root of word*
W: Test word in Modern Arabic*
P: Part of speech*
M: Main meanings of word*

59.	ħ w d	ħa:d	v. turn away	66.	l w k	la:k	v. chew
60.	ħ y ð	ħa:ð	v. menstruate	67.	l y q	la:q	v. be proper
61.	ʕ y b	ʕa:b	v. deficient	68.	l ʕ b	laʕʕab	v. make play
62.	ʕ w d	ʕa:d	v. return	69.	l ʕ b	laʕu:b	adj. coquettish
63.	ʕ w ð	ʕa:ð	v. compensate	70.	r w d	ra:d	v. walk about
64.	h w d	ha:d	v. to be a Jew	71.	r w ð	ra:ð	v. coach,train
65.	h y ð	ha:ð	v. be powerless	72.	r t q	rataq	v. mend

Table 2.2 *Word pairs with reversed (exchanged) letters in the initial and the final position of root*

01.	m w t	ma:t	v. die	021.	q y l	qa:l	v. say
02.	m y ŧ	ma:ŧ	v. remove	022.	l y q	la:q	v. be proper
03.	t y m	ta:m	v. be infatuated	023.	q t r	qatar	v. be miserly
04.	n w b	na:b	v. substitute	024.	r t q	rataqa	v. mend
05.	b y n	ba:n	v. comeout	025.	q ŧ r	qaŧar	v. tow,pull
06.	b w s	ba:s	v. kiss	026.	b w ħ	ba:ħ	v. reveal
07.	s y b	sa:b	v. let free,run	027.	ħ w b	ħa:b	v. make a mistake
08.	ʂ w b	ʂa:b	v. hit the target	028.	d w ħ	da:ħ	n. family tree
09.	b w ʃ	ba:ʃ	v. roar	029.	ħ y d	ħa:d	v. deviate
010.	ʃ y b	ʃa:b	v. become old	030.	ħ w d	ħa:d	v. turn away
011.	ʃ w b	ʃa:b	v. vitiate	031.	ð ħ w	ðaħa:	v. become visible
012.	d w r	da:r	v. circle	032.	ħ y ð	ħa:ð	v. menstruate
013.	r w d	ra:d	v. walk about	033.	b ʕ l	baʕʕal	v. have as a husband
014.	ð y r	ða:r	v. harm	034.	l ʕ b	laʕʕab	v. make play
015.	r w ð	ra:ð	v. coach,train	035.	l ʕ b	laʕu:b	adj. coquettish
016.	d w s	da:s	v. crush	036.	b y ʕ	ba:ʕ	v. sell
017.	s w d	sa:d	v. dominate	037.	ʕ y b	ʕa:b	v. deficient
018.	ʂ y d	ʂa:d	v. hunt,catch	038.	d ʕ w	da:ʕ	n. call,appeal
019.	k y l	ka:l	v. measure	039.	ʕ w d	ʕa:d	v. return
020.	l w k	la:k	v. chew	040.	ð y ʕ	ða:ʕ	v. get lost
				041.	ʕ w ð	ʕa:ð	v. compensate

Table 2.3 */x/, /h/, /ʕ/ and /ħ/ being of the initial letter of root, the other two letters of which are geminated*

73.	x	d	d	xadd v. sharpen
74.	x	ɗ	ɗ	xaɗɗ v. incite
75.	ħ	θ	θ	ħaθθ v. urge
76.	ħ	ʃ	ʃ	ħaʃʃ v. notch
77.	ħ	t	t	ħatt v. rub off
78.	ħ	ɬ	ɬ	ħaɬɬ v. let down
79.	ħ	s	s	ħass v. feel
80.	ħ	s	θ	ħasθ v. fall as a share
81.	ħ	ʃ	ʃ	ħaʃʃ v. mow
82.	h	ɗ	ɗ	haɗɗ v. walk fast
83.	h	ʃ	ʃ	haʃʃ v. be affable
84.	ʕ	d	d	ʕadd v. count
85.	ʕ	ɗ	ɗ	ʕaɗɗ v. bite

Table 2.4 *Simpler pairs for comparison between /t/, /ɬ/, /ɓ/ and geminated /b/*

86.	b	y	t	ba:t v. stay at night
87.	t	w	b	ta:b v. repent
88.	ɬ	w	b	ɬa:b v. ripen
89.	t	b	b	tabb v. be destroyed
90.	ɬ	b	b	ɬabb v. give medical treatment

Table 2.5 *Word pairs with /i/ only in word*

91.	t	y	n	ti:n n. fig
92.	ɬ	y	n	ɬi:n n. mud
93.	s	y	n	si:n n. 's' in Arabic
94.	loan word			ʃi:n n. Chaina
95.	s	y	b	si:b v. let go!
96.	ʃ	w	b	ʃi:b v. hit the target
97.	s	w	ħ	si:ħ v. travel!
98.	ʃ	y	ħ	ʃi:ħ v. cry!
99.	ɗ	n	n	ɗinn v. be stingy!, buzz!
100.	s	r	r	sirr n. secret
101.	ʃ	r	r	ʃirr v. insist!
102.	z	l	l	zill v. slip!, fail!

Table 2.6 *Word pairs with /u/ only in word*

103.	s	w	m	su:m v. bargain!
104.	ʃ	w	m	ʃu:m v. fast!
105.	s	w	r	su:r n. fence
106.	ʃ	w	r	ʃu:r n. horn
107.	d	b	b	dubb n. bear
108.	ɗ	b	b	ɗubb v. pack!
109.	d	r	r	durr n. pearl
110.	ɗ	r	r	ɗurr v. harm!
111.	s	b	b	subb v. insult!
112.	ʃ	b	b	ʃubb v. pour!
113.	s	d	d	sudd v. close!
114.	ʃ	d	d	ʃudd v. repel!

Table 2.6 respectively.

Application

Procedure

According to the tables designed, nine minimal pairs were selected for this experiment, being as follows:

/ma:d/ & /maḍa:/, /ba:d/ & /ba:ḍ/, /ra:d/ & /ra:ḍ/, /ɣada:/ & /ɣaḍa:/, /ʕa:d/ & /ʕa:ḍ/, /ħa:d/ & /ħa:ḍ/, /ha:d/ & /ha:ḍ/, /xadd/ & /xaḍḍ/ and /sa:d/ & /ṣa:d/.

For the purpose of comparing a velar sound /x/ with other sounds according to place of articulation, I dare to adopt a pair of /xadd/ & /xaḍḍ/ here for the lack of the pair /xa:d/ & /xa:ḍ/ desired actually. A pair of /sa:d/ & /ṣa:d/ serves out of necessity for the lack of an actual word /sa:ḍ/ exactly wanted, too. It is a matter of course that the word /sa:d/ absolutely serves the purpose other than /ṣa:d/. Even /ṣa:d/, however, is of use to observe another effect of pharyngealized consonant corresponding to an initial letter of root. The test word is presented as an insertion in the form of a sentence, the precursor of which is /ha:ðə/ in Arabic, meaning 'This is'. For instance, /ha:ðə ba:b/ means 'This is a door'.

The informant in this experiment is a native speaker of the standard Cairo dialect of modern Arabic. The whole words in the tables are transcribed into simpler phonemes, taking no account of the subtle distinction concerning the phonological definition. The differences between classical and modern Arabic are beside the question in this experiment. As the root of words has been established, root, phoneme of word in modern Arabic, part of speech and main meanings are listed in tables.

The recording was performed in the recording studio in RILP, while the informant was asked to read the sentences at normal tempo of his speech six times over. The recording tape used here is SONY ULH-7550. Soundspectrograms were measured with Digital Sona-Graph 7800. (KAY Elemetric Corp.).

Result and discussion

The whole speech of sentences has been compared in the features of formant and duration. As being investigated previously, the decrease of F2 has been characteristic to pharyngealization. (Fig. 1) The general aspect of speeches was obtained and relationships between F1 and F2 of each segment has become clear. (Fig. 2.1 & Fig. 2.2) It seems that the decrease of F2 has already started during the segment of vowel /a/ in /ðə/, which is a part of precursor of the carrier sentence. It led me to divide the interval into three parts for convenience, i.e. left side (l) neighbouring with the preceding consonant /ð/, the center (c) and right side (r) next to the following consonant /Cl/ of test word. Results are found in Table 3, Fig. 3.1 and Fig. 3.2. Average values are available here. Ratio of decrease, $-\Delta F2/\Delta F1$ derived from pharyngealized consonant /ḍ/ here, is changing significantly in the former half part of the duration of vowel /a/ in /ðə/. It seems that the lowering of F2 sets out approximately at the point of 37.6 percent of the duration of the whole speech. /xadd/ & /xaḍḍ/ and /ṣa:d/ are excluded from object.

Fig. 4 shows some features of durations of the whole speeches. Vowel-like

sounds are uttered constantly by the informant here. It became clear that the duration of voiceless consonants in the initial part of the test words is much longer than that of the voiced one, having the same syllable structure i.e. CVC system in this case, not only as a single word, but also even in speech of sentences.

The relative duration of segments within each speech presents some remarkable features characteristic to the vowel structure of sentence and word contained there. On the other hand, the comparison of each rate of duration between the sentences promises significant information with regard to the acoustic and physiological phenomena of speech in Arabic language as well.

Details are under discussion at present.

Summary

1) The utilization of the systematically designed table of Arabic words is reasonable in every experiment.
2) Some vowel-like utterance was observed after the final consonants.
3) F2 is decreased in vowels next to the pharyngealized consonants.
4) The lowering of F2 has already started approximately at the point of 36.7 per. of the duration of the whole speech from the beginning.

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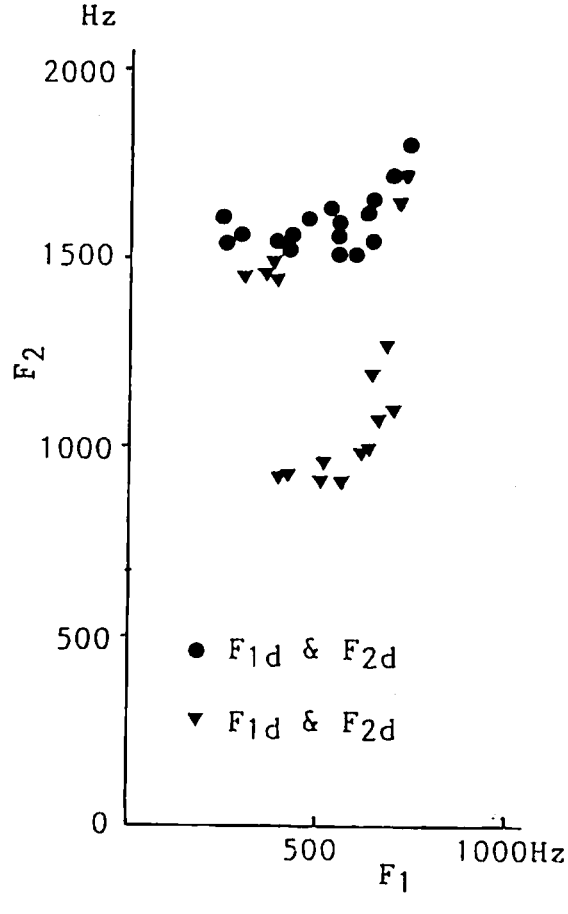

Fig. 1 *Comparison of formant F1 & F2 in relation to pharyngealized and non-pharyngealized sentence*

Notes:

Test speech : /haʕa $C_1V_1C_2(V)$/,
/haʕa $C_1V_1C_2V_2$/ or /haʕa $C_1V_1C_2C_2$/
$/V_1/$: /a/ in this experiment
/(V)/: Vowel-like sound found in case of no vovwl following consonant /d/ or /ḍ/ in context.
$/V_2/$: Vowel after consonant /d/ or /ḍ/ in test word.

F_{1d}, F_{2d} : Average value of formant F_1, F_2 in speech where test word is of structure $/C_1V_1d/$, $/C_1V_1dV_2/$ or $/C_1V_1dd/$

$F_{1ḍ}$, $F_{2ḍ}$: Average value of formant F_1, F_2 in speech where test word is of structure $/C_1V_1ḍ/$, $/C_1V_1ḍV_2/$ or $/C_1V_1ḍḍ/$.

$\Delta F_1 = F_{1d} - F_{1ḍ}$, $\Delta F_2 = F_{2d} - F_{2ḍ}$

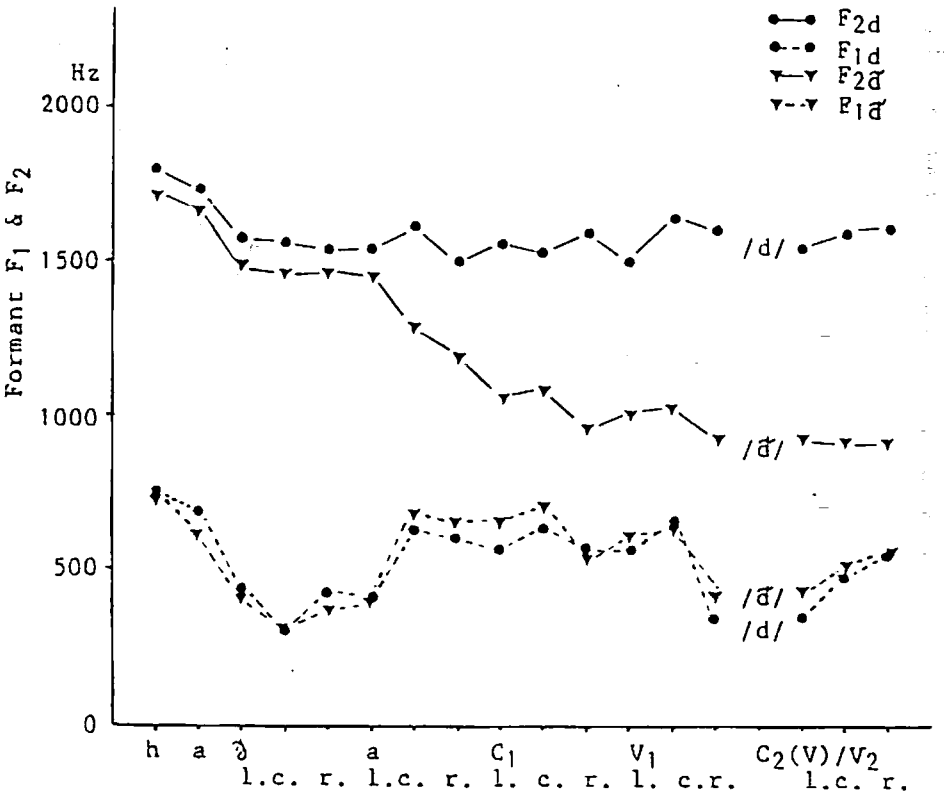

Fig. 2.1 *Total feature of formant F1 & F2 concerning each segment of whole speech of test sentences*

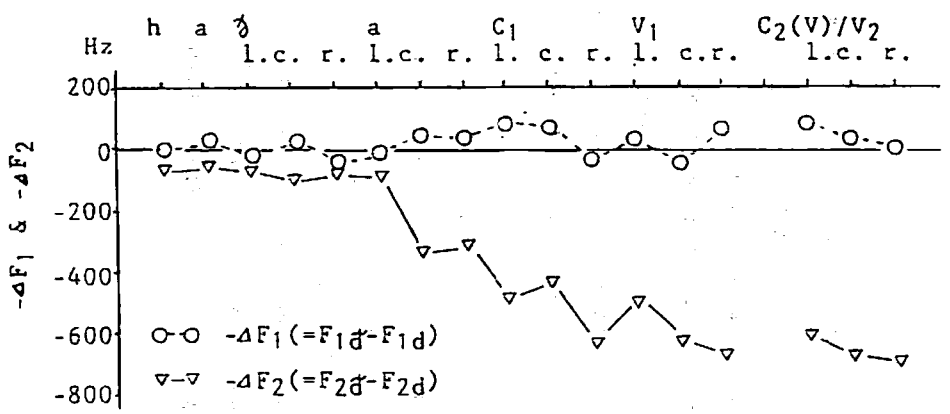

Fig. 2.2 *Decrease of F2 in contrast with tendency of increasing F1 due to pharyngealized consonant /d/*

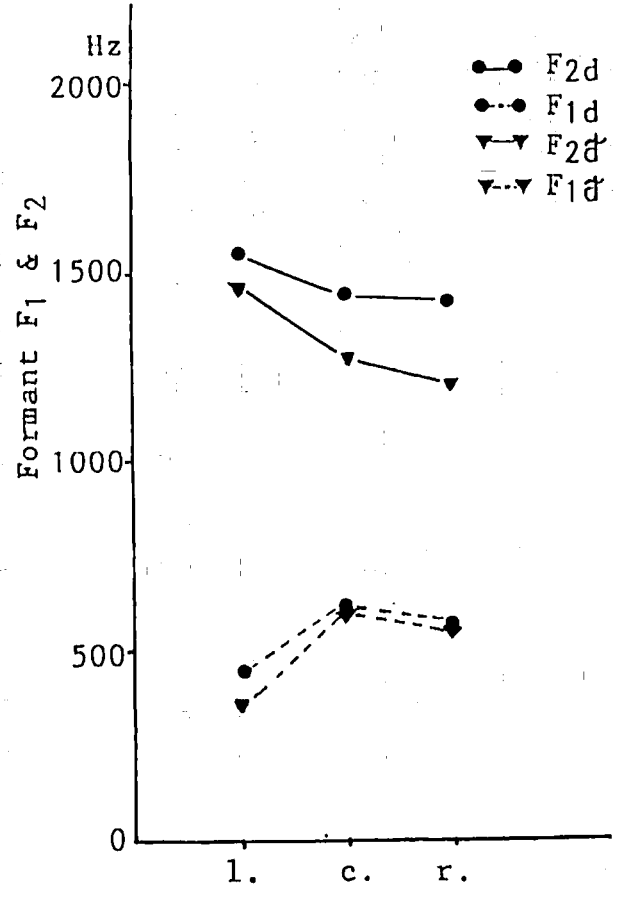

Fig. 3.1 *Comparison of F1 and F2 for the part of /a/ in /ʒa/ between pharyngealized and non- pharyngealized sentence*

Table 3 *F1 & F2 concerning the part of /a/ in /ʒa/*

	1.	c.	r.
F_{2d}	1547.4	1442.1	1428.9
F_{1d}	444.7	607.9	573.7
$F_{2ð}$	1458.3	1269.7	1197.2
$F_{1ð}$	355.6	600.0	563.9
$F_{2d}-F_{2ð}(=\Delta F_2)$	89.1	172.4	231.7
$F_{1d}-F_{1ð}(=\Delta F_1)$	89.1	7.9	9.8
$\Delta F_2/\Delta F_1$	1.0	21.8	23.6

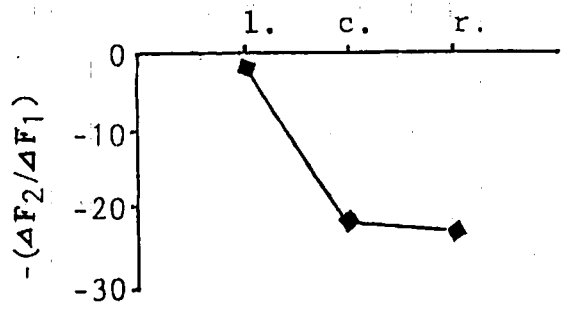

Fig. 3.2 *Decreasing ratio of F2 to F1 of /a/ in /ʒa/*

1. : Left side of the interval of /a/ in /ʒa/.

c. : Centre of the interval of /a/ in /ʒa/.

r. : Right side of the interval of /a/ in /ʒa/.

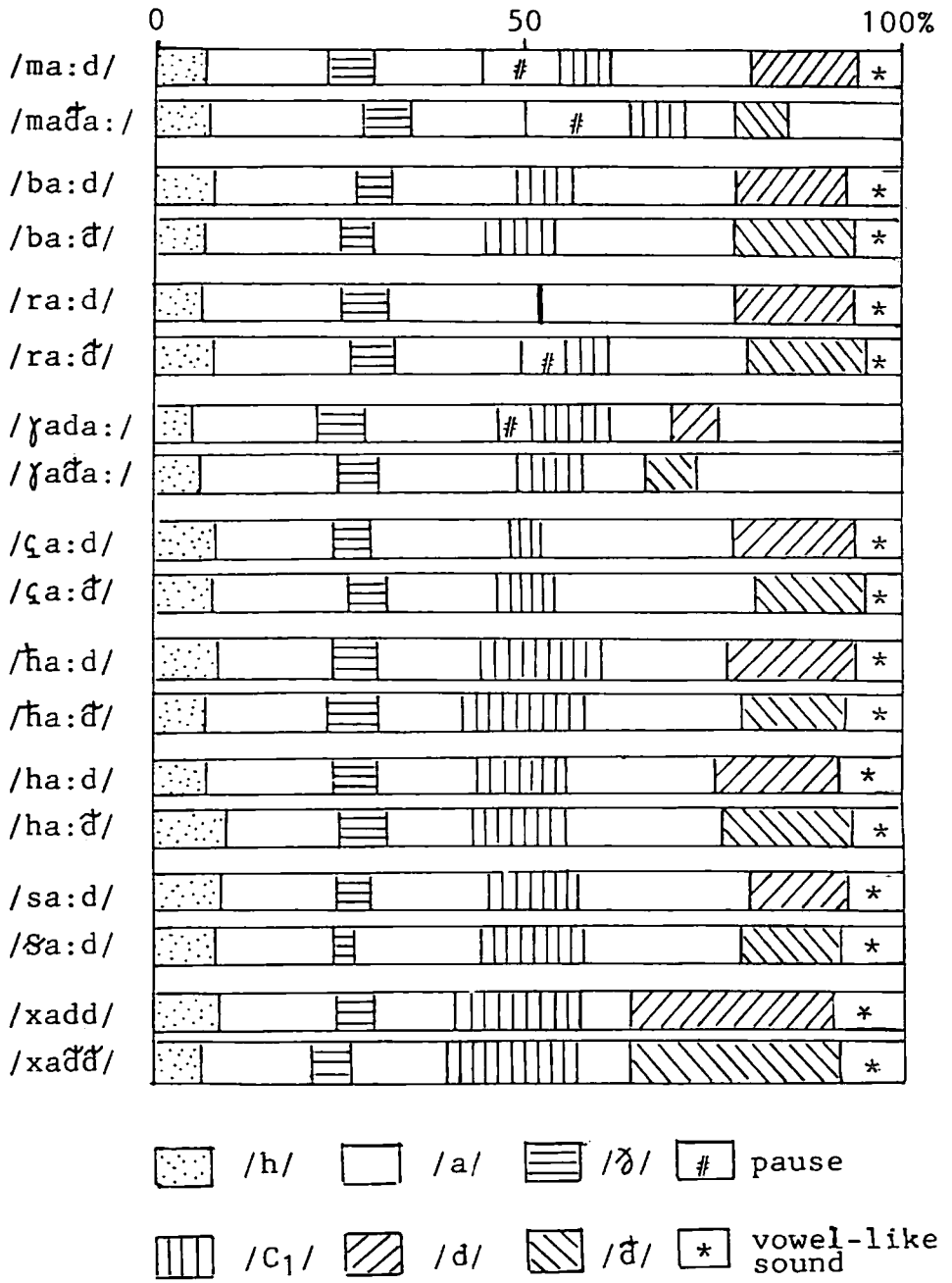

Fig. 4 *Relative duration of each segment of whole speech (%), contrasting different consonant in test word*