

THE DURATION OF VOWELS IN THE CONSTRUCT STATE OF MODERN HEBREW

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1. Introduction

The construct state of nouns in Hebrew is one of the word forms which are common to other Semitic languages like Arabic or Aramaic¹). The construct state is called /smixút/ in Hebrew (using phonemic transcription in I.P.A.^{2,3}). The word /smixút/ which had already been used in the period of Mishnaic Hebrew, began to be used in the terminology of Hebrew grammar since Medieval times. /smixút/ is defined in Hebrew grammar as the combination of two or more nouns, which have no relation of meaning to one another, to express one concept⁴). An important fact about /smixút/ is that it is one concept and can be considered one word phonetically⁵). Greenberg described the phenomenon as follows:

The first, or governing, noun loses its main stress (retaining, at best, a secondary stress), which now falls on the second, or governed, noun. Consequently, the governing noun often undergoes vowel reduction or loss. Nouns in the construct state undergo various internal vowel changes⁵).

The accent in Hebrew falls on one of the last two syllables of a word: on the ultimate syllable or on the penultimate one. One may say that in Hebrew the ultimate accentuation is dominant, though the penultimate is also found⁴⁻⁷). Vowel changes can occur in a word owing to a shift in the position of its stress. The occasions for stress shifts in nouns are (a) the additional of the plural, dual, or feminine ending; (b) entrance into the construct state; or (c) the addition of a possessive suffix⁸).

The word /smixút/ is an abstract noun, the root of which is /s/, /m/ and /x/. The form of the third person, masculine, singular in the past tense of a QAL-verb is /samáx/. The final sequence of /smixút/ words is called /soméx/, meaning 'support', while a noun (or compound nouns) followed by /soméx/ is (are) called /nismáx/ meaning 'supported'⁴). /soméx/ delimits the range of /nismáx/ and indicates possession or another relationship, while /nismáx/ is the nucleus and changes its form according to gender and number¹). /soméx/ is said to be in the absolute state, while /nismáx/ is said to be in the construct state. A form neither in the construct state nor having pronominal suffixes is called /nifrád/, meaning 'separated' in Hebrew grammar. A noun in /nifrád/ is used as /soméx/ with no change, although it undergoes vowel changes (reduction or loss) when used as /nismáx/. Sometimes we find that /nismáx/ is called a 'nomen regens' or 'governing noun', while /soméx/ is called a 'nomen rectum' or 'governed noun' in descriptions of Hebrew grammar^{5,9}).

The definite article is normally added to beginning of

/soméx/, if necessary. Sometimes other forms of /smixút/ can be found¹⁰⁾, one of which is called the /šel/-construction, which was born in the time of Mishnaic Hebrew under the influence of Aramaic and has been in use since then¹¹⁻¹³⁾.

An important point of the Hebrew language is that every sentence must agree among its parts in person, gender and number⁷⁾. Every noun may appear in one of three states: absolute, construct or with pronominal suffixes. There is no fixed system in the grammar books to arrange the different ways of declining nouns into a set number of classes as is the case for Greek or Latin. However, at least eleven declensions may be identified, and some scholars determine 14¹⁴⁾. Berkeley classifies Hebrew nouns into eight categories¹⁵⁾. Nouns belonging to each category have many patterns, namely mishqál, in the phonology and morphology of Hebrew grammar^{16,17)}.

- (1) full-spelled final vowel of word¹⁸⁾
- (2) qamaṣ, masculine
- (3) qamaṣ, feminine
- (4) šere
- (5) word-final הָֿ
- (6) pataḥ
- (7) ḥolam
- (8) accentuation of penultimate syllable

In Hebrew nouns, as in most pronouns and most of the verbal forms, there are two genders, masculine and feminine, but only the feminine is normally marked. This mark (in the singular) establishes the gender, whereas the feminine and masculine plural marks are not decisive. The noun in the construct state or, with pronominal suffixes, usually undergoes changes in its form: the feminine, singular ending הָֿ (/a/) changes to הַֿ (/at/), and both the plural ending הִֿ (/im/) and the dual ending הֵֿ (/aim/) change to הֶֿ (/e/), because the plural and dual are the same in the construct form. The feminine plural ending הִֿ (/ot/) does not undergo changes in either the absolute state or the construct one.

The masculine singular noun, the word-final vowel of which is /e/, has the descriptive vowel sign הָֿ (segol malé) in the absolute state, but הַֿ (šere malé) in the construct state. The masculine plural noun, the ending of which is /im/ in the absolute state, which changes to the vowel /e/, whose descriptive vowel sign is הֶֿ (šere malé), in the construct state. Though these two descriptive vowel signs of word-final vowels in the construct state are different, both of their phonemes are /e/ and called 'šere malé', because their different consonant letters of ה (he) and ם (jod), which are preceded by the descriptive vowel sign, 'šere' assimilate to preceding vowels to lose their quality consonants¹⁹⁾. Though the change in the written vowel signs is apparent, it has scarcely been investigated whether speech subjects discriminate between the singular form and plural form in actual speech, or what kind of differentiation of acoustic features parallels the written signs, if any.

This study discusses differences in the duration of word-final vowels between the singular and plural forms of masculine singular nouns in the construct state with the descriptive vowel sign of מָלֵ (segol malé) in the absolute state and the phoneme /e/ in actual speech.

2. Experiments

2.1 Preparation of test words

Three pairs of singular and plural nouns with מָלֵ (segol malé) as the word-final vowel in the absolute state/mumhē/, /maš asē/, /mexabē/were used as governing nouns (/nismáx/), and six words: /bat/, /gat/, /dat/, /pat/, /kat/, /tat/, all beginning with stop consonants were used as governed nouns (/soméx/). There were thirty six constructions for each in the singular or plural form. Governing nouns, governed nouns and their combined forms are listed, using phonemic transcription, in Table 1.

2.2 Procedures and method

The subject was a female native speaker of Israeli Hebrew who was twenty-five years old. The test words were presented to her to read individually at a normal tempo in terms of her own speech more than three times each. The recording was performed in an anechoic studio. Speech signals low-pass filtered with a cut-off frequency of 4.5kHz were passed through A/D converters with a sampling frequency of 10 kHz and entered in a computer system. The duration of the vowels was determined both by observing the speech wave forms displayed on a graphic display screen and by listening to the speech sounds which had been D/A converted. The results were then processed by a SPSS program using VAX-11/780 system.

2.3 Duration of vowels

The onset of the wave form of each test word in combined form was at the beginning of the speech signal for the consonant /m/. The offset of the wave form was at the end of the duration of the aspiration following the closure for the stop consonant /t/. The duration of each vowel or consonant in the test words was measured. The duration of the word-final vowel of a governing noun using /pat/ as an example of governed noun was defined as below.

2.3.1 /mumhēpát/ (Figs. 1.1, 1.2)

Fig. 1.1 gives both the speech wave form and the assignment of consonants and vowels for the singular form of /mumhēpát/. The

onset of the vowel /e/ was at the beginning of the periodical wave form for /e/, which followed the fricating wave form for the preceding consonant /h/. The end of the wave form for /e/ was defined as the boundary which the closure for the consonant /p/ followed.

2.3.2 /maʃasepát/ (Fig. 1.3)

The onset of the vowel /e/ was at the beginning of the periodical wave form for /e/, which followed the fricating wave form for the preceding consonant /s/. The end of the wave form for /e/ was defined as the boundary just before the onset of the closure for the consonant /p/ following the vowel /e/.

2.3.3 /mexabepát/ (Fig.1.4)

The periodical wave form, of small intensity, for the consonant /b/ changed to show a small amount of frication caused by the burst which occurred after the closure of /b/ for the vowel /e/. The onset of the vowel /e/ was at the beginning of the periodical wave form with strong intensity for /e/, which followed the wave form for the preceding consonant /b/. The end of the wave form for /e/ was defined as the boundary just before the onset of the closure for the consonant /p/, which followed the vowel /e/.

3. Results

The total number of samples obtained in the repetitions of the test words was 132: singular forms of governing nouns were 57, and plural ones were 75. The duration of the word-final vowels of governing nouns with a governed noun in the combined form was measured for both the singular and plural forms.

Duration of noun in combined form:	W(msec)
Duration of governing noun:	Y(msec)
Duration of vowel /e/:	X(msec)
Normalized value of X to W:	$P = (X/W) \cdot 100(\%)$
Normalized value of X to W:	$Q = (X/Y) \cdot 100(\%)$
Normalized value of X to W:	$R = (Y/W) \cdot 100(\%)$

The difference in duration between the singular and plural form for the values W, X, P, Q and R was examined via t-tests. Tables 2.1, 2.2, 2.3, 2.4 and 2.5 give the results for the above values. The values with an asterisk were significant at the level $p < 0.05$ in Table 2.1, and at the level $p < 0.01$ in Tables 2.2, 2.3, 2.4 and 2.5.

3.1 Difference in duration of nouns in the combined form (W) (Table 2.1 and Figs. 2.1, 2.2, 2.3)

When the governing noun was /mumhē/, the mean duration (W)

for the six kinds of governed nouns was 1048 msec for the singular form of /mumḥé/ (19 cases), and 970 msec for the plural (22 cases). The difference in duration between the singular and plural forms for the values (W) was significant at the level $p < 0.05$. The duration (W) was longer in the singular form of the governing nouns than that in the plural regardless of the type of word-initial consonant.

When the governing noun was /maíasé/, the mean duration (W) for the six kinds of governed nouns was 1010 msec for the singular form of /maíasé/ (19 cases), and 997 msec for the plural (19 cases). The difference in duration between the singular and plural forms for the values (W) was not significant at the level $p < 0.05$.

When the governing noun was /mexabé/, the mean duration (W) for the six kinds of governed nouns was 991 msec for the singular form of /mexabé/ (19 cases), and 1012 msec for the plural (34 cases). The difference in duration between the singular and plural form for the values (W) was not significant at the level $p < 0.05$.

The mean duration (W) for the three kinds of governing nouns was 1079 msec for the singular form (57 cases), and 1023 msec for the plural (75 cases) in the case of /bat/. The difference in duration between the singular and plural forms for the values (W) was significant at the level $p < 0.05$.

3.2 Duration of the word-final vowel /e/ for governing nouns in the construct state (X) (Table 2.2 and Figs. 2.1, 2.2, 2.3)

When the governing noun was /mumḥé/, the mean duration (X) for the six kinds of governed nouns was 126 msec for the singular form of /mumḥé/ (19 cases), and 166 msec for the plural (22 cases). When the governing noun was /maíasé/, it was 102 msec for the singular form of /maíasé/ (19 cases), and 154 msec for the plural (19 cases). When the governing noun was /mexabé/, 119 msec for the singular form of /mexabé/ (19 cases), and 157 msec for the plural (34 cases). For any governing noun, the mean duration (X) for the six governed nouns was longer in the plural form of governing noun than that in the singular. For any governed noun, the mean duration (X) for the three kinds of governing nouns was longer in the plural form of the governing noun than in the singular. The difference in duration between the singular and plural forms for the values (X) was significant at the level $p < 0.01$.

3.3 Normalized values of the word-final vowel /e/ for governing nouns in the combined form (P)(%) (Table 2.3 and Figs. 2.1, 2.2, 2.3)

When the governing noun was /mumḥé/, the normalized value (P) for the six kinds of governed nouns was 12.0% for the

singular form of /mum^hé/ (19 cases), and 17.1% for the plural (22 cases). When the governing noun was /maíasé/, it was 10.1% for the singular form of /maíasé/ (19 cases), and 15.5% for the plural (19 cases). When the governing noun was /mexabé/, it was 12.0% for the singular form of /mexabé/ (19 cases), and 15.5% for the plural (34 cases). For any governing noun, the mean value (P) for the six governed nouns was longer in the plural form of the governing noun than that in the singular. For any governed noun, the mean value (P) for the three kinds of governing nouns was longer in the plural form of governing noun than in the singular. The difference in duration between the singular and plural forms for the values (P) was significant at the level $p < 0.01$.

3.4 Normalized values of the word-final vowel /e/ for governing nouns to governing noun (Q)(%) (Table 2.4 and Figs. 2.1, 2.2, 2.3.)

When the governing noun was /mum^hé/, the normalized value (Q) for the six kinds of governed nouns was 29.1% for the singular form of /mum^hé/ (19 cases), and 37.5% for the plural (22 cases). When the governing noun was /maíasé/, it was 23.3% for the singular form of /maíasé/ (19 cases), and 32.9% for the plural (19 cases). When the governing noun was /mexabé/, it was 26.6% for the singular form of /mexabé/ (19 cases), and 32.0% for the plural (34 cases). For any governing noun, the mean value (Q) for the six governed nouns was longer in the plural form of the governing noun than that in the singular. For any governed noun, the mean value (Q) for the three kinds of governing nouns was longer in the plural form of the governing noun than in the singular. The difference in duration between the singular and plural forms for the values (Q) was significant at the level $p < 0.01$.

3.5 Duration of governing nouns in the construct state (R)(Table 2.5 and Figs. 2.1, 2.2, 2.3)

When the governing noun was /mum^hé/, the normalized value (R) for the six kinds of governed nouns was 41.4% for the singular form of /mum^hé/ (19 cases), and 45.5% for the plural (22 cases). When the governing noun was /maíasé/, it was 43.4% for the singular form of /maíasé/ (19 cases), and 47.0% for the plural (19 cases). When the governing noun was /mexabé/, it was 45.3% for the singular form of /mexabé/ (19 cases), and 48.4% for the plural (34 cases). For any governing noun, the mean value (R) for the six governed nouns was longer in the plural form of the governing noun than that in the singular. For any governed noun, the mean value (R) for the three kinds of governing nouns was longer in the plural form of the governing noun than in the singular. The difference in duration between the singular and plural forms for the values (R) was significant at the level $p < 0.01$.

4. Discussion

The common phonological feature between the singular and plural forms of the three nouns used as governing nouns is the word-final /e/, while there are two descriptive vowel signs, $\overline{\text{ה}}$ (šere malé) and ְ (šere malé) for this phoneme /e/ previously. It has not been made clear whether there is some difference in speech between these two signs though they are classified in the same category, 'šere malé', in Hebrew phonology¹⁹⁾. The duration of vowels may be a distinctive feature to differentiate the plural form from the singular of nouns in /smixút/, if the difference is significant between them in terms of the duration of the word-final /e/.

In this study, the duration of nouns in construction (the combined form) was about 1 msec. It was significantly longer in singular nouns than in the plural in /mumħe/, while it was shorter in singular nouns than in the plural in /mexabé/ (Table 2.1 and Figs. 2.1, 2.2, 2.3). It seems that the duration of nouns in construction (combined form) depends on the syllable-structure and consonants included.

When any of the three governing nouns was used with any of the six example governed nouns, the mean duration (X) and its normalized values (P),(Q) and (R)s were longer in the plural form of the governing noun than that in the singular. The difference in duration between the singular and plural forms for each of the values (X),(P),(Q) and (R) was significant at the level $p < 0.01$.

According to phonological and morphological studies of Hebrew language, vowel length is not supposed to be distinctive but is longer in accented syllables than in unaccented ones²⁰⁻²²⁾. It is a moot question whether or not, and to what extent, length is distinctive in Biblical Hebrew²³⁾. The vowel signs were designed to indicate the quality (sound) of the vowels, not their quantity (duration in speech)^{18,20,22)}. It seems that the duration of vowels in Hebrew is controlled by the stressed syllable of the word¹⁷⁾.

The results of this study seem to show that the subject distinguishes two word-final vowels /e/, one for the singular and another for the plural, of governing nouns in her speech. The two descriptive vowel signs of 'šere malé' for word-final vowel /e/ correspond to the differentiation of the duration of these vowels: the duration of the vowel corresponding to $\overline{\text{ה}}$ is shorter than that corresponding to ְ . Since only one subject was available, the number of speech samples were increased here.

The singular form of governing nouns has stress on the word-final vowel /e/ in the absolute state. It is possible to assume that secondary stress remains there even if main stress is lost because the state of the noun changes from the 'absolute' to the 'construct'. The evidence that the difference in duration between the singular and plural forms for word-final /e/ suggests a new

way to understand the stress-structure of the construct state¹⁷⁾. It is very important to comprehend the structure of the construct state in Hebrew to know the ratio of the duration of governing nouns to that of nouns in the combined form (in construction). The values (R) were between 39.7% for /mumḥepát/ and 49.7% for /mexabebát/ or /mexabedát/ (Table 2.5 and Figs. 2.1, 2.2, 2.3). It must be remarked that each ratio of the duration of governed noun to nouns in the combined form was greater than 50% in this study.

5. Conclusion

The duration of word-final vowels of nouns in the construct state was measured using actual speech for masculine singular nouns, the word-final vowels of which is phoneme /e/ with the descriptive vowel sign of םֿ (segol malé) in the absolute state. A difference was found in the duration of vowels between the singular and plural forms in the construct state. The duration of the vowels in question was longer in the plural form than in the singular for both mean and the normalized values not only in the combined form but also in governing nouns. The duration of word-final vowels in the construct state may be a distinctive feature to differentiate the plural from the singular of nouns with word-final vowel םֿ /e/ whose descriptive vowel sign is in the absolute state in Hebrew; the longer corresponds to the descriptive vowel sign of םֿֿ (šere malé) for the plural, while the shorter corresponds to םֿֿֿ (šere malé) for the singular.

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Table 1 Test words (by phonemic transcription)

	Absolute form (singular)	Construct state (singular)(plural)	Meaning
Governing nouns	Hebrew letters		
/mum ^h é/	מִמְחָה	מִמְחָה מִמְחֵי	expert
/ma ^e asé/	מַעֲשֵׂה	מַעֲשֵׂה מַעֲשֵׂי	deed
/mexabé/	מִכְבֵּה	מִכְבֵּה מִכְבֵּי	extinguisher
Governed nouns	Meaning		
/bát/	daughter		
/gát/	wine-press		
/dát/	faith, religion		
/kát/	sect		
/pát/	a piece of bread		
/tát/	Jewish religious school		

Construction forms consisted of three governing nouns and six governed nouns.

/mum^hebát/ /mum^hegát/ /mum^hedát/ /mum^hekát/ /mum^hepát/ /mum^hetát/
 /ma^easebát/ /ma^easegát/ /ma^easedát/ /ma^easekát/ /ma^easepát/ /ma^easetát/
 /mexabebát/ /mexabegát/ /mexabedát/ /mexabekát/ /mexabepát/ /mexabetát/

(Both the word-final vowels of the singular and plural forms of governing nouns are /e/.)

Table 2 Duration of the word-final vowel /e/ of governing nouns of construction form.

2.1 Duration of the construction form(msec)									
Governing nouns		Governed nouns							
		/bat/	/gat/	/dat/	/kat/	/pat/	/tat/	average	
/aueño/	(s)	1116	1029	1067	1003	1056	1025	1048*	
(sample)	3	4	3	3	3	3	3	19	
(pl)	1035	951	980	963	963	937	969	970*	
(sample)	3	4	4	3	4	4	4	22	
/ma'aso/	(s)	1070	1003	999	986	999	1006	1010	
(sample)	3	3	4	3	3	3	3	19	
(pl)	1056	995	964	1037	998	998	946	997	
(sample)	3	3	4	3	3	3	3	19	
/mexabo/	(s)	1051	981	987	996	978	954	991	
(sample)	3	4	3	3	3	3	3	19	
(pl)	1005	989	1027	1042	997	1018	1012	1012	
(sample)	7	5	4	6	7	5	5	34	
average	(s)	1079*	1004	1016	995	1010	995		
(sample)	9	11	10	9	9	9	9		
(pl)	1023*	978	990	1021	980	984			
(sample)	13	12	12	12	14	12			

*) significant at p<0.05

2.2 Duration of the word-final vowel /e/ of governing nouns (msec)

Governing nouns		Governed nouns							
		/bat/	/gat/	/dat/	/kat/	/pat/	/tat/	average	
/aueño/	(s)	128	119	118	146	125	122	128*	
(pl)	178	153	177	173	157	161	166*		
/ma'aso/	(s)	100	106	102	97	97	110	102*	
(pl)	169	148	151	156	155	149	154*		
/mexabo/	(s)	115	116	117	125	131	112	119*	
(pl)	150	146	167	160	167	164	157*		
average	(s)	114*	115*	111*	122*	118*	114*		
(pl)	161*	169*	165*	162*	157*	159*			

2.3 Normalized duration of the word-final /e/ to the construction form(%)

Governing nouns		Governed nouns							
		/bat/	/gat/	/dat/	/kat/	/pat/	/tat/	average	
/aueño/	(s)	11.5	11.6	11.1	14.6	11.9	11.9	12.0*	
(pl)	17.2	16.2	18.0	17.9	16.7	16.6	17.1*		
/ma'aso/	(s)	9.4	10.6	10.2	9.8	9.7	10.9	10.1*	
(pl)	15.9	14.9	15.7	15.0	15.5	15.7	15.5*		
/mexabo/	(s)	10.9	11.9	11.8	12.5	13.3	11.7	12.0*	
(pl)	14.9	14.8	16.3	15.3	15.8	16.2	15.5*		
average	(s)	10.6*	11.4*	11.0*	12.3*	11.6*	11.5*		
(pl)	15.7*	15.3*	16.7*	15.9*	16.0*	16.2*			

*) significant at p<0.01

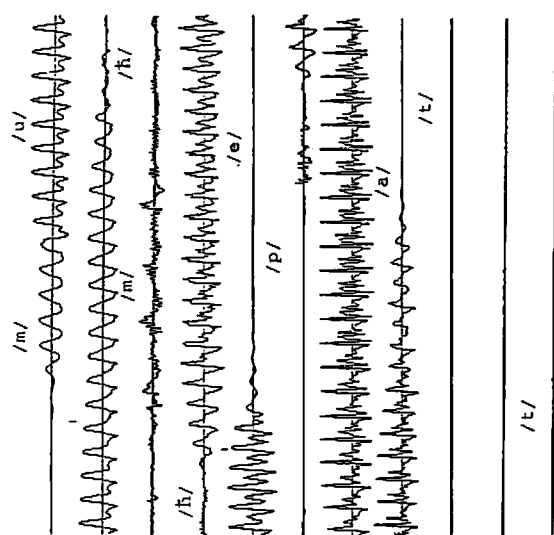


Fig. 1.1. Wave form for /aunhópá/ (/aunhópá/ : singular).

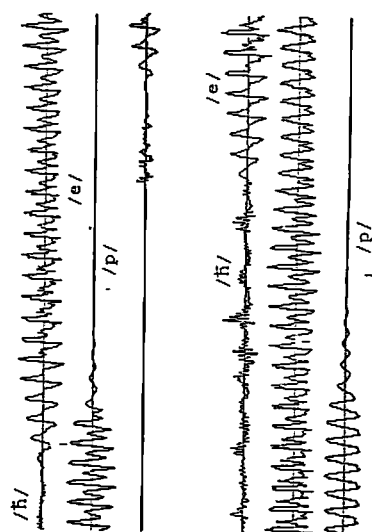


Fig. 1.2. Wave form for /a/ in /aunhópá/.

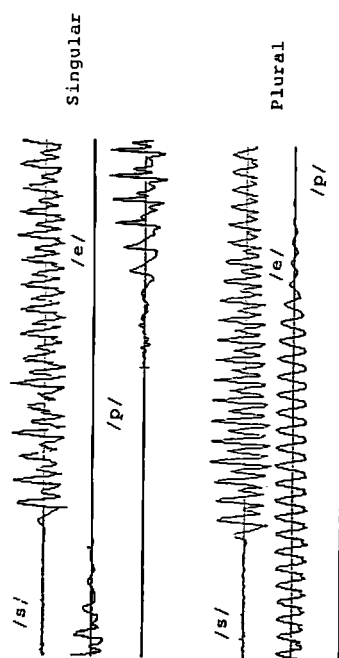


Fig. 1.3. Wave form for /e/ in /matasepát/.

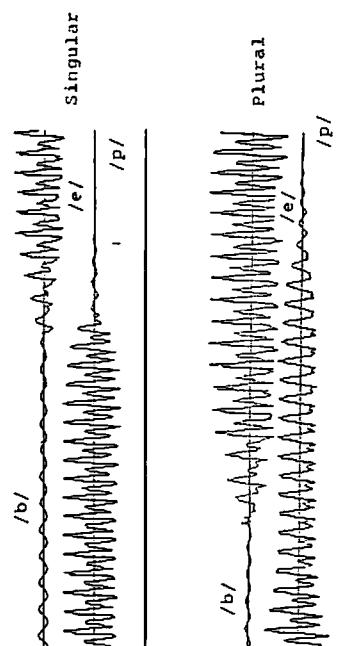


Fig. 1.4. Wave form for /o/ in /acxabópát/.

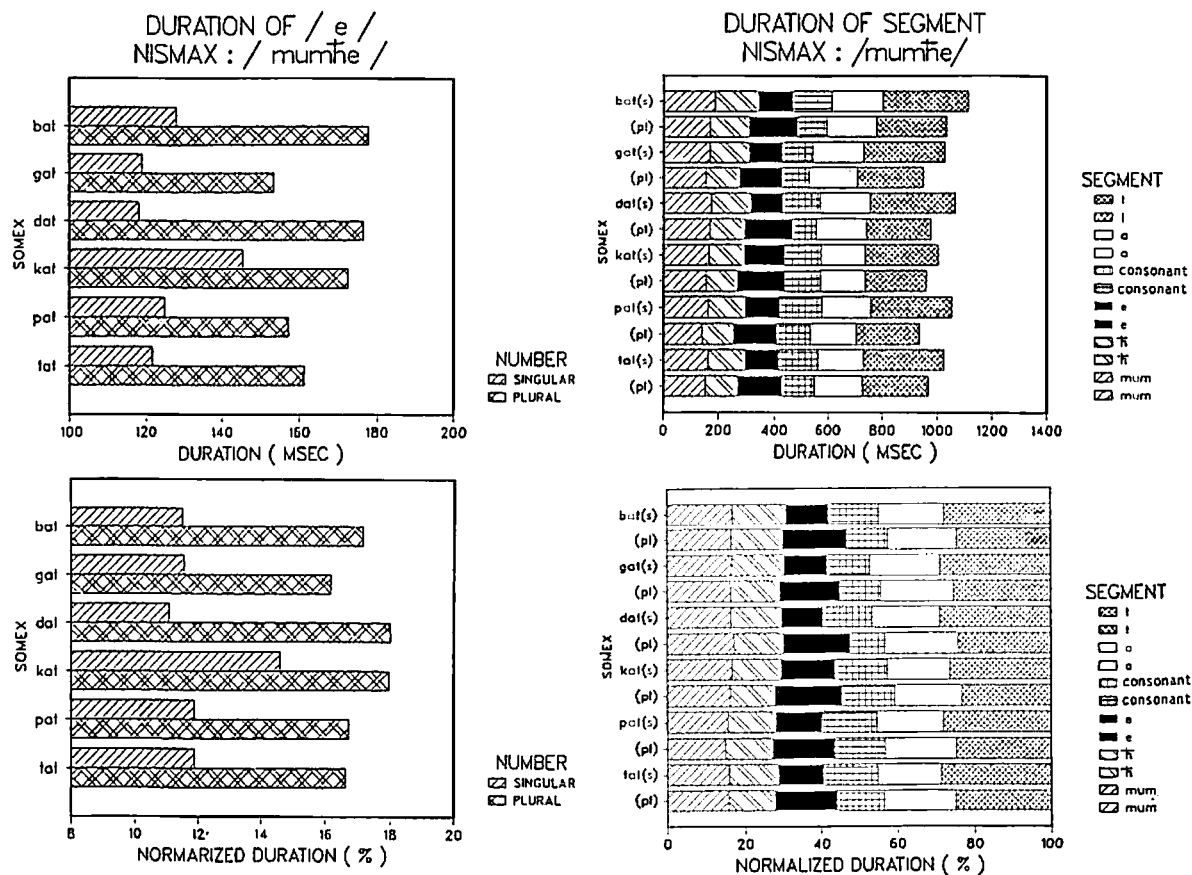


Fig. 2.1 Duration of the word-final vowel /e/ of /mumheCat/ (C:consonant) and its normalized value to the construction form (left-top & left-bottom). The duration of the construction form and normalized duration of consonants and vowels to the construction form (right-top & right-bottom). s:singular, pl:plural

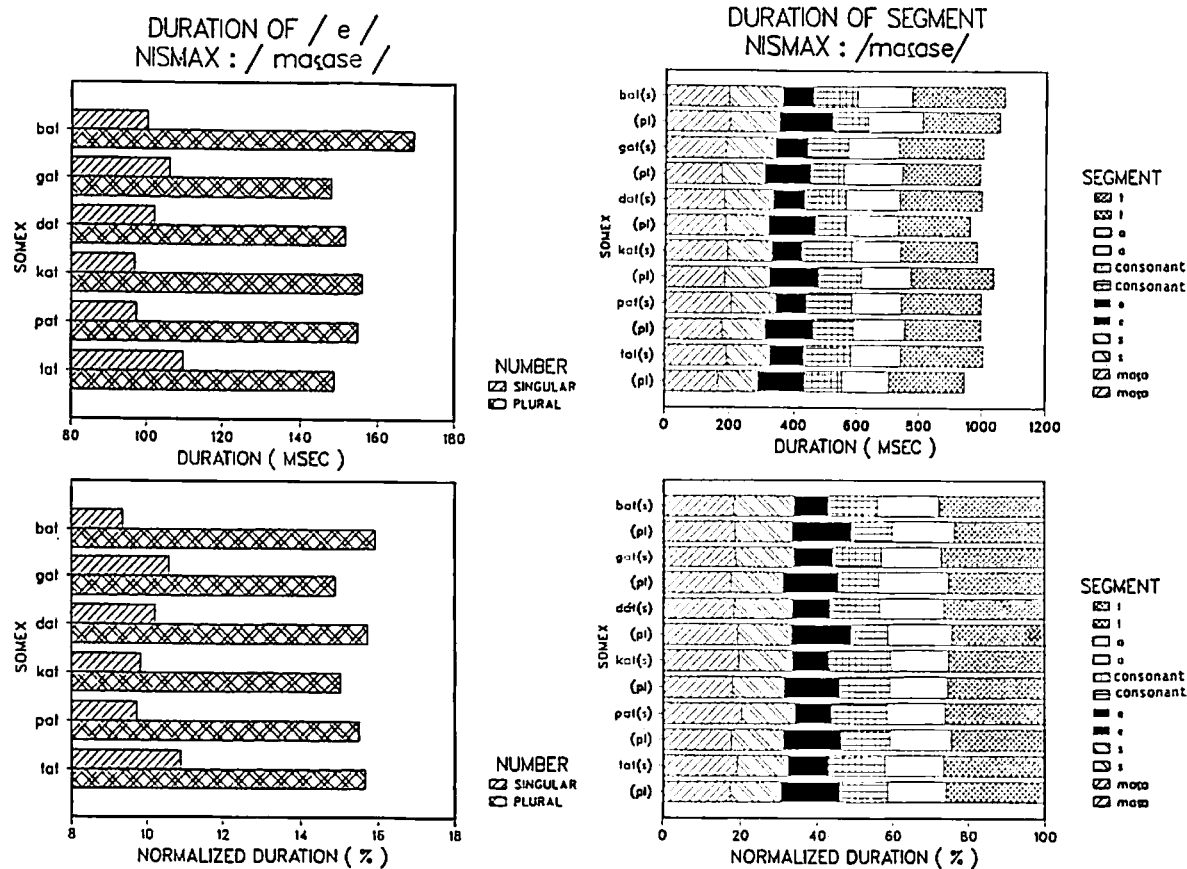


Fig.2.2 Duration of the word-final vowel /e/ of /maɣase/ (C:consonant) and its normalized value to the construction form (left-top & left-bottom). The duration of the construction form and normalized duration of consonants and vowels to the construction form (right-top & right-bottom). s:singular, pl:plural

DURATION OF / e /
NISMAX : / mexabe /

SOMEX

NUMBER
SINGULAR
PLURAL

DURATION (MSEC)

Syllable Type	Condition	Number	Duration (msec)
bat	NISMAX	Singular	~115
		Plural	~150
gat	NISMAX	Singular	~115
		Plural	~145
dat	NISMAX	Singular	~115
		Plural	~165
kat	NISMAX	Singular	~125
		Plural	~155
pat	NISMAX	Singular	~135
		Plural	~155
tat	NISMAX	Singular	~110
		Plural	~165