

FORMANT FEATURES OF HEBREW VOWELS

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1. Introduction

I previously discussed the following two problems using experimental data from modern Hebrew: the relationship between the duration of vowels and the concepts of the so-called "long vowel", "short vowel" and "mobile sheva" as phonological vowel signs; and the relationship between the syllable on which stress falls and the duration of vowels within a word¹). The present study discusses the quality of Hebrew vowels in terms of F1 and F2.

2. Design

Four word roots, a carrier sentence, two verbs with inflections and two segolate nouns were prepared as follows.

- 1) Root: gvr, mtg, ktv, hyh
- 2) Carrier sentence: /zo:t#hamila:/
- 3) QAL verb:

Root: ktv

1	KOOTEV	2	KOOTEVET	3	KOOT*VIIM	4	KOOT*VOOOT
5	KAATAVTTII	6	KAATAVTTAAH	7	KAATAVTT	8	KAATAV
9	KAAT*VAAH	10	KAATAVNUU	11	K*TAVTTEM	12	K*TAVTTEH
13	KAAT*VUU						

Root: hyh

1	HAAYIITII	2	HAAYIITAAH	3	HAAYIIT	4	HAAYAAH
5	HAY*TAAH	6	HAAYIINUU	7	H*YIITEM	8	H*YIITEN
9	HAAYUU						

- 4) Segolate nouns:

m t g	METEG	/meteg/	M*TAAGIIM	/m*tagi:m/
g v r	GEVER	/gever/	G*VAARIIM	/g*vari:m/

Here, the capital letters are for convenience utilized to transcribe the vowel signs in Hebrew. The vocalization signs are transcribed as follows:

pataḥ:A, qamaṣ:AA, segol:E, šere:EE, ḥiriq malee:II, ḥolam:OO, ḥolam malee:OOO, šuruq:UU, sheva na':(*), qamaṣ followed by quasi-vowel H of word final:AAH (/a:/) ,

- 5) Five sustained five vowels: /a/, /e/, /i/, /o/, /u/

3. Procedure and method

The subjects were three female, native speakers of Israeli Hebrew. They read the test words in the carrier sentence /zo:t#hamila:/, meaning "It is the word", at a normal tempo in terms of their speech three times. The recording was performed in an anechoic studio, and the speech sound was then analyzed with an LPC analysis program²). The results were then processed by a SPSS program on the VAX-11/780 System.

4. Results and discussion

4.1 Vowels in words

Table 1 and Fig. 1 give the frequencies of F₁ and F₂ of the Hebrew vowels in the carrier sentence and the test words for subject S.A. Fig. 2 and Fig. 3 give the F₁-F₂ diagrams for certain vowels in "segolate" nouns with the roots "mtg" and "gvr" respectively.

Fig. 2 gives the formants for the four vowels of METEG (E₁ and E₂ are the first and the second vowels respectively.) and M*TAAGIIM. It was apparent that the frequencies of F₂ for E₁, E₂, "sheva na'" and AA were almost the same at 2kHz. The F₁ of "sheva na'" was a little bit lower than that of E₁ and E₂, but the F₁ of AA was more or less higher. the F₁ of E₁ and that of E₂ were almost the same. It seems that the height of the tongue at the articulation of "sheva na'" and the vowel AA (/a/) was almost similar to that of /e/, while the shape of the vocal tract in terms of constriction was similar to that of /u/, but not of /e/.

Fig. 3 gives the formants of four vowels for the GEVER (E₁ and E₂ are the first and the second vowels /e/ respectively.) and G*VAARIIM. Contrary to the case of root "mtg", the F₂ of "sheva na'" and the vowel AA were different from that of E₁ and E₂. Table 1 shows that the F₂ of "sheva na'" was lower by about 500 Hz than that of E₁(/e/) and E₂(/e/). The F₁ of "sheva na'" was lower than that of E₁ and E₂, while the F₁ of AA was more or less higher. The F₁ of E₁ and that of E₂ were almost the same. It seems that the height of the tongue at the articulation of "sheva na'" is a bit higher than /e/, while the shape of the vocal tract in terms of constriction was similar to that of /o/.

previous studies concerning the Hebrew language have not sufficiently mentioned the details of the quality of "sheva na'" in actual speech³⁻⁶). It seems inadequate to regard the sound of "sheva na'" as [e] or [ə]^{3,4,6}).

Table 1: Frequencies of F1 and F2 for Hebrew vowels in sentences and words. Subject: S.A.

<u>Vowel</u>	<u>No.</u>	<u>F1 (Hz)</u>	<u>S.D.</u>	<u>F2 (Hz)</u>	<u>S.D.</u>
/a/	1044	510	174	1582	205
/e/	202	439	80	2006	162
/i/	484	340	84	2221	331
/o/	365	371	69	1521	186
/u/	92	303	86	1075	371
Sheva na' (mtg)	65	269	35	2017	144
Sheva na' (gvr)	26	323	29	1482	132

Table 2 Frequencies of F1 and F2 for sustained Hebrew vowels.

1. Subject: N.Z.

<u>Vowel</u>	<u>No.</u>	<u>F1 (Hz)</u>	<u>S.D.</u>	<u>F2 (Hz)</u>	<u>S.D.</u>
/a/	132	719	25	1356	54
/e/	196	482	23	1908	67
/i/	163	335	21	2112	58
/o/	145	499	25	1021	33
/u/	264	372	43	851	74

2. Subject: N.F.

<u>Vowel</u>	<u>No.</u>	<u>F1 (Hz)</u>	<u>S.D.</u>	<u>F2 (Hz)</u>	<u>S.D.</u>
/a/	135	941	18	1413	31
/e/	383	503	40	2353	68
/i/	209	325	17	2694	38
/o/	241	547	52	940	38
/u/	266	406	11	781	43

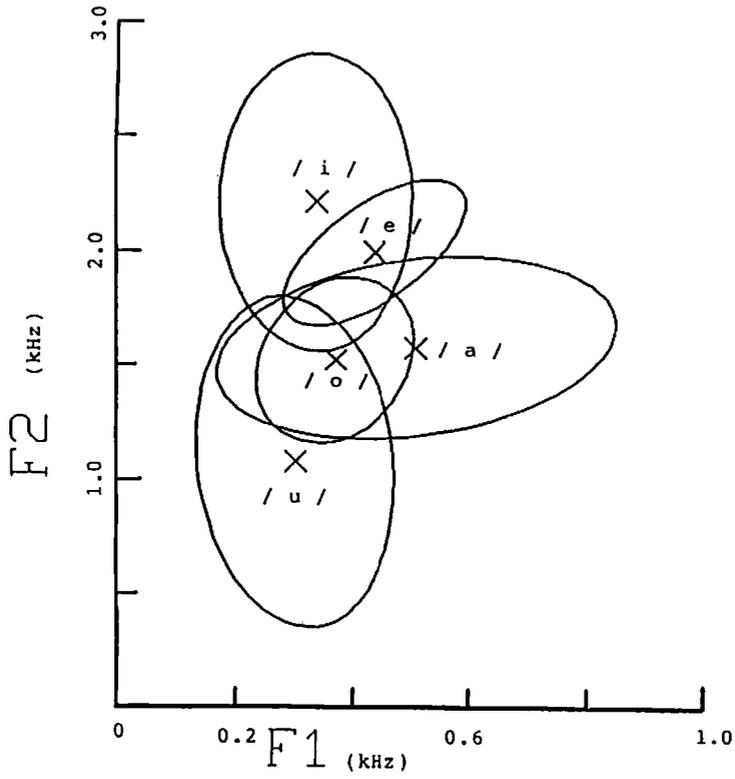


Fig. 1 F₁-F₂ diagram of the five vowels in modern Hebrew.

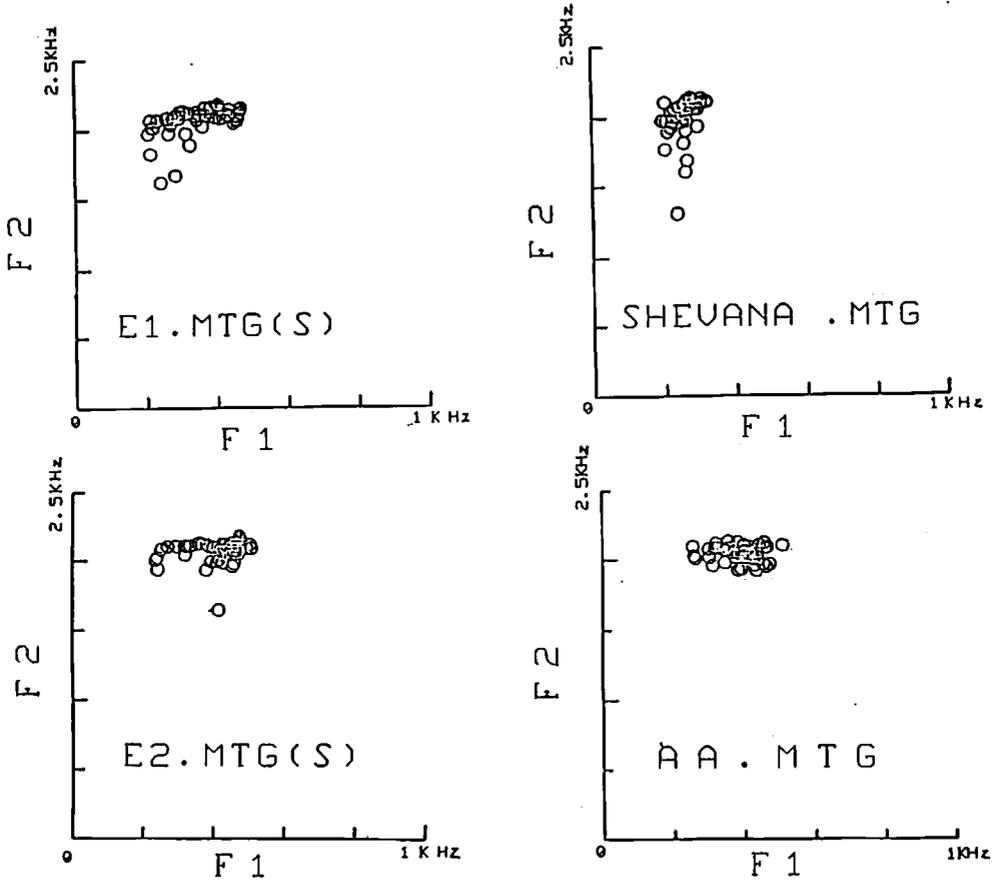


Fig. 2 F₁-F₂ diagram of the vowels of modern Hebrew in a segolate noun for the root "mtg".

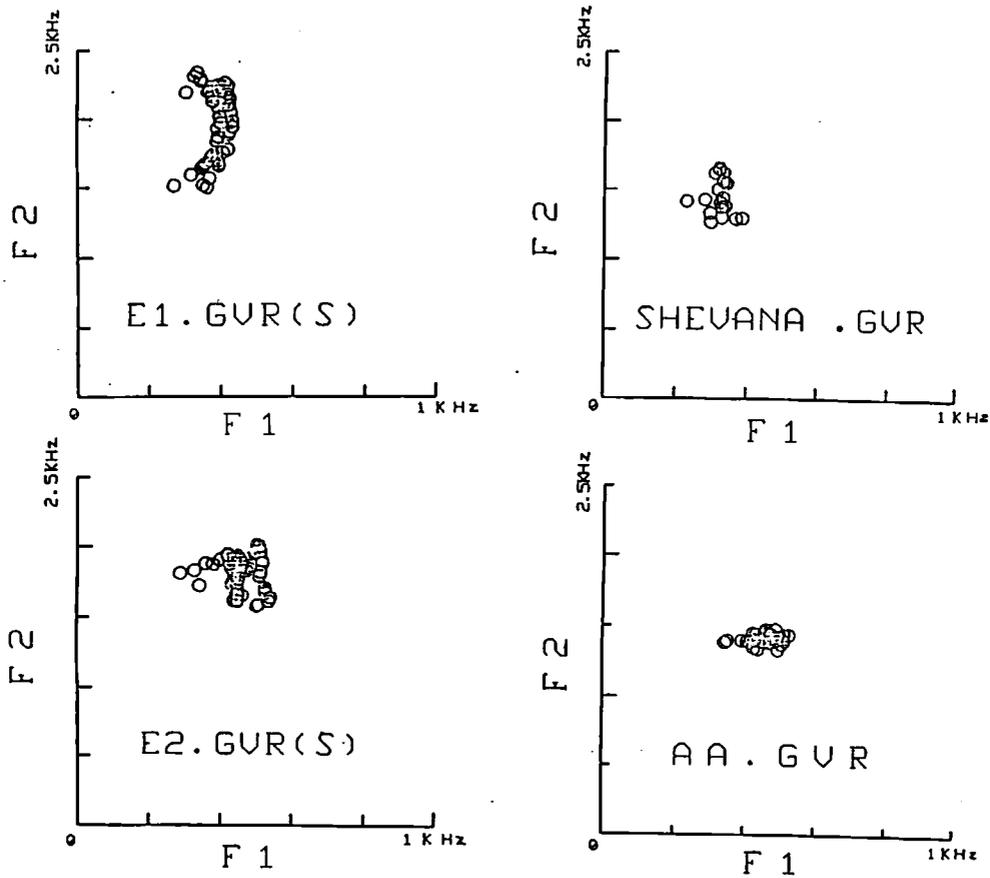


Fig. 3 F₁-F₂ diagram of the vowels of modern Hebrew in a segolate noun for the root "gvr".

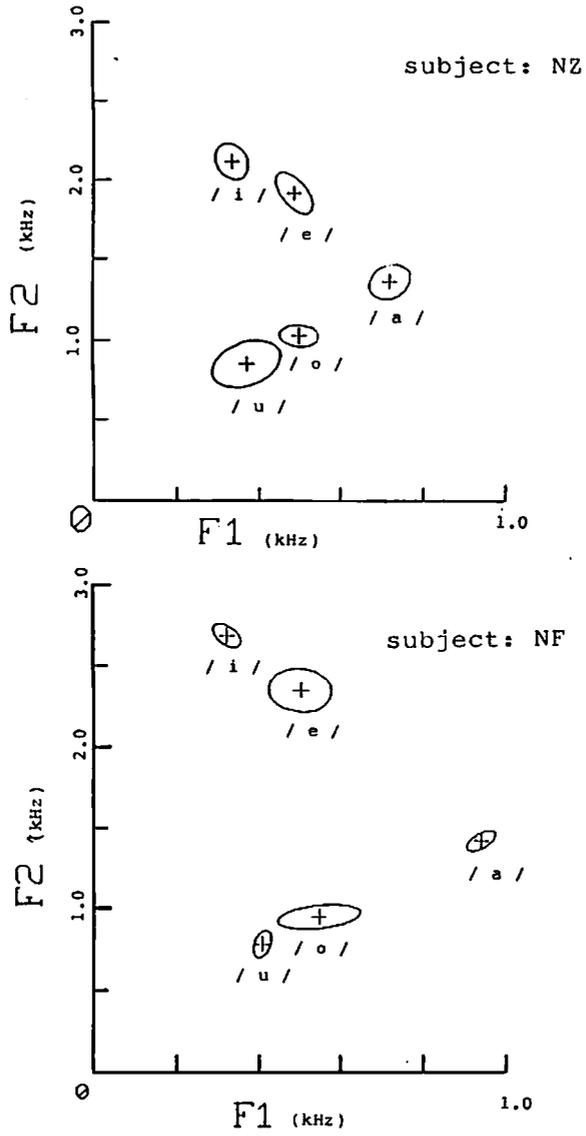


Fig. 4 F₁-F₂ diagram of the five Hebrew vowels.

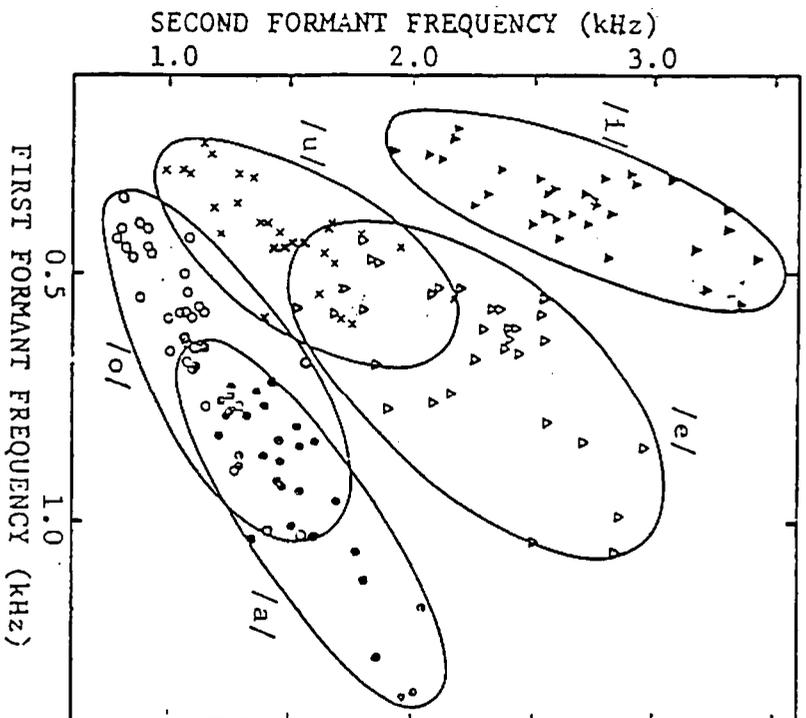


Fig.5 F₁-F₂ diagram of the five Japanese vowels.

4.2 Five sustained vowels

Table 2 and Fig. 4 give the frequencies of F1 and F2 for the five Hebrew vowels by subjects NZ. and NF., respectively. As for relationship between the vowels in terms of the frequencies of F1 and F2, /i/ was closer to /e/, and /u/ was closer to /o/ in the articulation of vowels separately. On the other hand, Fig. 1 shows that /u/ and /o/, /o/ and /a/ and /e/ and /i/ overlapped by more than 95% of a probable ellipse in the articulation of words and sentences.

Comparing the vowels of Hebrew with those of Japanese⁷⁾, it became clear that there was a remarkable difference between the vowels /u/. In Hebrew the F1 of /u/ was 406 Hz for subject NZ. and 372Hz for subject NF. The F2 of /u/ was 851 Hz for subject NZ., and 781 Hz for subject NF. In Japanese, however, the F2 of /u/ is approximately 1500Hz (Fig. 5). Though the F2 of /o/ is lower than the other five vowels in Japanese^{7,8)}, the F2 of /u/ is lower than the other five vowels in Hebrew (Fig. 1, 4, and 5).

5. Conclusion

The formant of "sheva na^o" does not always have the quality of [e] or [ə]. The vowel quality of "sheva na^o" fluctuates according to the consonants which precede or follow the "sheva na^o" it.

The formant of the Hebrew vowel /u/ is remarkably different from that of the Japanese vowel /u/. The frequency of the F2 of /u/ in Hebrew is 780-850Hz, while that of the F2 of /u/ in Japanese is approximately 1500Hz.

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