The Prosody of Modern Hebrew - A Quantitative Study

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Abstract

The current paper presents a preliminary study of Modern Hebrew prosody using a quantitative model. In a small corpus of segmentally identical utterances the place of focus and sentence mode were systematically varied. Following the rationale of MFGI, the Mixdorff-Fujisaki Model of German intonation, the phonetic properties of the contrast lending intonemes were examined. These properties are remarkably similar to those of German: The place of focus is marked by high accent command amplitudes and reduction of post-focal accents whereas pre-focal accents remain almost unaffected. Questions and non-terminal utterances are marked by rising intonation on the last accented item.

1. Introduction

The application of quantitative models in the study of prosody has become widely adopted. One problem arising when examining languages that have been less investigated than English, German or French, for instance, is how to properly adapt the methodology developed for these 'well-known' languages, as most of the models are based on assumptions concerning the particular language for which they were created.

The present study applies the methodology developed by Mixdorff for German to the analysis of Modern Hebrew (MH). The Mixdorff-Fujisaki model of German Intonation (MFGI) utilizes the Fujisaki formula [2] for parametrizing a given *F0* contour. Resulting parameters are then related to intonational events, so-called 'intonemes', which define intonational contrasts in a language. Since the Fujisaki model is per-se production-oriented and physiologically motivated, it is applicable to all languages, though the functions of model components may vary depending on the particular language.

Hebrew belongs to the North-Central branch of the semitic family of languages. It strongly resembles Aramaic and Arabic, sharing many linguistic features with them. Hebrew is currently spoken by a community of about 10 million people, of whom about 5 million live in the State of Israel, and the rest in the various countries of the Jewish diaspora. Hebrew is one of the three official languages of Israel, alongside with English and Arabic.

Hebrew was not used as a spoken language for about 2300 years, but was revived by the efforts of Eliezer Ben-Yehuda (1858-1922) who emigrated to Palestine in 1881. Motivated by the ideal of renovation and the rejection of the diaspora lifestyle, Ben-Yehuda developed a new language that the Jews could use for everyday communication. A Committee of the Hebrew Language was established. Later it became the Academy of the Hebrew Language, an organization that stills exists today. MH incorporates influences from Russian, English and Arabic.

The metrical system of MH displays a lexical accent system, where main stress assignment is a result of the interaction between lexical properties of the stem and lexical properties of the affix. In the case that no lexical properties are specified for stem and/or suffix, a general stress rule is activated, which assigns stress to the rightmost accentable syllable. Therefore word-final stress is the phonological “default” stress [3].

The current study is not concerned with the rules of the lexical accent system of MH, but the manifestation of accents in the prosodic parameters. As MFGI is based on the importance of accented syllables as anchor points for the *F0* contour in the sense that major rises and falls - so-called 'tone switches' - are closely linked to accented syllables the attempt will be made to apply this paradigm to MH.

The intonational description in MFGI distinguishes between three major types of intonemes: Declarative-final falls (Information Intonemes I↓), question-final rises (Contact Intonemes C↑) and non-terminal rises (Non-terminal Intonemes N↑). The phonetic properties of these intonemes are quantified using the Fujisaki model by aligning accent command onsets and/or offsets with accented syllables.

2. Speech Material and Method of Analysis

In order to examine the prosodic properties of MH, a small corpus was created. The sentence "Amarti lahem lavoh" - *"I told them to come"* was uttered with several different connotations by a single native speaker of MH five times altogether. In the following the conditions examined are listed. The underlying context is given in brackets with narrowly focused items set in bold type.

1. Neutral declarative (broad focus)
2. Declarative, narrow focus on "amarti" (I **told** them to come, but they forgot about it)
3. Declarative, narrow focus on "lahem" (I told **them** to come, not their friends)
4. Declarative, narrow focus on "lavoh" (I told them to **come**, not to go home)

5. Echo-question, broad focus
6. Echo-question, narrow focus on "lahem". (Is it true that I told **them** to come, not their friends ?)
7. Neutral non-terminal, followed by an additional phrase: "Amarti lahem lavoh aval hem lo ratzu."-*"I told them to come, but they didn't want to."*
8. Neutral non-terminal, followed by two additional phrases: "Amarti lahem lavoh aval hem lo ratzu ki hem ratzu lalexet lemakom axer."-*"I told them to come, but they didn't want to because they wanted to go to a different place."*

The utterances were checked for consistency with the intended message by informal listening. A trained phonetician produced a coarse SAMPA transcription and syllabification of the sentence 'amarti lahem lavo' as [a-ˈmal-tI-leIm-la-ˈvo]. The second and third phrase (context 8) was transcribed as [va-lEm-ˈlo-ra-ˈtsu][kim-ra-ˈtsu-la-ˈlE-xIt-l@-ma-ˈkO-ma-ˈxEr]. The accents are marked for the neutral utterance.

The transcription indicates that the speaker produced certain reductions, especially in function words. The bisyllabic 'lahem' was reduced to a diphthongized monosyllabic [leIm], the leading [a] in 'aval'-*'but'* was deleted, 'ki hem' *'because they'* was reduced to [kim]. The reduction also changed the syllabification of "lemakom 'axer", as the glottal stop in the onset of 'axer' was deleted.

The *F0* contours of all examples were extracted at intervals of 10 ms and parametrized using an automatic procedure for determining the Fujisaki parameters [3]. Parameter configurations yielded were checked and if necessary corrected. The constants *Fb*, α and β were set to 91.5 Hz, 2/s and 15/s. Syllabic boundaries were marked by listening and inspection of the speech waveform and the narrow-band spectrum. The duration contour was then calculated by determining the syllabic z-score in the log duration domain.

3. Results of Analysis

3.1. Fujisaki Parameter Configurations

Figure 1 shows examples of analysis for the first six contexts of single-phrase utterances. The figures display from top to bottom: The speech waveform, the extracted (+ signs) and model generated *F0* contours (solid line), the duration contour in terms of the syllabic z-score indicated as horizontal lines of the length of the respective syllables, the SAMPA transcription, and the underlying Fujisaki parameter configuration of impulse-wise phrase commands and step-wise accent commands.

The top left panel shows an example of context 1, declarative with broad focus. We see that the *F0* contour is modeled by a single phrase command and a single accent command. The onset of the accent command is aligned with the accented syllable [mal] and the offset with the accented syllable [vo]. The relatively deep dip preceding [vo] initially suggested the existence of a separate small accent command on this syllable, but verification on an example where the labio-dental fricative was replaced by a lateral [l] showed that the dip in the *F0* contour was due to microprosodic influence. The configuration corresponds to the classical 'hat-pattern' that can be observed when two accents are relatively close to each other, one with a rising and one with a falling *F0* contour. If we now compare contexts 2 to 4 (narrow foci) with context 1 (broad focus), three main observations can be stated: Narrow focus boosts the accent command assigned to the focused item while post-focal accents are deleted. Pre-focal accents (here: the accent on [mal]) prevail and the accent command assigned to the pre-focal item concatenates with the accent command of the focused one, forming a longer melodic pattern. Especially the last property differs from German where narrow focus generally reduces tone switches at pre-focal accents as well as fully deletes tone switches on post-focal accents.

Comparison between context 1 and 5 (bottom left) shows that question intonation is marked by a steep rise on the utterance-final [vo] of more than one and a half octave. The accent command assigned to 'amarti' extends into the clitically linked 'lahem'. This configuration is disrupted when 'lahem' is narrowly focused (context 6, bottom right). The accent command assigned to 'lahem' concatenates with an even higher command on the syllable [vo]. In the framework of MFGI this additional rise at the end of an intonationally marked question is called a boundary tone B↑. The actual interval of the boundary tone is hence given by the accent command amplitude difference.

Figure 2 shows examples of two-and three phrase utterances. The parameter configuration for the non-terminal condition in the first phrase consists of an accent command assigned to the clitic group 'amarti lahem', and another command for the N↑ intoneme on 'lavo'. The numerical values of accent command amplitudes averaged over five repetitions are listed in Table 1. The arrow next to the number indicates the direction of the tone switch.

*Table 1: Mean accent command amplitude Aa for all contexts averaged over five repetitions. *) Accent command amplitude difference in the case of boundary tone B↑.*

Context	a	mal	tI	leIm	la	vo
1	0.00	0.30↑	0.00	0.00	0.00	0.30↓
2	0.00	**0.42↓**	0.00	0.00	0.00	0.00
3	0.00	0.38↑	0.00	**0.68↓**	0.00	0.00
4	0.00	0.39↑	0.00	0.00	0.00	**0.73↓**
5	0.00	0.37↑	0.00	0.00	0.00	1.42↑
6	0.00	0.71↑	0.00	**0.92↑**	0.00	0.30↑*)
7	0.00	0.38↑	0.00	0.00	0.00	0.36↑
8	0.00	0.33↑	0.00	0.00	0.00	0.36↑

Table 2: Mean syllable durations in ms for all contexts averaged over five repetitions

Context	a	mal	tI	leIm	la	vo
1	53	205	133	235	106	229
2	56	**247**	153	245	99	229
3	50	173	136	**332**	135	197
4	52	172	120	241	112	**298**
5	59	185	129	226	116	340
6	43	177	137	**323**	115	329
7	44	198	123	211	97	297
8	55	172	111	205	103	275

3.2. Syllable durations

Focal Condition. Table 2 lists the mean syllable durations for all the contexts averaged over five repetitions. The instances were a syllable is narrowly focused are indicated by bold type. In the following discussion we refer to context 1 (neutral, broad focus) as a reference. As can be seen from the figures

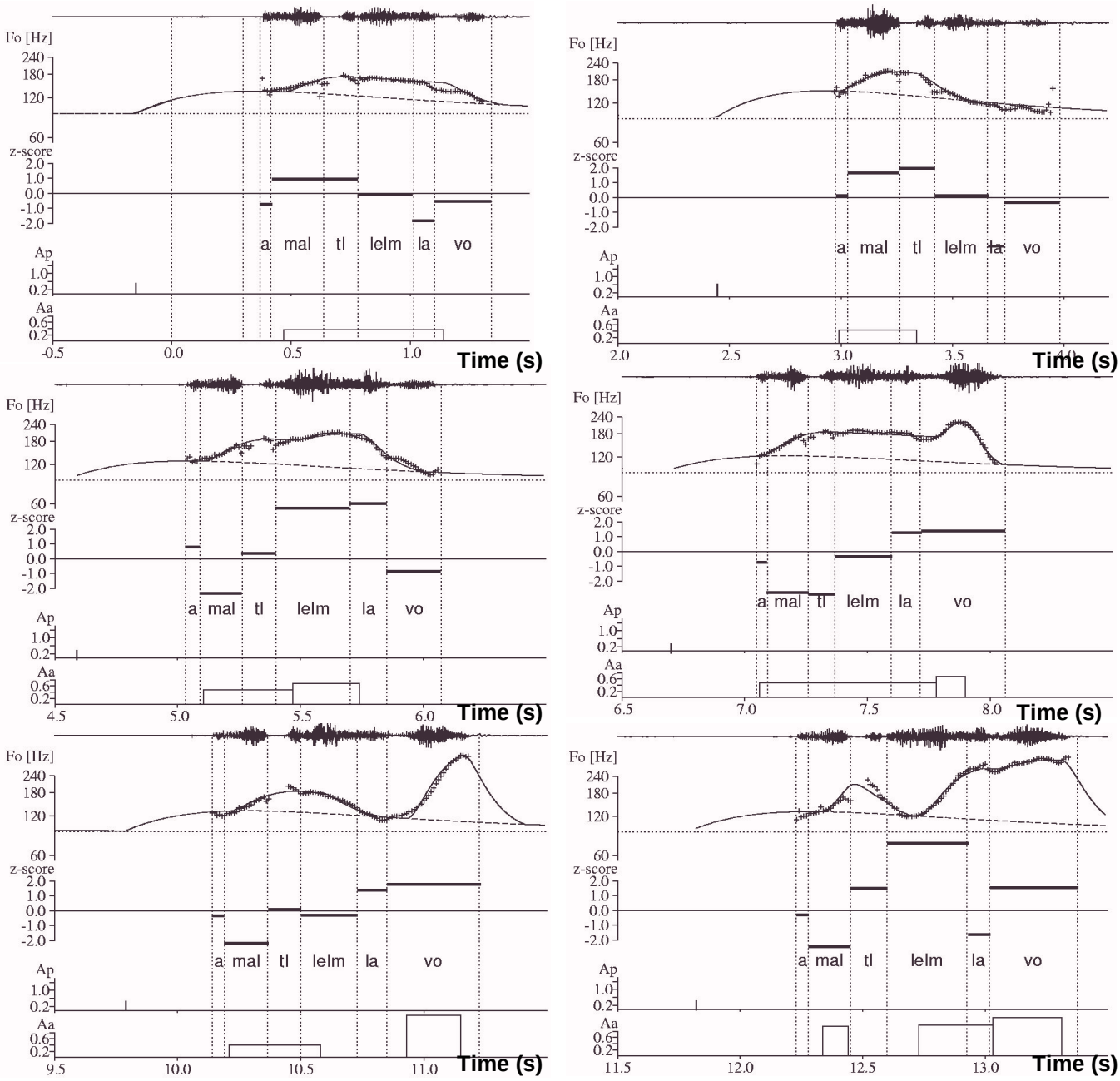

Figure 1: Examples of analysis. Declaratives: broad focus (top left), narrow focus on 'amarti' (top right), narrow focus on 'lahem' (center left), narrow focus on 'lavoh' (center right). Interrogatives: broad (bottom left), narrow on 'lahem' (bottom right).

for contexts 2, 3 and 6, narrow focusing not only increases the duration of the accented syllable, but also stretches the following syllable. Furthermore, a narrow focus in medial [leIm] and final position [vo] reduces the duration of the accentable syllable [mal] (contexts 3, 4 and 6) whereas- probably due to pre-final lengthening - a similar effect cannot be stated for the syllable [vo] when the focus is placed on [mal]. The degree to which the duration of a syllable is varied due to focusing, is not the same for the syllables [mal], [leIm] and [vo]. The usually unaccented personal pronoun 'lahem' is stretched by 41%, whereas [mal] and [vo] are lengthened only by 20 and 30%, respectively.

Sentence Mode. Questions (contexts 5 and 6) exhibit a lengthened final syllable [vo]. A similar effect can be observed under the conditions where the phrase is part of a two-phrase and three-phrase utterance (contexts 7 and 8). The average duration of the first five syllables is 146, 135 and 129 ms for single, two-phrase and three-phrase conditions, respectively, indicating a 'speeding up' in the first phrase (see also Figure 2).

4. Discussion and Conclusions

The current paper presented a small study on the prosody of Modern Hebrew. The relatively limited amount of data

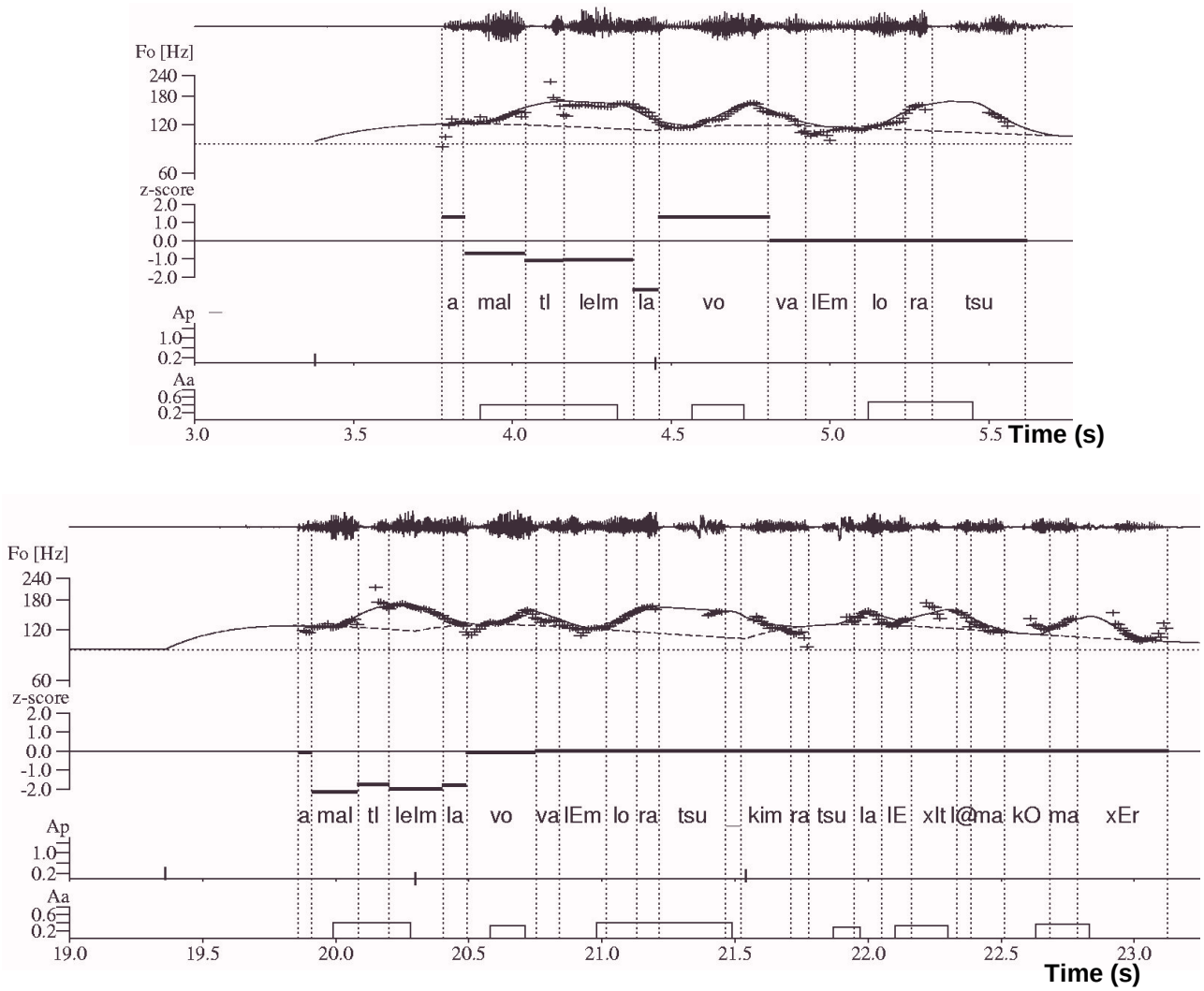

Figure 2: Examples of analysis for context 7 (top) and 8 (bottom) with two and three phrases, respectively. The syllabic z-score for the second and third phrase is set to 0, as the linguistic context in these was not varied. The first phrase final syllable [vo] exhibits pre-boundary lengthening. The onset of new phrases is aligned with the onset of a new phrase command and preceded by non-terminal rises on the syllables [vo] (contexts 7 and 8) and [lo] (context 8 only).

examined only permits tentative conclusions.

We found that the framework of MFGI for German can be readily applied, and similar intonational patterns were found in MH for the three main types of intonemes: Falls for declarative accents, rises in non-terminal position and very strong rises for question-final accents. In the case where the last syllable in a question is unaccented, a boundary tone can be observed.

Accented syllables are aligned with tone switches which are boosted in the presence of a narrow focus. Accentuation and pre-boundary effects lengthen a syllable whereas lexical accent syllables are shortened under pre-focal conditions.

Different from German, tone switches in pre-focal position do not undergo deletion in MH, but the underlying accent commands extend to and concatenate with the command assigned to the narrowly focused item. Future research will concern the analysis of data by several Israeli speakers of different cultural and language background.

5. References

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