Metathesis in Modern Hebrew: An Analysis in Articulatory Phonology

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ABSTRACT

This study proposes an account for metathesis in Modern Hebrew (henceforth Hebrew) in the framework of Articulatory Phonology (e.g. [2]). First, it is proposed that metathesis is restricted to binyan *hitpa'el*, because word-medial, hetero-morphemic clusters, which allow metathesis because of their weak gestural cohesion, occur only in this context. This was supported by the present experiment. Second, it is proposed that metathesis occurs in stop+sibilant sequences, because there is a gestural instability between the sibilant and the following vowel due to the sibilant gesture's resistance to overlap with the following vowel. Based on these proposals, a gesture-based Optimality Theoretic analysis of *hitpa'el* metathesis is proposed.

1. INTRODUCTION

Metathesis involves reversing the serial order of two segments, typically two consonants or a consonant and a vowel. In Hebrew, consonant/consonant metathesis occurs in binyan *hitpa'el*, a verb conjugation group for reflexive, reciprocal, and inchoative verbs. Metathesis occurs when the final /t/ of the prefix *hit-* is followed by a stem-initial sibilant /s/, /z/, /ʃ/, or /c/, e.g.:

(1) /hit+sarek/ → [histarek] 'he combed his hair'
(2) /hit+labeʃ/ → [hitlabeʃ] *[hiltabeʃ] 'he got dressed'

2. PREVIOUS ACCOUNT: PERCEPTIBILITY

Previously, a perceptibility-based account [7] proposed that *hitpa'el* metathesis occurs because the perceptibly vulnerable stop /t/, which has relatively weak internal or contextual cues to place or manner of articulation, shifts to an acoustically more salient prevocalic position at the expense of a perceptibly stronger fricative or affricate. However, the above example (2) poses a problem for this account. The perceptibility account wrongly predicts metathesis in this word, since /t/ should move to the more salient prevocalic position at the expense of the liquid, which is perceptibly more salient than a stop. Another critical shortcoming of the perceptibility account is that it does not account for the fact that metathesis is restricted to binyan *hitpa'el*, and non-*hitpa'el* stop+sibilant sequences do not metathesize. The proposed gesture-based analysis accounts for this fact by assuming varying cohesion of consonant gestures in different contexts. Two influencing factors of *hitpa'el* metathesis, namely position within word and morphological boundary, are discussed in the next section.

3. INFLUENCING FACTORS OF *HITPA'EL* METATHESIS

3.1 Effect of position within word

One crucial difference between stop+sibilant sequences that metathesize and those which do not is position. It is word-medial in *hitpa'el* verbs, while it is frequently word-initial in non-*hitpa'el* words, e.g.:

(3) *Hitpa'el* verb: /hit+saper/ → [histaper] 'he cut his hair'

(4) Non-*hitpa'el* verb (*pi'el* verb): /t+saper/ → [tsaper] 'you (m. sg.) will tell'

In an EPG study on American English, [4] found that onset consonant clusters are less overlapped and less variable in timing than those in coda or hetero-syllabic sequences. In an EMMA (Electromagnetic Midsagittal Articulometer) study on Georgian consonant clusters, [5] found more gestural overlap word-internally than word-initially. Following these results, greater variability in gestural timing is predicted in word-medial consonant clusters than in word-initial consonant clusters in Hebrew.

3.2 Effect of morphological boundary

Another important difference between the metathesized and the non-metathesized cluster is the presence of a morphological boundary. The cluster is hetero-morphemic in *hitpa'el* verbs, while it is mono-morphemic in other word-medial contexts, e.g.:

(5) *Hitpa'el* verb: /hit+saper/ → [histaper] 'he cut his hair'

(6) Non-*hitpa'el* verb (*hif'il* verb): /hi+tsis/ → [hitsis] 'it fermented'

In an EMMA/EPG study on Korean, [6] found that gestural timing is less variable and more stable between two gestures within-morpheme than across-morpheme. Following this result, it is assumed that variability in gestural timing is greater across-morpheme than within-morpheme in Hebrew.

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4. PROPOSED ACCOUNT: VARIABILITY IN GESTURAL TIMING

The hypothesis of the present study is two-fold, concerning why metathesis is restricted to binyan *hitpa'el*, and why it occurs in stop+sibilant sequences. First, it is hypothesized that metathesis occurs only in binyan *hitpa'el,* because it is the only environment where word-medial, hetero-morphemic clusters, which show variability in gestural timing, occur in Hebrew. Greater variability in gestural timing means that the gestures exhibit less cohesion and more flexibility [3], so as to allow a change in the gestural sequence. Second, it is hypothesized that metathesis occurs in stop+sibilant sequences, because there is a gestural instability between the sibilant and the following vowel due to the sibilant gesture's resistance to overlap with the following vowel. The second hypothesis was not tested in the present experiment. However, it will be discussed later in the proposed Optimality Theoretic analysis. The first hypothesis was tested in the following experiment.

5. EXPERIMENTAL METHODS

5.1 Material

22 Hebrew words were used as test words: (1) 6 *hitpa'el* verbs with word-medial, hetero-morphemic target clusters; (2) 8 *pi'el* verbs with word-initial, hetero-morphemic target clusters; and (3) 8 nouns and adjectives with mono-morphemic target clusters in either word-initial or word-medial position. None of the *hitpa'el* clusters were stop+sibilant, but rather were stop+stop or stop+fricative sequences. All test words were placed in a carrier phrase. The test sentences were randomized and given in the Hebrew script on sheets of paper.

5.2 Speaker

A female native speaker of Modern Hebrew from Israel participated as a subject. No history of hearing or speech impairment was reported by the speaker.

5.3 Recording

Digital recording at 44kHz was made in a sound-proof recording booth. The speaker was instructed to speak at her usual conversational speed. Six repetitions were recorded.

5.4 Analysis

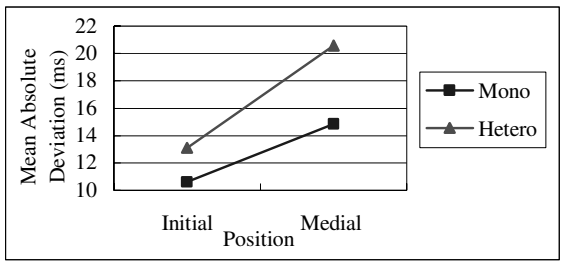
The data were analyzed using Macquirer. Onset-onset lag between C_1 and C_2, i.e. lag between C_1 onset of closure and C_2 onset of closure/frication, was measured for each token. Waveform and wide-band spectrogram were used to determine the two onset points. Value of variability in gestural timing was measured as the absolute deviation of each repetition in onset-onset lag from the group mean. Absolute deviation is based on the Levene statistic, which allows a comparison in variability within pooled data [4, 6]. Effects of position within word and morphological boundary on variability were tested in a 2×2 ANOVA.

6. RESULTS AND DISCUSSION

6.1 Effects of position and morphological boundary

Figure 1 shows the effects of position and morphological boundary on variability in gestural timing.

Figure 1: Average variability of onset-onset lag



It can be seen that word-medial clusters are more variable than word-initial clusters, and hetero-morphemic clusters are more variable than mono-morphemic clusters. Two-way ANOVA showed that both the effects of position ($F = 5.57$; $p = 0.0199$) and morphological boundary ($F = 4.04$; $p = 0.0468$) were significant. The interaction effect, however, was not significant ($F = 0.42$; $p = 0.5162$).

6.2 Summary of findings

There were two main findings in the present experiment. First, it was found that word-medial clusters exhibited significantly greater variability in gestural timing than word-initial clusters. Second, it was found that hetero-morphemic clusters were significantly more variable than mono-morphemic clusters. The experimental results support the hypothesis that metathesis is restricted to binyan *hitpa'el* because it is the only environment where word-medial, hetero-morphemic clusters, which exhibit great gestural variability in timing and weak gestural cohesion, may occur.

When stop+sibilant sequences occur in this context, the weak gestural cohesion is assumed to allow metathesis so as to satisfy other constraints. In the next section, an Optimality Theoretic analysis of *hitpa'el* metathesis is proposed to formalize the interaction of these constraints. The proposed Optimality Theoretic analysis assumes a uniform default gestural structure in the input. Varying degree of variability in gestural timing in different contexts will be captured by positional and morphological faithfulness constraints.

7. OPTIMALITY THEORETIC ANALYSIS

7.1 Markedness constraints

Two markedness constraints, C-V REL (C-V RELATION) and *SIB+V (*SIBILANT+VOWEL), are proposed. C-V REL states that a vowel gesture must be overlapped with a consonant gesture in an onset [3]. *SIB+V prohibits overlap between a sibilant and a vowel. It is hypothesized that

metathesis occurs in a stop+sibilant+vowel sequence, because the stop switches places with the sibilant so that the two constraints, C-V REL and *SIB+V, can both be satisfied.

*SIB+V is supported by previous studies [8, 9, 10]. [9] on V-to-C coarticulation of Catalan /n/ and /s/ and [8] on production of VCəCV (C is /ʃ/ or /t/) sequences by speakers of Catalan and American English show that sibilants resist coarticulation. Their results suggest that gestural overlap is not allowed between a sibilant and a vowel, because a sibilant takes control of the same articulators as required by vowel gesture. [10], a study on phonological development of English-speaking American children, provides more indirect support for *SIB+V. In [10], while stops and nasals tended to appear first in initial position (CV) and later in final position (VC), no such preference was found for fricatives with approximately the same numbers of children producing fricatives first in word-final position (VC) as in word-initial position (CV). This may be because in sibilant+V, a sibilant resists overlap with the following vowel, making the gestural coordination not as stable as stop+V. Since C-V REL is possible only when *SIB+V is not violated, *SIB+V must be higher ranked than C-V REL.

Ranking 1: *SIB+V >> C-V REL

7.2 Faithfulness constraints

Metathesis of stop+sibilant sequences allows satisfaction of both C-V REL and *SIB+V, but incurs a violation of faithfulness. In word-initial position, this appears to outrank the markedness constraints. To capture the effect of position on metathesis, positional faithfulness constraints [1] for gestures are proposed: IDENT-MED(G) (IDENT-MEDIAL (GESTURAL COORDINATION)) for word-medial consonant clusters, and IDENT-INIT(G) (IDENT-INITIAL (GESTURAL COORDINATION)) for word-initial consonant clusters. Since word-medial consonant clusters exhibit greater variability in timing than word-initial consonant clusters, IDENT-MED(G) is ranked lower than IDENT-INIT(G). Metathesis can be accounted for by ranking C-V REL between IDENT-MED(G) and IDENT-INIT(G).

Ranking 2: *SIB+V >> IDENT-INIT(G) >> C-V REL >> IDENT-MED(G)

Tableaux for a metathesized *hitpa'el* verb [histaper] (Tableau 1) and a non-metathesized *pi'el* verb [tsaper] (Tableau 2) are given below. In the tableaux, each candidate is given a schematic representation of its gestural structure with boxes. A box represents a consonant or vowel gesture. C-V REL applies only to the shaded gestures since this constraint applies to an onset. The amount of gestural overlap between two gestures is indicated by different degrees of overlap between the two boxes. The default input coordination is assumed to be the structure in which no two gestures are overlapped.

Word-medial stop+sibilant sequences outside binyan *hitpa'el*, e.g. *hif'il* verb [hitsis] 'it fermented', are not yet accounted for, since Ranking 2 wrongly predicts metathesis.

Tableau 1: /hit+saper/ → [histaper] 'he cut his hair'

Input: *hit+saper*	*SIB+V	IDENT-INIT (G)	C-V REL	IDENT-MED (G)
(a) tsa	*!			*
(b) tsa	*!			*
(c) tsa			*! (s)	
☞(d) sta				*
(e) sta			*! (t)	*

Tableau 2: /t+saper/ → [tsaper] 'you (m. sg.) will tell'

Input: *t+saper*	*SIB+V	IDENT-INIT (G)	C-V REL	IDENT-MED (G)
(a) tsa	*!	*		
(b) tsa	*!	*		
☞(c) tsa			*! (s)	
(d) sta		*!		
(e) sta		*!	* (t)	

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Non-*hitpa'el* word-medial stop+sibilant clusters are crucially mono-morphemic. Metathesis does not occur because bonding strength between morpheme-internal gestures is greater than that between across-morpheme gestures, as shown in the experiment. An additional constraint, STEM-INT(G) (STEM-INTERNAL COHESION (GESTURAL COORDINATION)), is proposed to account for the effect of morphological boundary on metathesis. This constraint applies only to morpheme-internal clusters. Parallel to word-initial clusters, mono-morphemic clusters exhibit less variability in gestural timing. Therefore, STEM-INT(G) is ranked higher than C-V REL. Co-ranking of STEM-INT(G) and IDENT-INIT(G) captures the absence of metathesis in non-*hitpa'el* clusters, which are word-medial but importantly mono-morphemic.

Ranking 3: *SIB+V >> IDENT-INIT(G) / STEM-INT(G) >> C-V REL >> IDENT-MED(G)

A tableau for a non-metathesized *hif'il* verb [hitsis] is given below.

Tableau 3: /hi+tsis/ → [hitsis] 'it fermented'

Input: *hi+tsis*	*SIB +V	IDENT -INIT (G)	STEM -INT (G)	C-V REL	IDENT -MED (G)
(a) tsi	*!		*		*
(b) tsi	*!		*		*
☞(c) tsi				* (s)	
(d) sti			*!		*
(e) sti			*!	* (t)	*

Ranking 3 yields the correct output. Great bonding strength in mono-morphemic clusters prohibits metathesis in non-*hitpa'el* words.

8. CONCLUSION

Experimental results supported the hypothesis that metathesis is restricted to binyan *hitpa'el,* because it is the only context where word-medial, hetero-morphemic stop+sibilant clusters may occur. This context was shown to exhibit weaker gestural cohesion. Results of the present and previous studies suggest that the effects of position and morphological boundary on gestural variability in timing may be universal. These effects may account not only for metathesis but also for other processes such as assimilation. Less variability in word-initial clusters seems to suggest the need for lexical access at the beginning of a word, while less variability in mono-morphemic clusters suggests a close correlation between morphological structure and phonetic realization. Gestural instability between a sibilant and a vowel, which was also hypothesized by the present study, may also be universal. However, in other languages this constraint may be undominated, and may not interact with other constraints.

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