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Phoneme complexity and frequency in the acquisition of Hebrew rhotics

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Abstract

This study investigates the roles of two factors potentially affecting acquisition order of phonemes: (a) the lexical frequency of the phoneme in various prosodic positions, and (b) phoneme consistency. The research analyses rhotic attempts and productions in the spontaneous speech of two Hebrew-acquiring children from the onset of speech until the completion of rhotic acquisition. I show that the more consistent (i.e. less allophonic variation) a phoneme is in a given prosodic position, the more likely the infant is to attempt targets with this phoneme in this position (selectivity) and the earlier the faithful production of the phoneme in this position will be. Lexical frequency is shown to play no noticeable role in the early acquisition of Hebrew rhotics. Rather, it is phoneme consistency which drives selectivity and biases acquisition order.

Keywords phoneme consistency, frequency, acquisition, allophony, rhotic, Hebrew

1. Introduction

Rhotic acquisition in Hebrew differs from that of most other consonants primarily because coda rhotics are acquired before onset rhotics, whereas other consonants are ordinarily acquired in onset position before being acquired in coda position (the exception of stridents is noteworthy, as in Ben-David's (2001) analysis of strident acquisition in Hebrew). This holds for other languages, not just Hebrew. Note, the motivation for the earlier acquisition of onsets may also be prosodic, due to processes such as coda deletion, which is very common within children during the early stages of acquisition.

This study investigates the roles of two factors potentially affecting acquisition order: (a) the frequency of the Hebrew rhotics (henceforth: ʁ) in the lexicon per prosodic position and (b) phoneme consistency. The term acquisition as used in this paper refers to the faithful production of phonemes (see elaboration in 1.3.).

The notion of phoneme consistency refers to the degree of allophonic variation per prosodic position a phoneme undergoes. I show that the greater the inconsistency, the later the acquisition. The frequency (in the lexicon) of phonemes per prosodic position, on the other hand, does not play a noticeable role in early acquisition of ʁ, though the final stages of acquisition, which are more adult-like, do reflect lexicon frequencies as would be expected.

Phoneme consistency biases acquisition order. Briefly, consistent forms are attempted, acquired and produced before inconsistent forms, as follows:

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i) Selectivity: more consistent prosodic positions are attempted before less consistent prosodic positions.
ii) Production: More consistent prosodic positions are faithfully produced before less consistent prosodic positions.
iii) The less consistent word-initial ʁ's allophony hinders the necessary generalizations required for its encoding, abstract representation and production.
iv) More consistent coda ʁs and intervocalic ʁs (very little variation) facilitate the necessary generalizations required.

The paper is structured as follows. §2 presents basic data and the theoretical background of the study. §3 outlines the methodology with respect to the collection of the data used. This is followed by the results in §4. I conclude with the analysis and discussion.

1.1 Rhotics

In Cohen, Savu and Laks' (2013) extensive acoustic study of ʁ allophony in Hebrew, controlling for position and neighbouring segments, prosodic position is shown to affect phoneme consistency. The likelihood of the surface form of the rhotic to be a non-approximant depends on its prosodic position. ʁs display variable consistency according to prosodic position, which can be generalised as follows:

i) Word-final ʁ: little variation, approximant with some frication.
ii) Intervocalic ʁ: little variation, approximant with some frication.
iii) Word-initial ʁ: substantial variation, approximants, fricatives, trills, taps, plosives.
iv) Consonant-adjacent ʁ (not included in Cohen, Savu and Laks, 2013): nightmare, with onset C_V showing marginally more consistency than coda V_C.

In Hebrew, ʁ is the one of the last consonants to emerge during acquisition (Lavie, 1978; Ben-David, 2001), and, with the exception of sibilants, the last consonant to be fully acquired in Hebrew (Ben-David, 2014). Assuming three stages of acquisition (deletion→substitution→faithful), Ben-David, Adi-Bensaid and Ezrati's (in progress) cross-sectional study shows that word-medial ʁs are acquired before word-initial ʁs (no distinction between word-medial codas and onsets, or word-final ʁs). Note, consonant adjacent word-medial rhotics are not addressed in these papers, but are addressed in this current study). This finding is very strange when compared to other segments' acquisition (e.g. Ben-David, 2001).

Crosslinguistically, the late acquisition of rhotics is common (Bosma-Smit et al., 1990 for English; Hua, 2000a/b for Putonghua; Amayreh and Dyson, 1998 for Jordanian Arabic, Freitas, 1994 for Portuguese, inter alia). Rose's (2003) analysis of rhotic acquisition in final position in Quebéc French shows that for some children, dorsal rhotics in word-final position are acquired several months after other consonants similarly positioned, and after the acquisition of rhotics in other positions. However, the patterning in Hebrew of the ʁ's acquisition (i.e. being fully acquired in coda position before being fully acquired in onset position), is somewhat unusual (no known similar studies for other languages). This stands in sharp contrast to other Hebrew consonants, where onset acquisition generally precedes coda

acquisition (Ben-David, 2001:236-237, with the exception of fricatives, similarly to the acquisition of word-final fricatives before onset fricatives in other languages, as presented in Dinnsen 1996). McCallister-Byun (2011) attributes the neutralisation of fricatives in prosodically strong contexts (onsets vs. codas) to speech motor control, presenting evidence for fricatives being produced more frequently in coda than in onset position. The explanation offered hinges on articulation, specifically gestural timing patterns. Note, these studies refer to the phonological classification of the phonemes, rather than to the actual phonetic realisation of the categories by adults in these positions.

1.2 Phoneme consistency

Phonemes can vary phonetically, fluctuate in phonetic consistency (allophony). The notion of phoneme consistency is as follows: The more allophonic variation, the less consistent the phoneme is. Phoneme consistency may vary per position.

1.3 Phoneme Acquisition Criterion (PAC)

In each developmental stage, all target phonemes are counted. The targets' productions are classified according to the various categories in §2.2: deletion, substitution, faithful. A phoneme fulfills the Phoneme Acquisition Criterion (PAC) in a certain position when:

i) it reaches a stage during which "faithful" is the dominant category (over 50%),
and
ii) "faithful" is the dominant category in all subsequent stages (no reversion to earlier stages).

Amayreh and Dyson (1998) refer to three stages in a phoneme's acquisition (adapted from Sander, 1972): (a) customary production, at least 50% of the subjects produce the segment in two prosodic positions, (b) acquisition, at least 75% of the subjects produce the segment in all prosodic positions investigated, and (c) mastery, at least 90% of the subjects produce the segment in all prosodic positions. Though I follow their general notion regarding stages in acquisition, due to inherent differences in the types of study, it is necessary to use different criteria to define acquisition. Namely, a phoneme can be considered fully acquired by a specific speaker only when it reaches PAC in all prosodic positions for the speaker, as follows:

i) Emergence – even one instance
ii) Acquisition – fulfills PAC (50% accuracy), more likely than not to be faithfully produced
iii) Mastery – adult-like

I deviate from their precise definitions as they do not deal with specific speakers in longitudinal studies over a substantial period, but rather they deal with averages over a large age-based group, referring to average acquisition ages rather than precise acquisition stages.

2. Methodology

This study is based on data collected from two children, RM and SR (Language Acquisition Project directed by Bat-El and Adam at Tel-Aviv

University). The data analyzed in this paper were collected during weekly recordings of natural speech from the first recognizable word until 2;01.06 (SR) and 2;04.19 (RM). The data were transcribed and partially analyzed acoustically (PRAAT, Boersma and Weenink, 2014).
The entire period covered was broken down into developmental stages (according to the principles of Adam and Bat-El, 2008; 2009) based on vocabulary size rather than chronological age. The first stage ended after the child's lexicon included 10 distinct words. Each subsequent stage is 50 words (or more), with a single session never including more than one stage (though one stage may cover several sessions).
All productions are classified into three primary categories:

i) Deletion – no surface correspondent for the target phoneme was produced
ii) Substitution – the surface correspondent of the target segment is noticeably different from what adult speakers produce
iii) Faithful – the produced segment is recognized by adult speakers as the target segment
iv) Other types of production (e.g. metathesis) are ignored henceforth, as they are statistically negligible.

3. Findings

3.1 Selectivity

This notion refers to the likelihood of certain targets being attempted (for Hebrew: Ben-David, 2001:342 ; Bat-El, 2012; Becker, 2012; Cohen, 2012. For other languages: Drachman, 1973; Schwartz and Leonard, 1982, to name a few). Acquirers are more likely to attempt harmonic ("better") targets than disharmonic targets. The notion of selectivity demonstrates the children's preferences during the earliest stages of acquisition. The following (1) and (2) present the attempts of targets including ʁ by SR and RM respectively:

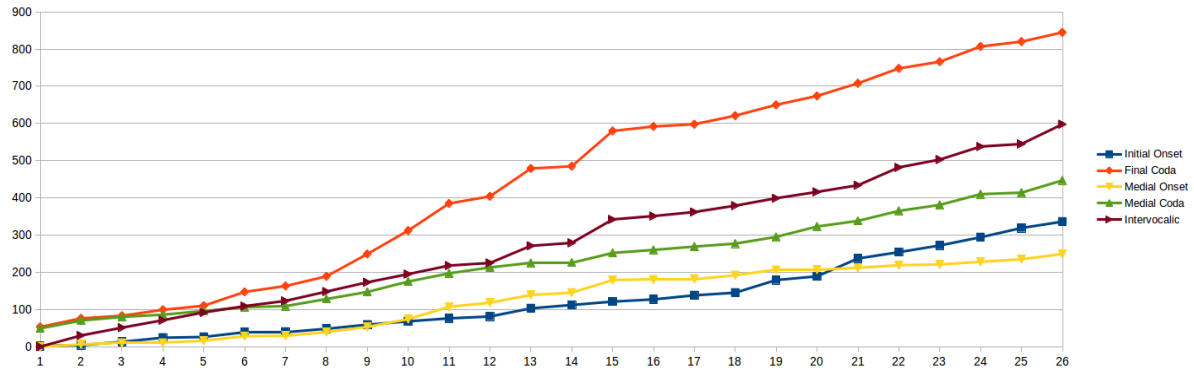

Figure 1: Target selectivity in ʁ production – SR

In Figure (1), we observe the data for SR:

i) Targets with word-final ʁ are the preferred targets throughout, followed by intervocalic ʁ.
ii) Consonant adjacent targets are the least frequent, with codas V_C being preferred to onsets C_V.

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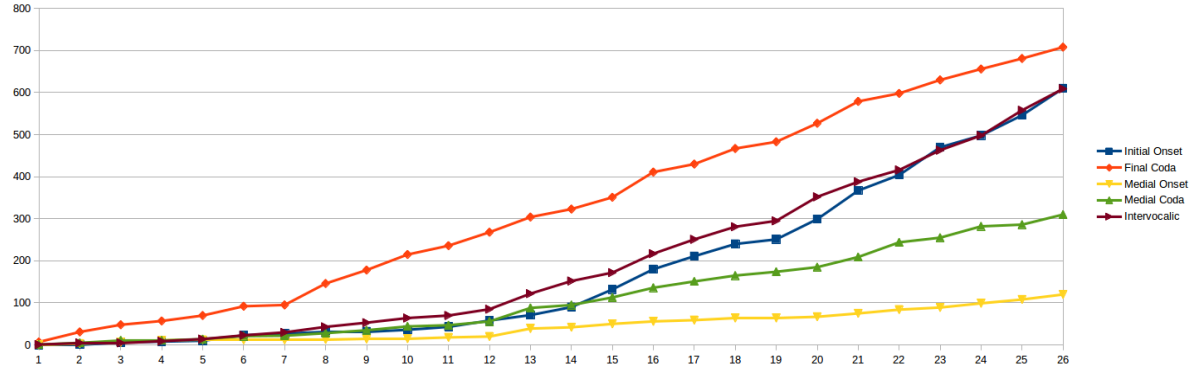

Figure 2: Target selectivity in ʁ production – RM

In Figure (2), we observe the data for RM:

i) Targets with word-final ʁ are the preferred targets throughout, followed by intervocalic ʁ, which is in close competition with initial ʁ from stage 23.

ii) Consonant adjacent targets are the least frequent, with codas V_C being preferred to onsets C_V.

The major difference between SR and RM is that RM's word-initial targets are "better off" than SR's. To summarize, both children demonstrate the role of selectivity in early acquisition, attempting the coda-ʁ forms before the onset-ʁ forms. Word-final coda-ʁ forms are attempted before ʁs in all other prosodic positions. Word-final coda ʁs are preferred targets.

3.2 Production

The actual production of rhotics follows a similar ordering pattern to the selectivity. According to Ben-David, Adi-Bensaid and Ezrati (in progress), the order of acquisition is as follows: word-final→word-medial (V_V)→word-initial (Note: their study did not investigate word-medial C_V or V_C). The following Figures (3a-3e) present the ʁ production data from SR, and (4a-4e) present the ʁ production data from RM:

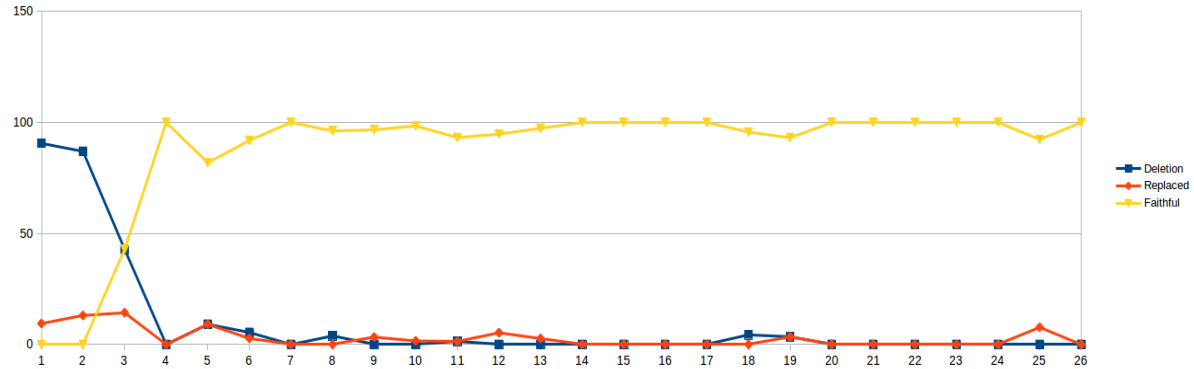

Figure 3a: Word-final (_#) ʁ production – SR – PAC reached at Stage 4

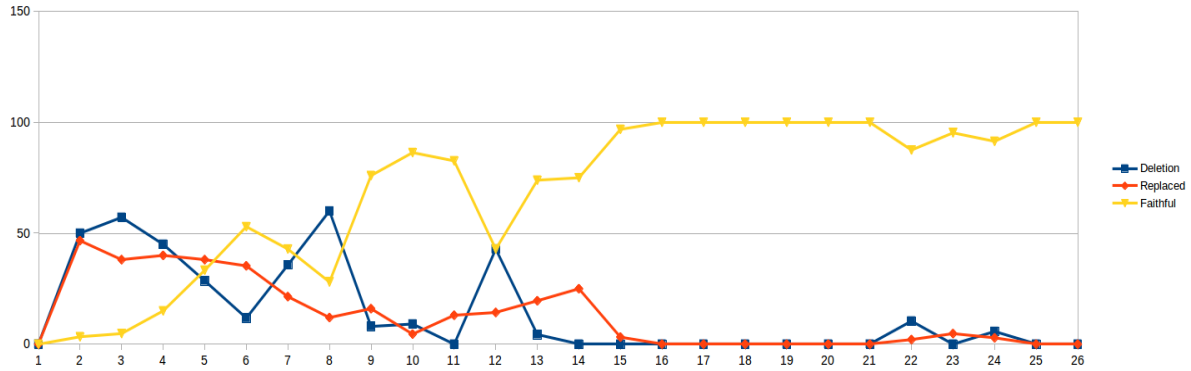

Figure 3b: Intervocalic (V_V) ʁ production – SR – PAC reached at Stage 9

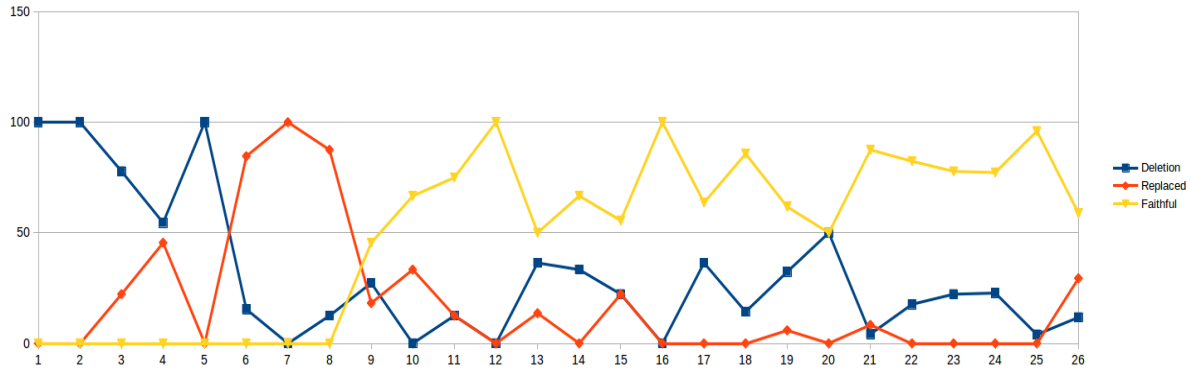

Figure 3c: Word-initial (#__) ʁ production – SR – PAC reached at Stage 9

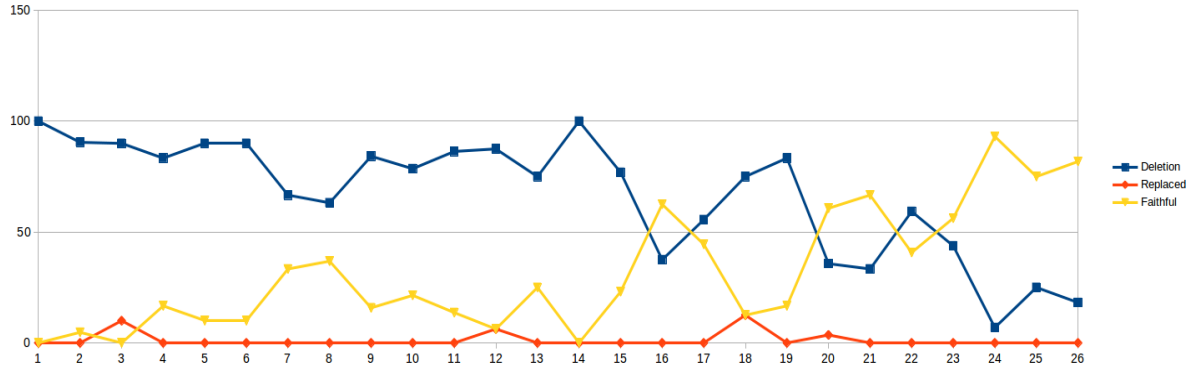

Figure 3d: Word-medial coda (V_C) ʁ production – SR – PAC reached at Stage 23

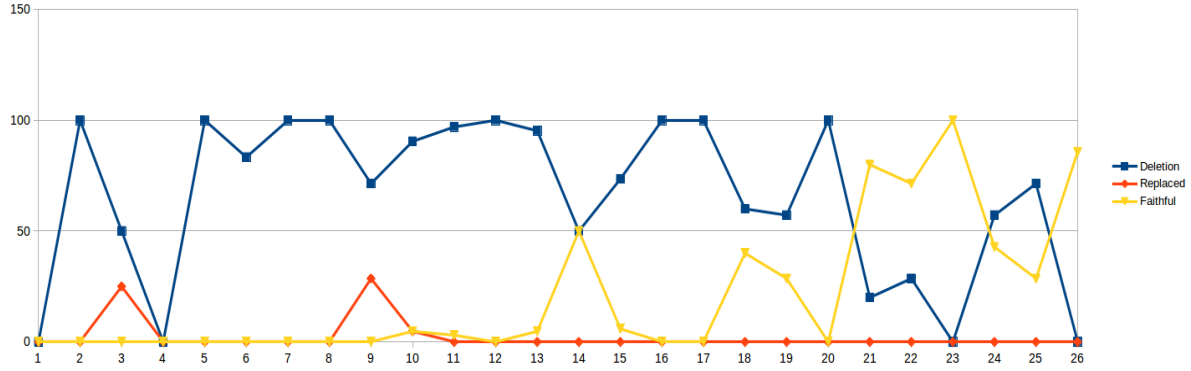

Figure 3e: Word-medial onset (C_V) ʁ production – SR – PAC reached at Stage 26

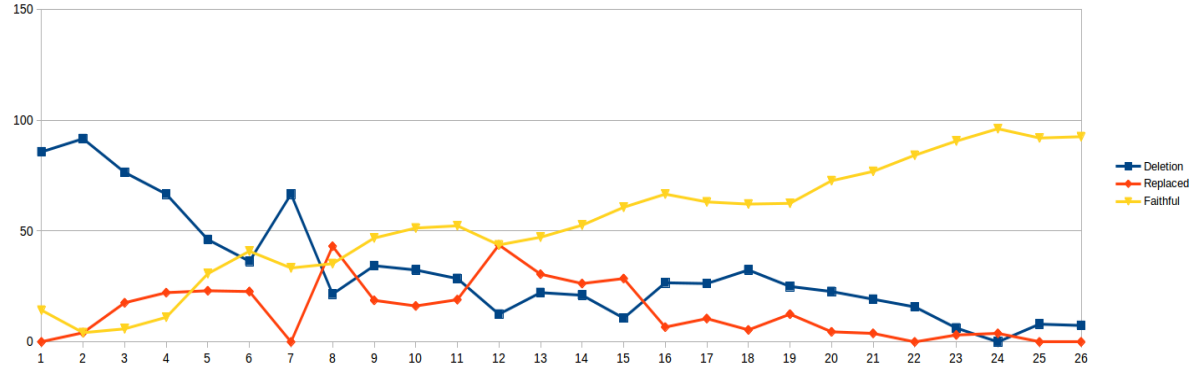

Figure 4a: Word-final (_#) ʁ production – RM – PAC reached at Stage 9

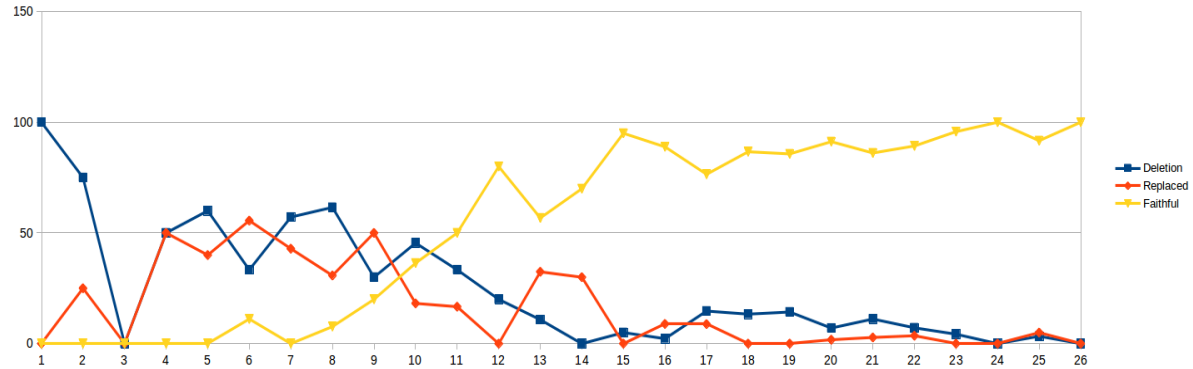

Figure 4b: Intervocalic (V_V) ʁ production – RM – PAC reached at Stage 11

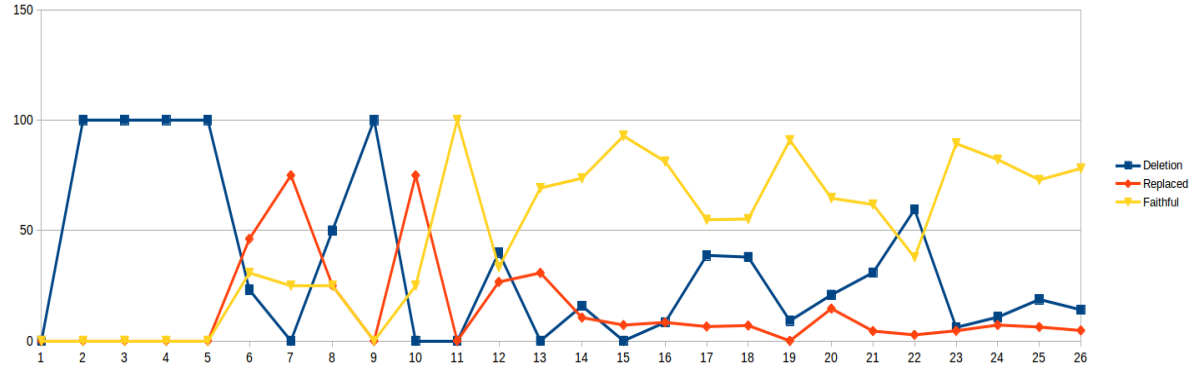

Figure 4c: Word-initial (#__) ʁ production – RM – PAC reached at Stage 13

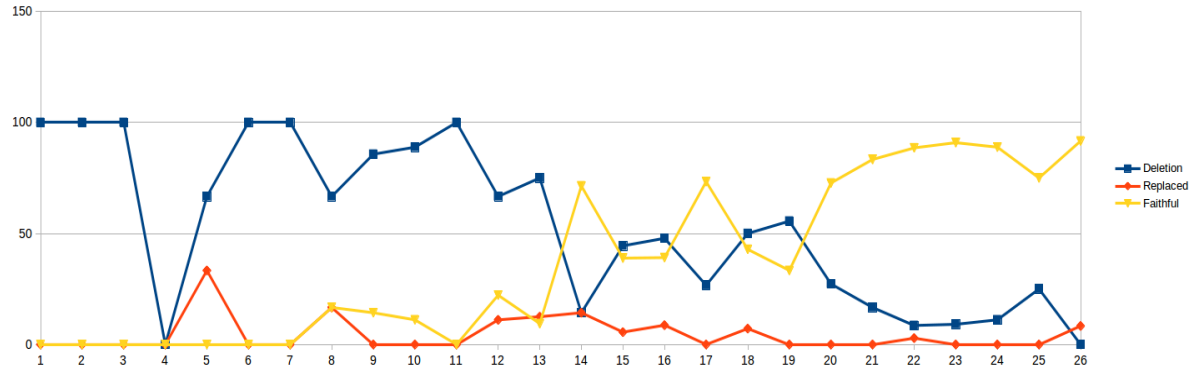

Figure 4d: Word-medial coda (V_C) ʁ production – RM – PAC reached at Stage 20

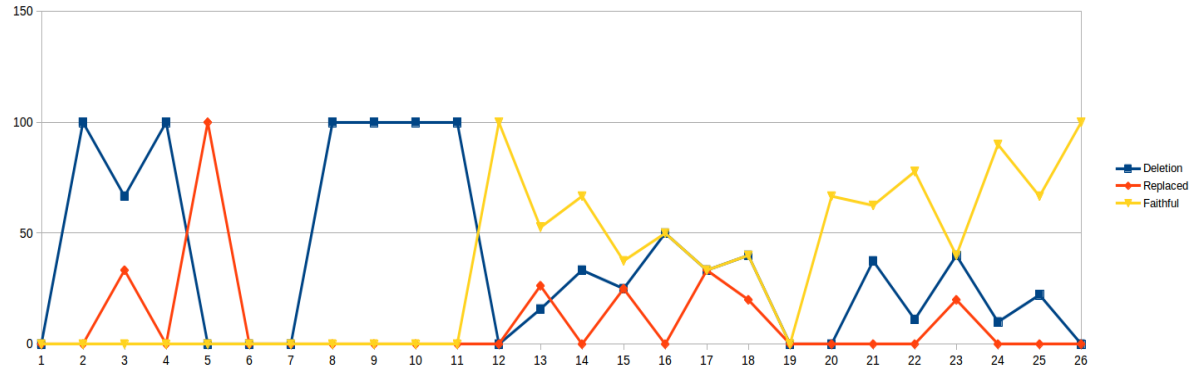

Figure 4e: Word-medial onset (C_V) ʁ production – RM – PAC reached at Stage 24

The above figures show both children following the same path. Observing the paths of the yellow graph (faithful production), the gradual rise until reaching PAC (50%) is clear. Furthermore, it is clear how PAC is reached earlier in some positions (e.g. 3a, 2b) than in others (e.g. 3d, 3e). Initially, attempted rhotics are deleted. As deletion declines, there is a rise in substitution. Finally, the rate of faithful production exceeds that of substitution, eventually leading to the overall faithful production of rhotics. For both children, PAC is reached per position in the following order: _# > V_V > #_ > V_C > C_V. This precise pattern of production mirrors the order observed in selectivity.

4. Conclusions and Discussion

The data presented in §3 show the selectivity preference and order of acquisition of ʁ. In this section, ʁ frequency and phoneme consistency in Hebrew are examined in light of this data.

4.1 Frequency

The notion of frequency-dependent acquisition suggests that the more frequently a segment appears in a certain prosodic position, the more rapid its acquisition in the position should be (e.g. Zamuner 2003:70). The following Table (1) shows ʁ frequency in Hebrew nouns:

Onset			Coda	
#_	C_V	V_V	V_C	_#
445	633	1264	634	818
	2342		1452	

Table 1: ʁ-frequency-per-position in Hebrew nouns (Bolozky and Becker, 2006)

The frequency order is: V_V > _# > V_C=C_V > #_. One can make the following generalizations regarding ʁ frequency in the Hebrew lexicon. ʁ is more common in onset position than in coda position. Consonant-adjacent

ʁs are equally common in onset and coda position. The most common position for ʁ by far is intervocalic. Recall §4.2 regarding target production. For both children, PAC is reached in the following order: _# > V_V > #_ > V_C > C_V. At the very least, word-medial onsets should be first, onsets, in general before codas, but this is not the case, suggesting that acquisition order is not determined by lexicon frequency.

4.2 Phoneme consistency

According to the notion of phoneme-consistency-dependent acquisition, the more phonetically varied, the less consistent, the productions of a phoneme are in a given position, the slower its acquisition should be. Coda ʁs are more consistent than onset ʁs, intervocalic ʁs are more consistent than consonant adjacent ʁs, as in the following scale: _# > V_V > #_ > V_C > C_V. Both selectivity and the stage during which PAC is reached support this precise ranking. Bottom line, as the data show, acquisition order correlates strongly with phoneme consistency, as opposed to frequency, which does not.

However, phoneme consistency does not merely demonstrate a correlation with acquisition order. In fact, it provides an explanation for this order. The more consistent a phoneme is in a certain position, the easier the formulation of generalizations is by the acquiring speakers. It stands to reason that the more variation a position displays, the more difficult it is to make the necessary generalizations for the encoding, representation and production of the phoneme.

These data suggest that the acquisition of phonemes per prosodic position depends on the allophonic variation of the phonemes in these positions rather than the mere acquisition of prosodic positions, shedding light on the weird behaviour of rhotics in acquisition. Rather than surfacing faithfully as prosodic positions are acquired, segments surface in positions in which they are more consistent before surfacing in other positions. Future research into the allophonic variation and acquisition-per-position of other phonemes is necessary in order to further establish this.

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References

Adam, G. and Bat-El, O. (2008). Segmental effects on syllable selection: Evidence from Hebrew. In A. Gavarró and M.J. Freitas (Eds.), Language Acquisition and Development: Proceedings of GALA 2007 (pp. 1-11). Newscastle: Cambridge Scholars Publishing.

Adam, G. and Bat-El, O. (2009). When do universal preferences emerge in language development? The acquisition of Hebrew stress. Brill's Annual of Afroasiatic Languages and Linguistics 1, 1-28.

Amayreh, M., and Dyson, A. (1998). The acquisition of Arabic consonants. Journal of Speech, Language, and Hearing Research 41, 642-653.

Bat-El, O. (2012). Phonological constraints on morphological development: The acquisition of Hebrew verb inflectional suffixes. Brill's Annual of Afroasiatic Languages and Linguistics 4, 189-212.

Becker, M. (2012). Target selection in error selective learning. Brill's Annual of Afroasiatic Languages and Linguistics 4, 120-139.

Ben-David, A. (2001). Language acquisition and phonological theory: Universal and variable processes across children and across languages. Unpublished Ph.D. dissertation. Tel-Aviv University, Israel (in Hebrew).

Ben-David, A. (2014). Developmental norms in the phonology and articulation in Hebrew. Paper presented at the 50th conference of the Association of Speech Therapists. Tel-Aviv.

Ben-David, A., Adi-Bensaid L. and Ezrati R. (in progress). The acquisition of dorsal rhotics.

Boersma, P. and Weenink, D. (2014). Praat: Doing phonetics by computer (computer programme). <http://www.fon.hum.uva.nl/praat/)>.

Bolozky, S. and Becker, M. (2006). Living Lexicon of Hebrew Nouns. Ms., University of Massachusetts Amherst. Available at http://becker.phonologist.org/LLHN.

Bosma Smit, A., Hand, L, Freilinger, J.J., Bernthal, J. E. and Bird, A. (1990). The Iowa articulation norms project and its Nebraska replication. Journal of Speech and Hearing Disorders 55, 779-798.

Cohen, E-G. (2012). Vowel harmony and universality in Hebrew acquisition. Brill's Annual of Afroasiatic Languages and Linguistics 4, 7-29.

Cohen, E-G., Savu, C. and Laks, L. (2013). Crazy little things called /r/: Unlocking the mysteries of the Hebrew rhotic. Paper presented at R-atics4, GIPSA-Lab, Bernin (Grenoble).

Dinnsen, D. (1996). Context effects in the acquisition of fricatives. In B. Bernhardt, J. Gilbert and D. Ingram (Eds.), Proceedings of the UBC International Conference on Phonological Acquisition (pp. 136-148). Somerville, MA: Cascadilla Press.

Drachman, B. (1973). Generative phonology and child language acquisition. Ohio StateUniversity Working Papers in Linguistics 15, 146–159.

Freitas, M. J. (1994). Alveolar trill(ions of problems): Evidence from children acquiring European Portuguese syllables. Paper presented in the First Lisbon Meeting on Child Language. University of Lisbon, Lisbon.

Hua, Z., and Dodd, B. (2000a). The phonological acquisition of Putonghua (modern standard Chinese). Journal of Child Language 27, 3-42.

Hua, Z., and Dodd, B. (2000b). Phonological systems of a set of Putonghua-speaking twins. International Journal of Language and Communication Disorders 35, 487-506.

Lavie, S. (1978). Norms of the Hebrew consonants system between the ages 3 to 5. Unpublished M.A. thesis. Tel-Aviv University, Israel (in Hebrew).

McCallister Byun, T. (2011). A gestural account of a child-specific neutralisation in strong position. Phonology 28, 371-412.

Rose, Y. (2003). Place specification and segmental distribution in the acquisition of word-final consonant syllabification. Canadian Journal of Linguistics 48(3/4), 409-435.

Sander, E. K. (1972). When are speech sounds learned? Journal of Speech and Hearing Disorders, 37, 55–63.

Schwartz, R. and Leonard, L. (1982). Do children pick and choose? An examination of phonological selection and avoidance in early lexical acquisition. Journal of Child Language 9, 319–336.

Zamuner, T. 2003. Input-based phonological acquisition. New York and London: Routledge.