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ARMENIAN SCHWA: A PHONETIC AND PHONOLOGICAL ANALYSIS

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## ABSTRACT OF THE THESIS

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Eastern Armenian (EA) has been described as having stress on the final full vowel of a word (i.e., non-schwa) (Dum-Tragut 2009, Hulst 1999, Khachatryan 1988, Vaux 1998), making the language a sonority-driven stress system (Kenstowicz 1994, de Lacy 2004). The phonological evidence involves high vowel reduction in derived environments (Vaux 1998), while the phonetic evidence demonstrates lengthened vowel duration consistent with the sonority-driven stress pattern (Khachatryan 1988). The current study reanalyzes the phonological evidence as motivated independent of stress, and provides evidence from an acoustic analysis that, on the contrary, EA is more accurately analyzed as having a consistently final metrical head.

The study involves a production experiment whose subject is a native EA speaker who read aloud a number of disyllabic CVCVC words in two frame sentences which differed in whether the target was focused. Duration (normalized for speech rate), intensity, F0, and quality (F1/F2) were measured for each target vowel using Praat (Boersma & Weenink 2015) and VoiceSauce (Shue et al 2011). Results were evaluated using standard statistical models (R Core Team 2015).

The finding is that there is no distinction in duration, intensity, and vowel quality between putatively stressed and unstressed vowels. There is, however, a pitch rise over

the final syllable. This pitch excursion is analyzed as involving an LH\* tonal contour, where the high pitch accent associates with a word-final metrical head. The word-final LH\* contour occurs consistently, regardless of vowel quality. Ultimately, the study casts doubt on impressionistic reports of stress, which are possibly tonal or pitch accent systems (see e.g., Gordon 2014).

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## 1 Introduction

Many descriptions of Eastern Armenian (EA) agree that word stress lies on the final syllable unless it contains a schwa, in which case stress retracts to the penult (Khachatryan 1988, Vaux 1998, Dum-Tragut 2009). Consequently, this makes EA a sonority-driven stress system (Kenstowicz 1994, de Lacy 2004).

- (1) Example words
- |                           |                   |
|---------------------------|-------------------|
| anúf                      | ‘sweet’           |
| anúf-ə                    | ‘the sweet’       |
| anúf-ət                   | ‘your sweet’      |
| anuf-íts <sup>h</sup> -ət | ‘from your sweet’ |

However, recent work has cast doubt on the existence of at least some types of sonority-driven stress systems (Shih 2015). In this paper, I provide new evidence that in EA there is neither phonological nor phonetic evidence to support the previous stress descriptions. Instead, EA is analyzed most accurately as exhibiting a uniformly final metrical head.

Apparent evidence for stress has come from both phonological and phonetic sources. The phonological evidence involves reduction of high vowels to schwa: e.g. [tún] ‘house’ vs. [tən-íts<sup>h</sup>] ‘from the house’. This process has been argued to refer to stress insofar as only stressed high vowels in a root may be reduced in derived forms (Vaux 1998: 148-149). Crucially, high vowels do not reduce when the final vowel is schwa: e.g. [tún-ət] ‘your house’, not \*[tən-ét]. A lack of vowel reduction suggests that in such words the root-final high vowel is stressed, and therefore EA stress is sonority-driven. However, I observe a number of other restrictions in EA that conspire to block vowel reduction in such forms, such as a ban on consecutive schwas. This leaves the phonological evidence unable to distinguish between the sonority-driven and final stress analyses. The phonological evidence for EA stress is discussed further in section 2.

Since the phonological evidence is shown to be inconclusive, the majority of this paper is devoted to an acoustic analysis of Armenian stress. The ultimate finding is that evidence from duration, intensity, vowel quality, and fundamental frequency supports consistently final stress. There is no distinction in duration, intensity, and vowel quality between putatively stressed and unstressed vowels. However, there is a consistent pitch rise over the final syllable. I analyze this pitch rise as involving a LH\* tonal contour, where the H\* associates with a word-final metrical head. The acoustic analysis of Armenian stress is discussed in section 3.

Section 4 concludes with a discussion of the implications of these findings for the analysis of EA, and for the analysis of systems with putative sonority-driven stress.

## 2 Phonological evidence for EA metrical structure

EA has the following vowels in contrastive opposition in all environments:

(2) EA vowel inventory

i		u
ε	ə	ɔ
		ɑ

Vowels do not contrast in length; all vowels are short. EA permits the following syllable structures on the surface:

(3) EA surface syllable structures

V	<b>a.tʃ-εl</b>	‘to grow’
VC	<b>atʃ<sup>h</sup></b>	‘right’
VCC	<b>əst</b>	‘according to’
VCCC	<b>astχ</b>	‘star’
CV	<b>t<sup>h</sup>ε</b>	‘or’
CVC	<b>pat</b>	‘wall’
CVCC	<b>gandz̄</b>	‘treasure’
CVCCC	<b>partk<sup>h</sup></b>	‘debt’
CCV	<b>stɛ.κən</b>	‘dactyl’
CCVC	<b>sχal</b>	‘error’
CCCVC	<b>struk</b>	‘slave’

Finally, EA has no limit on the size of morphological words as the language is agglutinating. Individual morphemes do not seem to surpass three syllables, notwithstanding onomatopoeic forms, which I disregard.

Hayes (1995) and de Lacy (2014) emphasize that there are many potential sources of evidence for metrical structure, including phonological and morphological processes that are conditioned by metrical structure. Unfortunately, almost no such processes are reported in grammars of Armenian. There is no metrically-conditioned allophony, no stress-controlled harmony or neutralization, and no affixes that are attracted to metrical heads. The exception is a process of apparently stress-conditioned high vowel reduction (Vaux 1998). The pattern is as outlined below:



- (4) Reduction of monosyllabic root high vowel in morphologically derived environment
- |                   |           |                          |                   |
|-------------------|-----------|--------------------------|-------------------|
| tsit              | ‘sparrow’ | tsət-i                   | ‘of the sparrow’  |
| tun               | ‘house’   | tən-its <sup>h</sup>     | ‘from the house’  |
| dʒur              | ‘water’   | dʒər-ɛr-əv               | ‘with the waters’ |
| girk <sup>h</sup> | ‘book’    | gər <sup>h</sup> -ɛr-i-n | ‘to the books’    |
- (5) Preservation of root non-high vowel
- |                    |           |                         |                    |
|--------------------|-----------|-------------------------|--------------------|
| dʒen               | ‘sound’   | dʒen-i                  | ‘of the sound’     |
| karak <sup>h</sup> | ‘butter’  | karak <sup>h</sup> -i-n | ‘to the butter’    |
| hət                | ‘smell’   | hət-its <sup>h</sup>    | ‘from the smell’   |
| tʃak <sup>h</sup>  | ‘fissure’ | tʃak <sup>h</sup> -əv   | ‘with the fissure’ |
- (6) Preservation of high vowel elsewhere
- |                                   |          |                                     |                   |
|-----------------------------------|----------|-------------------------------------|-------------------|
| t <sup>h</sup> ut <sup>h</sup> ak | ‘parrot’ | t <sup>h</sup> ut <sup>h</sup> ak-i | ‘of the parrot’   |
| hifatak                           | ‘memory’ | hifatak-its <sup>h</sup>            | ‘from the memory’ |
- (7) Preservation of root high vowel when preceding schwa
- |        |               |
|--------|---------------|
| tsit-ə | ‘the sparrow’ |
| tun-ət | ‘your house’  |
| muk-əs | ‘my mouse’    |
- (8) Deletion of root-final high vowel
- |       |           |            |              |
|-------|-----------|------------|--------------|
| zəpit | ‘smile’   | zəpt-al    | ‘to smile’   |
| hatuk | ‘special’ | hatk-a-pəs | ‘especially’ |
- (9) Preservation of polysyllabic root-final high vowel
- |        |         |            |                             |
|--------|---------|------------|-----------------------------|
| artsiv | ‘eagle’ | artsiv-i   | ‘of the eagle’ <sup>1</sup> |
| jəɲnik | ‘doe’   | jəɲnik-i-n | ‘to the doe’                |

The examples in (4) and (5) point to a vowel reduction process of only monosyllabic root high vowels in morphologically derived forms. In contrast, the lack of reduction in (7) illustrates the potential for sonority-driven stress in that a high vowel will not reduce when the final vowel is a schwa. According to Vaux (1998: 20), “High vowels that surface in stressed syllables disappear or are replaced by schwa when unstressed.” Since the penultimate high vowels in (7) are stressed when not in derived forms, they must

<sup>1</sup> The standard Eastern Armenian genitive of [artsiv] ‘eagle’ is [artsəv-i]. Depending on dialect or idiolect, however, it is realized in the faithful form [artsiv-i]. Other polysyllabic roots, such as [jəɲnik] ‘doe’, never reduce; this leads me to conclude that as far as the standard language is concerned, high vowel reduction in polysyllabic roots must be learned for a subset of lexemes.

still be stressed in derived forms in which the high vowel precedes a schwa. As a result of this interaction, the stress system is analyzed as consistently assigning final stress except when the final syllable contains a schwa, in which case stress falls on the penult.

However, the alternative analysis proposed here is that this is due to a more general phonotactic constraint at play in the language, namely that schwas in consecutive syllables are prohibited.<sup>2</sup> So, /tʃit-i/→[tʃəti], but /tʃit-ə/→[tʃitə], \*[tʃətə]. For instances with epenthetic schwa, /tʃit-s/→[tʃitəs], \*[tʃətəs].

Support for this approach comes from several observations. One is that there are no sequences of schwas in surface forms in Armenian (barring onomatopoeic forms): e.g. \*CəCəCV, \*CVCəCə. Such a restriction cannot straightforwardly be explained by stress conditions because in \*CəCəCV the final vowel has stress. Even if the initial syllable in such words had secondary stress, schwa is clearly not banned under secondary stress because CəCVCV is a perfectly acceptable word: e.g. [təritʃ<sup>h</sup>k<sup>h</sup>-i] ‘of the flight’.

Thus, while a final, epenthetic schwa will surface on a suffix to break up an illicit cluster, a schwa will not surface from vowel reduction immediately preceding an epenthetic schwa. For example, /tʃit-s/→[tʃit-əs], not \*[tʃət-əs], \*[tʃət-s].

In addition, in roots of the form [CəCVC], the final V will not reduce before a high vowel. For example, [ʒəpit]→[ʒəpit-ɔv] ‘with a smile’, \*[ʒəpət-ɔv], \*[ʒəpt-ɔv]. In no such root does the root-final high vowel reduce to schwa.

On the same note, polysyllabic words such as [ʒəpit] ‘smile’ in group (8) delete their final high vowel rather than reduce in derived forms. For example, when deriving verbs from nouns, [ʒəpit] ‘smile’ becomes [ʒəpt-al] ‘to smile’, not \*[ʒəpətəl]. Words such

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<sup>2</sup> The recurring exception to this restriction is the class of onomatopoeic forms, such as [p<sup>h</sup>əɾəft-al] sneeze-INF.

as [hatuk] ‘special’ and [hatk-a-pəs] ‘especially’ in the same group support the hypothesis that EA stress is consistently word-final because if root-final high vowels can surface faithfully when stressed, they will delete in longer forms (such as the agglutinated compound form [hatk-a-pəs] ‘especially’) given that the remaining segments lend themselves to licit syllable structure.

Finally, the forms in (9) demonstrate that this process of high vowel reduction is likely restricted to monosyllabic roots. Further, polysyllabic root-final high vowel deletion may be learned only for a subset of lexemes: e.g. [jɛɾnik-i] ‘of the doe’, \*[jɛɾnək-i], \*[jɛɾnk-i].

To summarize, high vowel reduction occurs in monosyllabic roots followed by any suffix with a non-schwa; this includes cases with multiple suffixes. Suffixes themselves are not able to undergo high vowel reduction as their high vowels are always in the final syllable of the word. The only non-final suffix with a high vowel is the dative [i] followed by definite [n], also in the final syllable of the word.

The only suffixes which may surface with a schwa are the definite marker and epenthesis in the case of the first person possessive [-s] and second person possessive [-t]. Note that these three suffixes cannot co-occur and may be considered clitics. Although the results below do not demonstrate the following to be the case, if an EA speaker exhibits acoustic patterns with non-final stress on such forms, it may be the case that their phonology indeed considers these three suffixes extrametrical and thus clitics. Again, this is not the case for the speaker presented in this paper.

All monosyllabic roots undergo the pattern of high vowel reduction demonstrated above. The author is unaware of any previous examination of this process in loan words,

or any calculation of how many roots undergo this process. However, the pattern applies to the monosyllabic roots with high vowels without exception, though due to natural constraints due to their size and accidental gaps, the list of high vowel monosyllabic roots is not a large one.

Deletion of high vowels occurs in words of two syllables or longer followed by a case suffix (e.g. locative, instrumental, dative). This is blocked by the plural suffix [-nɛr], whether or not the plural suffix is followed by a case suffix. Note that the ban on consecutive schwas proposed below is not morphological; also note that high vowel reduction in monosyllabic roots still takes places before the plural suffix, again whether or not that plural suffix is followed by a case suffix.

The analysis I am proposing for vowel reduction in Armenian, then, is a complex ‘homogeneity of target, heterogeneity of process’ situation (McCarthy 2002):

- (10) Problem: Do not have high vowels in unstressed syllables  
Solutions:
- (a) Delete the high vowels (e.g. /ʒəpɪt-al/ → [ʒəp.t-al])  
...unless deletion would result in a syllable structure violation (e.g. /tun-its<sup>h</sup>/ → \*[tɲit<sup>h</sup>]), in which case:
  - (b) Neutralize to schwa (e.g. /tun-its<sup>h</sup>/ → [tə.nits<sup>h</sup>])  
...unless neutralization to schwa would produce two consecutive schwas (e.g. /tun-t/ → \*[tənət]), in which case:
  - (c) Remain faithful: (e.g. /tun-t/ → [tu.nət])

An analysis in classical OT is sketched below. Unfortunately, a thorough analysis would take us too far from the goals of this article, and would be premature because important details of the phonological system (e.g. the syllable structure) have not been fully explored yet.

## (11) Constraint Set

**σ-STRUC**: an abbreviation for those constraints that ban illicit syllable structures

**STRESS-IDENT[V]**: assign a violation for each stressed output vowel that differs in quality from its input correspondent (Beckman 1998)

**IDENT[-hi]**: assign a violation for each input segment that is [-hi] whose input correspondent is not [-hi]

**OCP(ə)**: assign a violation for each pair of consecutive schwas on the vowel tier

**\*UNSTRESSED<sub>≥{i,u}</sub>**: assign a violation for each unstressed vowel that has equal or greater sonority than ‘high vowels’ (de Lacy 2004)

**IO-MAX**: assign a violation for each input segment that lacks a corresponding output segment (McCarthy & Prince 1997)

Throughout this analysis I assume final stress, however that is achieved by constraints (e.g. IAMB with ALIGN-FT-R; see Kager 1997 for various options).

The key point is that avoidance of unstressed high vowels is preferentially achieved by deletion. In the tableau below, the winner [ʒəptál] avoids unstressed [i] by deleting it. An alternative way to eliminate it would be by turning it into schwa, but that would produce a sequence of schwas: \*[ʒəpətál].

## (12) High vowel deletion

/ʒəpit-al/	σ-STRUC	STRESS-IDENT[V]	IDENT [-hi]	OCP(ə)	*UNSTR <sub>≥{i,u}</sub>	MAX	Description
☞ ʒəptál						*	Deletion
ʒəpitál					*!		Faithful
ʒəpətál				*!			Reduction
ʒpətál	*!						Wrong Deletion


In some environments, though, deletion is not an option. When deletion would create an illicit syllable structure, deletion is blocked and neutralization occurs instead. In the tableau below, the form with deletion \*[tnítʰs] violates restrictions on complex onset sonority distance. So, neutralization occurs instead: [tənítʰs].

## (13) High vowel reduction

/tun-itsʰ/	σ-STRUC	STRESS-IDENT[V]	IDENT [-hi]	OCP(ə)	*UNSTR <sub>≥{i,u}</sub>	MAX	Description
☞ tənítʰs							Reduction
tunítʰs					*!		Faithful
tənətsʰ		*!		*!			Over-reduction
tnítʰs	*!					*	Deletion

In one situation, though, both vowel reduction and deletion are impossible: when deleting would create a syllable structure violation, and when reduction would create consecutive schwas:

(14) High vowel preservation

/tun-ət/	σ-STRUC	STRESS-IDENT[V]	IDENT [-hi]	OCP(ə)	*UNSTR ≥{i,u}	MAX	Description
 tunót					*		Faithful
tənót				*!			Reduction
tnít	*!					*	Deletion
tənít		*!					Anti-reduction

Note that high vowels do not delete in any instance which would result in a banned syllable structure. For instance, STOP+NASAL is an illicit onset, hence why [tn] is a blocked onset in (13) and (14). The sonority sequencing principle also plays a role, why FRICATIVE+STOP is an illicit onset in (12).<sup>3</sup> Besides forms beginning with an appendix sibilant, the only two-member onset clusters that can surface without schwa epenthesis are those which are STOP, NASAL, or a LIQUID all followed by a GLIDE (namely, [j]).

Codas in EA seem to be unexpectedly wide in their surface possibilities, along with several plateaus and reversals in sonority, violations of the sonority sequencing principle. (39) from Vaux (1998) lists all such possibilities, including when epenthesis must occur. Not all of the forms in (39) seem to accord with forms as spoken by the investigator of the current study, the participants of the study, and all EA speakers familiar to the investigator. For instance, [kazm] is the EA word for the spine, or binding of a book. Vaux's (1998) list in (39), however, lists this as [kazəm], and overapplication of schwa epenthesis; likewise with forms such as [astɤ] 'star'. In other words, there is a small but real minority of words such as [jɛɤnik] 'doe' for which high vowels do not delete, not because of any phonological

<sup>3</sup> Note that this does not prevent words such as [stipeɫ] 'to hasten' and [ʃtɔp] 'haste', which have extrametrical appendix sibilants according to Vaux (1998).

reason; such words must be learned (i.e. [jɛʁniki] ‘of the doe’, not \*[jɛʁnki], \*[jɛʁnəki], or \*[jɛʁnki]).

In conclusion, deletion is preferred over consecutive schwas, and reduction does not at all interfere with the claim that EA assigns final stress consistently. The phonotactic restriction against consecutive schwas and the demand of iambs results in both reduction in (13) and preservation in (14); it also explains deletion in (12). This analysis is consistent with the hypothesis that EA assigns word-final stress consistently, without altering final vowel quality (crucially only non-final, high vowels in derived environments).

### 3 Acoustic evidence for EA metrical structure

Without phonological evidence for EA metrical structure, it is necessary to seek phonetic evidence. The majority of stress descriptions are impressionistic (Gordon 2004, de Lacy 2007). However, there are two phonetic experiments that relate to acoustic correlates of the claimed stress pattern. One is written in Armenian (Khachatryan 1988) and finds results consistent with the claimed sonority-driven stress pattern, namely that stressed, final full vowels are lengthened in duration.

The other—Gordon et al. (2012)—is not intended to be an examination of the acoustics of Armenian stress. Their finding in that study is that Armenian schwa has a larger mean maximum intensity than the high vowels.

Consequently, the following sections describe an experiment that aimed to identify the acoustic correlates of EA metrical heads and non-heads. There are two obvious competing hypotheses in light of the claimed stress pattern for Armenian. One hypothesis is that of the claimed pattern, namely that Armenian stress is sonority-driven, with default final stress that retracts to the penult if the final vowel is a schwa. The alternative hypothesis considered here is that Armenian stress is not sonority-driven, and that stress is always final.

The two hypotheses assign the same metrical structure except in words with the shape CV(C)CəC (where V is not schwa). In just this situation, the sonority-driven hypothesis makes the penult the metrical head, while the final stress hypothesis makes the final syllable the head.



### 3.1 Hypotheses

In considering the acoustic realization of metrical heads and non-heads, the two hypotheses' predictions can be expressed as in (15) and (16).

#### (15) Sonority-Driven Stress Hypothesis

For the word shapes  $CV_1CV_2C$  and  $CV_3C\text{ə}C$ , putatively stressed  $V_2$  and  $V_3$  will pattern together on one or more acoustic parameters, while  $V_1$  will pattern separately from  $V_2$  and  $V_3$ , and may agree on one or more acoustic parameters with  $[\text{ə}]$ .

#### (16) Final Stress Hypothesis

For the word shapes  $CV_1CV_2C$  and  $CV_3C\text{ə}C$ , putative metrical heads  $V_2$  and  $[\text{ə}]$  will differ from putative non-heads  $V_1$  and  $V_3$ , respectively, on one or more acoustic parameters;  $V_2$  and  $[\text{ə}]$  may agree on some acoustic parameters, and  $V_1$  and  $V_3$  will agree on some parameters.

These predictions encapsulate the recognition that metrical heads are realized differently in various languages. For example, metrical heads and non-heads may be distinguished by different vowel durations (e.g. Kim 2011 on Spanish), vowel qualities (Beckman & Edwards 1994), intensity (Fry 1955), fundamental frequency (Lieberman 1960), spectral tilt (Campbell & Beckman 1997), and in other ways, too. A priori, it was not known how EA metrical heads were expressed acoustically, so duration, intensity,  $F_0$ , and vowel quality were examined.

### 3.2 Methods

Actually occurring (i.e. non-wug) words of the shape  $[CV_1CV_2C]$  and  $[CV_3C\text{ə}C]$  were recorded, where  $V$  is a full vowel that varies among  $[\text{a}, \text{ɔ}, \text{u}, \text{i}]$ .  $[\text{ɛ}]$  only occurs in  $V_2$ , so it was not included here.

Almost all of these words are morphologically-related pairs, sharing the same root: e.g.  $[\text{ha.t-is}]$  to my piece cf.  $[\text{ha.t-əs}]$  my piece. They are formed by combining a CVC

root with either a -VC case suffix or a -C possessive suffix (in which case a schwa would be inserted, leading to surface CVCəC).

There are schwa-initial words due to high vowel reduction (i.e. CəCVC), but if either stress hypothesis is correct, then stress would land on the final, full vowel in these cases.

Using roots ending in vowels would result in no forms with schwa in second position. Wug words were not used so as to avoid any hyperarticulation that might inadvertently accompany such words. The target words are provided in Appendix A.

To avoid list intonation, all target words were placed within two frame sentences.

(17) Frame sentences

Մեկ մեկ _____ բառն եմ ասում:		[target in focus]
mek mek _____ bar-n	em	as-um
sometimes _____ word-DEF	AUX.1.sg	say-PRES
“Sometimes I say the word _____.”		

_____ բառը հետաքրքիր ւ:		[target not in focus]
_____ bar-ə _____ hetakərkir	a	
_____ word-DEF interesting	be.3.sg.PRES	
“The word _____ is interesting.”		

The purpose of recording the target in focused and non-focused frames was to avoid focus effects on prosody and acoustics while retaining the possibility of investigating those same effects, if they arose. The terms ‘focused’ and ‘non-focused’ are used here to mean ‘new information’ and ‘old information’. Each word was said in both sentences with the focus frame immediately preceding the non-focus frame. The goal was for the target word to be new information for the first sentence, and potentially attract focus stress, while for the second sentence it would be old information and potentially not attract particular focus stress. This allows the separation of the influence of intonation and different phrasing from word stress, a point emphasized by Gordon (2014).

The stimuli set included filler target words. There were three randomized repetitions of the stimuli set, resulting in three recording cycles with breaks in between for each participant. The participants were taught the frame sentences before the recording sessions, and were presented each individual word on a computer screen as black text on a white background in clear, large font. The text was in Armenian script so as to avoid any influence from the various possible transliterations of the language into the Latin alphabet.

Three native Armenian speakers who emigrated from Armenia to the United States as adults were recorded at the Rutgers Phonology and Field Research Laboratory. The results of one of those speakers is presented here. The subjects were asked the following:

- How often they spoke Armenian at home as a child
- Which dialect of Armenian they speak
- The languages they currently speak at home, the percentage of time spoken, and age acquired
- Age and duration for which they studied other languages
- States and countries they have lived in, and during which years of their lives
- How often they speak Armenian since having been in the US
- Whether they have or have ever had difficulties speaking

The subjects were recorded in a sound-attenuated booth using a head-mounted microphone (AKG C420 condenser) to maintain consistent distance between the mouth and the microphone piece. The microphone was connected to an ART MPA Gold Microphone Preamplifier. The preamplifier was in turn connected to a sound card (M-Audio Delta 1010LT) installed in a custom built silent fanless PC so as to avoid as much external and electrical noise as possible. The audio files were recorded in Goldwave v5.70 in two channels at 44.1 kHz 16-bit resolution, lossless WAV format. The booth's microphone was in the left channel and a microphone outside the booth in the right channel (later removed from the file).

The audio file for each recording was split into multiple files such that each file contained both frame sentences for a single target word. The target in each frame in each file was annotated in Praat (Boersma & Weenink 2015) such that beginning of vowels were marked at the zero-crossing of the upward swing of the first periodic signal in the waveform. Vowel ends were marked similarly but at the zero-crossing of the downward swing of the last periodic signal. A sudden fall in the amplitude of F2 was used as a secondary criterion for when the waveform-based criterion failed (e.g. in a few cases with residual voicing). A fixed portion of each frame was marked as well so as to allow for speech rate per frame instance. The author annotated all files, with half of all files being annotated also by three undergraduate research assistants; the latter annotations were used to ensure a more accurate assessment of the vowel boundaries.

VoiceSauce (Shue et al. 2011) was used to automatically calculate F0, F1 and F2 for each target vowel; it was set to calculate F0 and the first two formants using Praat. The F0 settings were set to a range of 100-500 Hz, with smoothing, interpolation, and elimination of octave jumps. The formant settings were set to a maximum of 5500 Hz (as the subjects were all female), with 5 formants. Custom software was used to also calculate the duration and intensity using Praat's intensity calculation of each target vowel as a batch. Of four of the acoustic parameters (intensity, F0, F1, F2), the mean of the middle third portion of each target vowel was measured for each acoustic parameter so as to obtain the most stable portion of each vowel.

### **3.3 Results**

The finding is that Armenian stress is final, and not sonority-driven (i.e. not sensitive to the presence of a final schwa). The acoustic correlate of this final stress pattern is a rise in

F0 with the high point ending on the final vowel of the word. The other acoustic parameters that were measured (duration, intensity, F1, and F2) exhibit a correlation with neither the Sonority Driven Stress Hypothesis nor the Final Stress Hypothesis.

Each of the following subsections presents the measurements and results for each acoustic parameter, presenting each of the four vowels [a, ɔ, u, i] in positions V<sub>1,2,3</sub>. A final subsection is dedicated to comparing results for reduced schwas (in initial position) and epenthetic schwas (in final position).

Only results for one speaker are presented below. This speaker was subjectively the clearest of all participants insofar as it was easily perceptible which vowel qualities the speaker was uttering, crucial in determining whether a token exhibited high vowel reduction. It may be the case that analysis of the other speakers may bring to light a different pattern or set of patterns; this paper aims to demonstrate which hypothesis better explains the behavior exhibited by the phonology of this speaker.

As there was no significant effect of focus on the acoustic parameters (with the exception of overall raised pitch), the results below demonstrate the combined mean values for both focused and non-focused frames.

Note that significance here is meant as a statistically significant difference with an analysis p-value of less than 0.01 (following the phonetics literature).

### **3.3.1 Duration**

The duration of each vowel was normalized by multiplying the vowel's duration by a speech rate multiplier, calculated as proportional to the average duration a fixed portion of the frame sentence.

The results show that there is no evidence that vowels' durations differ meaningfully in different positions in the word. The only exception was for [i]: [i] in CiCəC forms was significantly shorter than in CVCiC. However, the difference is not perceptible<sup>4</sup>—for [i] a 5 ms difference between the means (a 9% difference). The importance of the fact that this difference is not perceptible is that it may provide a cue (or at least a secondary cue) for an infant learning the language. If no single or combination of acoustic parameters patterned with metrical prominence, then a learner would have no evidence to exhibit a phonetic behavior consistent with the acoustically distinct realization of metrical heads.

If the sonority-driven stress hypothesis was correct, one might expect these vowels to have the same duration, or at least both be longer than the putatively unstressed vowel in CiCVC/CuCVC.

However, duration also does not support the final-stress hypothesis: final vowels are not consistently longer than penultimate ones. In fact, the penultimate vowel in CVCVC vs. the final vowel in CVCVC did not differ in duration for any vowel—an unexpected result for both hypotheses if headedness influences duration.

It is important to realize that post-vocalic consonants in particular pose an ability to skew the duration of their preceding vowels (e.g. lengthened duration when followed by a sibilant or a voiced consonant) (de Lacy 1998). To minimize this effect, the middle consonant of the stimuli was almost always a voiceless obstruent. To increase the number of stimuli, it was necessary to include forms such as the first person possessive suffix [-s], which is a sibilant. As such forms had final schwas, this effect was primarily

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<sup>4</sup> The just-noticeable difference (JND) for duration is approximately 20% (Klatt 1976).

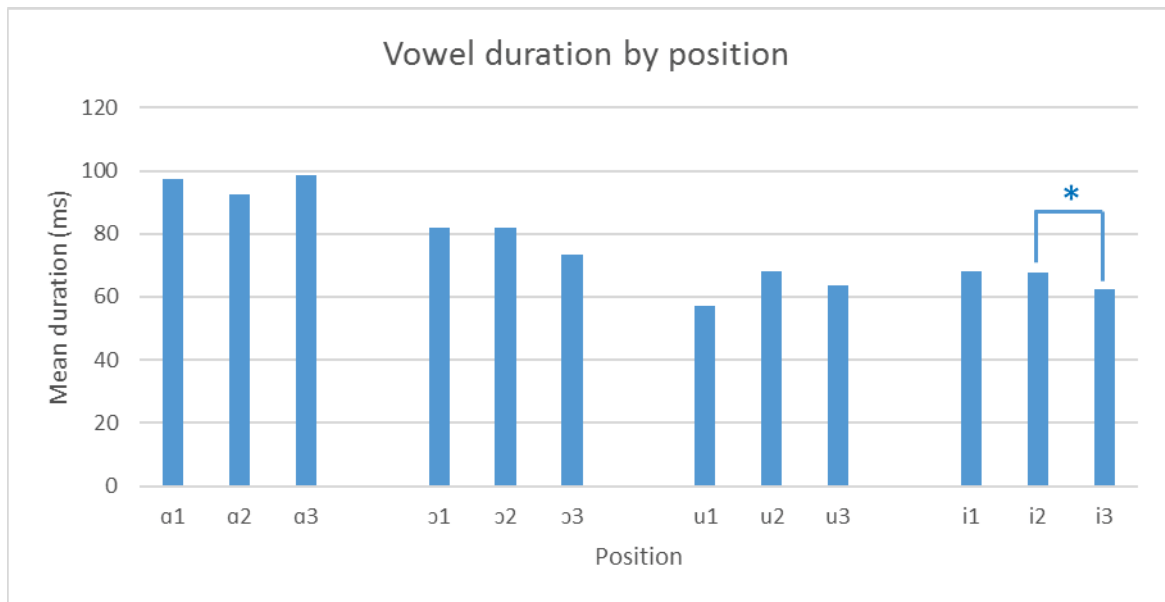
counterbalanced by having the very same monosyllabic CVC roots with a dative [i] intervening between the root and the first person possessive [s]. This allowed for approximately the same number of post-vocalic sibilants having an effect on schwas as on final vowels. The same applied to post-vocalic voiced consonants, particular in CVC roots, although such forms were as limited as possible.

Another factor to consider is whether a syllable being open or closed has an effect on the duration of a vowel in EA independent of stress. If closed syllables in EA are shorter than open syllables, all else being equal, then notwithstanding stress, it is expected that  $V_2$  (in a closed syllable) should be shorter than  $V_1$  and  $V_3$ . The duration measurements indicate no significant difference in the duration of vowels by position. If closed syllables are shortened, and stress lengthens the duration of a vowel in EA, then the results are consistent with stress on  $V_2$ , but crucially not on  $V_3$ , as  $V_3$  is not longer in duration (what would be expected of a stressed, open syllable). This is consistent with the final stress hypothesis, but partially inconsistent with the sonority-driven stress hypothesis as that hypothesis would anticipate lengthened duration on  $V_3$ .

If, on the other hand, the duration of closed syllables in EA are not significantly different from open syllables, then the results are actually not consistent with either stress hypothesis entertained in this paper. That is, one would anticipate a longer  $V_2$  in either hypothesis, as well as a longer  $V_3$  (as compared to  $V_1$ ).

(18) Vowel durations (in ms) in three positions:  $\underline{CV}_1CVC$  vs.  $CVC\underline{V}_2C$  vs.  $\underline{CV}_3C\grave{a}C$ 

	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	Differences		
	$\underline{CVCVC}$	$CVC\underline{VC}$	$\underline{CVC}\grave{a}C$	$\underline{CVCVC}$ vs $CVC\underline{VC}$	$\underline{CVCVC}$ vs $\underline{CVC}\grave{a}C$	$\underline{CVCVC}$ vs $\underline{CVC}\grave{a}C$
a	97.52 (n=168,sd=17.5)	92.68 (n=60,sd=11.6)	98.6 (n=60,sd=17.7)	p = 0.117 <sup>5</sup>	p = 0.898	p = 0.114
ɔ	81.88 (n=36,sd=12.6)	81.78 (n=42,sd=11.7)	73.34 (n=12,sd=10.2)	p > 0.999	p = 0.215	p = 0.211
u	57.15 (n=12,sd=17.4)	68.24 (n=60,sd=13.5)	63.55 (n=60,sd=14.8)	p = 0.055	p = 0.372	p = 0.205
i	67.92 (n=18,sd=18.7)	67.76 (n=264,sd=11)	62.23 (n=60,sd=8.5)	p = 0.998	p = 0.157	p = 0.002

Figure 1. Vowel durations in  $\underline{CV}_1CVC$  vs.  $CVC\underline{V}_2C$  vs.  $\underline{CV}_3C\grave{a}C$  <sup>6</sup>

Significance was calculated using an ANOVA and Tukey's test. The ANOVA was performed to test variation between the three sample means (i.e. three full-vowel positions), while Tukey's test (honest significant difference) was performed as part of a post-hoc analysis in determining which pairs of sample means were significantly different (i.e. a single step multiple comparison).

<sup>5</sup> All p-values are rounded to the nearest 0.001.

<sup>6</sup> An asterisk indicates a statistically significant difference as per a p-value below 0.01.



### 3.3.2 Intensity

The final stress hypothesis predicts similar intensities for  $V_1$  and  $V_3$ , while the sonority-driven stress hypothesis predicts similar intensities for  $V_2$  and  $V_3$ . The results indicate that intensity is not a correlate of stress, regardless of the two hypotheses.

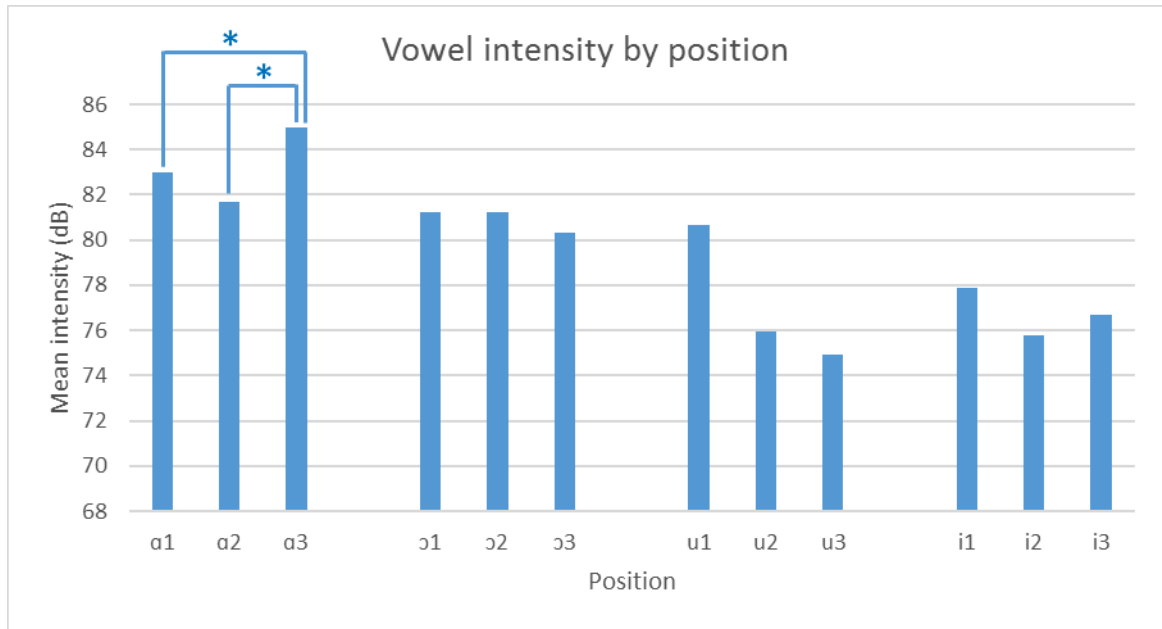
Analysis found a significant difference among the intensities of  $\alpha_1$  and  $\alpha_3$ , and  $\alpha_2$  and  $\alpha_3$ . Given that in either hypothesis  $\alpha_1$  is unstressed and  $\alpha_2$  is stressed, this result does not fully support either hypothesis insofar as the means of the intensities of  $\alpha_1$  and  $\alpha_2$  are not significantly different. The significantly higher intensity of  $\alpha_3$  compared to that of  $\alpha_1$  may be a result of observational error, given the surprisingly large standard deviation values for some of the sample groups.

Furthermore, the JND for intensity is about 0.6 dB at a sensation level of 60 dB in a normal ear at 250 Hz, and the JND decreases to about 0.4 dB at a sensation level of 80 dB (Zwislocki & Jordan 1986). Given the large spread of the data points, however, it is not clear that the results suggest intensity to be a productive and perceptible indicator of stress.

What is important to note here is that there was an error in data collection regarding intensity, as the gain on the digital preamplifier was modified while recording the stimuli. This is evident in the unexpectedly large standard deviations, the reason why despite large differences in means, there are no statistically significant differences found in the different positions for [u] and [i]. A controlled replication study would pan out whether or not intensity (or perhaps intensity contours) patterned with either stress hypothesis.

(19) Vowel intensities (in dB) in three positions:  $\underline{CV}_1CVC$  vs.  $CVC\underline{V}_2C$  vs.  $\underline{CV}_3C\text{ə}C$ 

	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	Differences		
	$\underline{CV}CVC$	$CVC\underline{V}C$	$\underline{CV}C\text{ə}C$	$\underline{CV}CVC$ vs $CVC\underline{V}C$	$\underline{CV}CVC$ vs $\underline{CV}C\text{ə}C$	$CVC\underline{V}C$ vs $\underline{CV}C\text{ə}C$
ɑ	82.97 (n=168,sd=3.5)	81.69 (n=60,sd=2.6)	85 (n=60,sd=3.5)	p = 0.032	p < 0.001	p < 0.001
ɔ	81.24 (n=36,sd=4.9)	81.25 (n=42,sd=3.9)	80.34 (n=12,sd=2.1)	p > 0.999	p = 0.793	p = 0.782
u	80.65 (n=12,sd=7)	75.96 (n=60,sd=6.7)	74.92 (n=60,sd=6.6)	p = 0.072	p = 0.021	p = 0.673
i	77.87 (n=18,sd=7)	75.78 (n=264,sd=4.4)	76.67 (n=60,sd=3.4)	p = 0.124	p = 0.565	p = 0.331

Figure 2. Vowel intensities in  $\underline{CV}_1CVC$  vs.  $CVC\underline{V}_2C$  vs.  $\underline{CV}_3C\text{ə}C$ 

### 3.3.3 Quality

If vowel quality correlates with stress in EA, then parameters associated with quality (F1 for height, F2 for backness) should pattern such that, for instance, stressed vowels group in a vowel space region that is significantly distinct and removed from that of unstressed vowels. As an example, unstressed vowels may be more centralized than stressed vowels.

Notwithstanding observational error, the results heavily suggest no correlation between vowel quality and stress. In both the final stress hypothesis and the sonority-driven stress hypothesis of EA stress,  $V_1$  is unstressed and  $V_2$  is stressed. Furthermore, the

direction of vowel quality shift for the low vowel is unexpected; final, stressed  $\alpha_2$  is more centralized than penult, unstressed  $\alpha_1$ . Ultimately, as the quality shift is not significant and consistent, vowel quality fails to behave as a reliable, consistent correlate of stress. Visually, as graphed in Figure 5, none of the vowels perform a qualitatively significant shift in quality due to position or stress.

(20) Vowel F1 (in Hz) in three positions:  $\underline{C}\underline{V}_1\underline{CVC}$  vs.  $CVC\underline{V}_2C$  vs.  $\underline{C}\underline{V}_3C\alpha C$

	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	Differences		
	$\underline{C}\underline{V}\underline{CVC}$	$CVC\underline{V}C$	$\underline{C}\underline{V}C\alpha C$	$\underline{C}\underline{V}\underline{CVC}$ vs $CVC\underline{V}C$	$\underline{C}\underline{V}\underline{CVC}$ vs $\underline{C}\underline{V}C\alpha C$	$CVC\underline{V}C$ vs $\underline{C}\underline{V}C\alpha C$
$\alpha$	874 (n=168,sd=114)	825.9 (n=60,sd=119)	894.4 (n=60,sd=52.1)	p = 0.008	p = 0.404	p = 0.001
$\alpha$	507.7 (n=36,sd=56.5)	524.3 (n=42,sd=72.2)	586.8 (n=12,sd=108.6)	p = 0.571	p = 0.004	p = 0.026
u	377.6 (n=12,sd=77.8)	396.9 (n=60,sd=147.4)	383.4 (n=60,sd=115.9)	p = 0.885	p = 0.989	p = 0.834
i	285.5 (n=18,sd=29.7)	313.9 (n=264,sd=28.8)	324.5 (n=60,sd=53.5)	p = 0.002	p < 0.001	p = 0.080

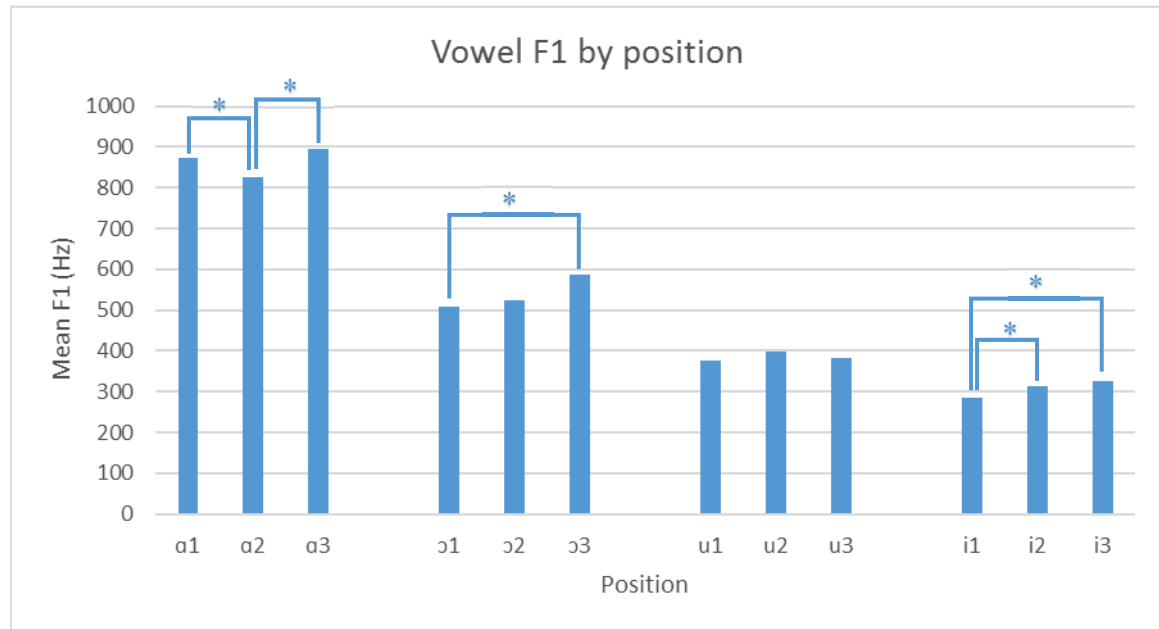


Figure 3. Vowel F1 in  $\underline{C}\underline{V}_1\underline{CVC}$  vs.  $CVC\underline{V}_2C$  vs.  $\underline{C}\underline{V}_3C\alpha C$

(21) Vowel F2 (in Hz) in three positions:  $\underline{C}\underline{V}_1\underline{CVC}$  vs.  $CVC\underline{V}_2C$  vs.  $\underline{C}\underline{V}_3C\text{ə}C$

	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	Differences		
	$\underline{C}\underline{V}\underline{CVC}$	$CVC\underline{V}C$	$\underline{C}\underline{V}C\text{ə}C$	$\underline{C}\underline{V}\underline{CVC}$ vs $CVC\underline{V}C$	$\underline{C}\underline{V}\underline{CVC}$ vs $\underline{C}\underline{V}C\text{ə}C$	$CVC\underline{V}C$ vs $\underline{C}\underline{V}C\text{ə}C$
a	1528 (n=168,sd=233.3)	1692 (n=60,sd=199.6)	1449 (n=60,sd=249)	p < 0.001	p = 0.062	p < 0.001
ɔ	1272 (n=36,sd=301.5)	1449 (n=42,sd=384.4)	1382 (n=12,sd=276.4)	p = 0.064	p = 0.601	p = 0.821
u	1081 (n=12,sd=127.4)	1288 (n=60,sd=401.8)	1161 (n=60,sd=351.5)	p = 0.171	p = 0.766	p = 0.136
i	2176 (n=18,sd=889.8)	2170 (n=264,sd=803.9)	2277 (n=60,sd=745.5)	p > 0.999	p = 0.884	p = 0.613

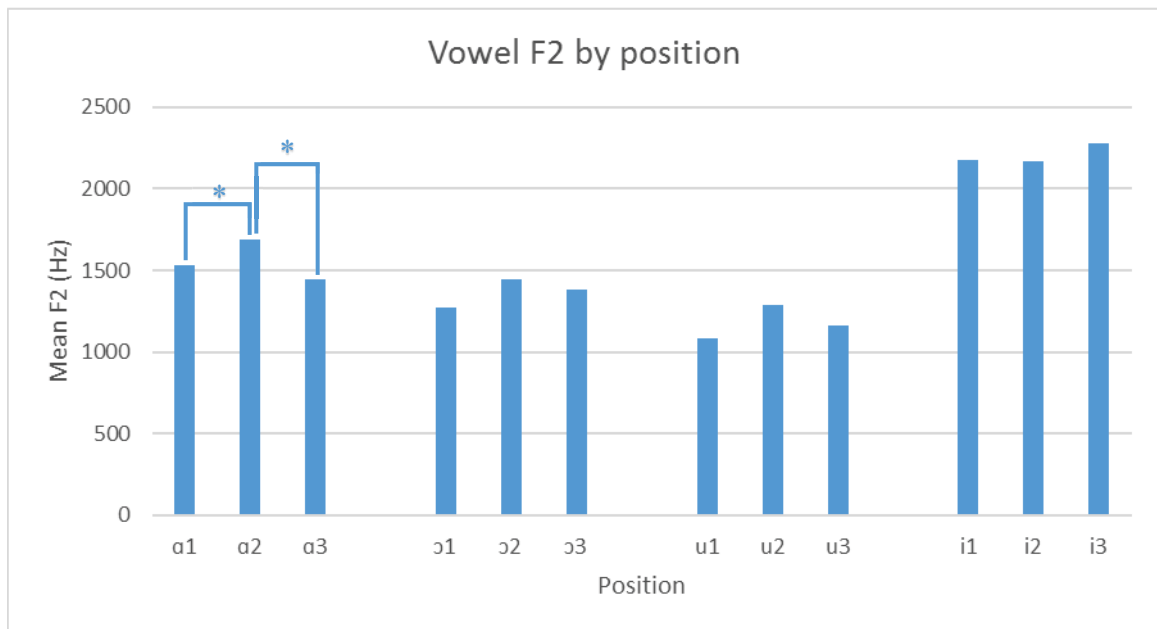


Figure 4. Vowel F2 in  $\underline{C}\underline{V}_1\underline{CVC}$  vs.  $CVC\underline{V}_2C$  vs.  $\underline{C}\underline{V}_3C\text{ə}C$

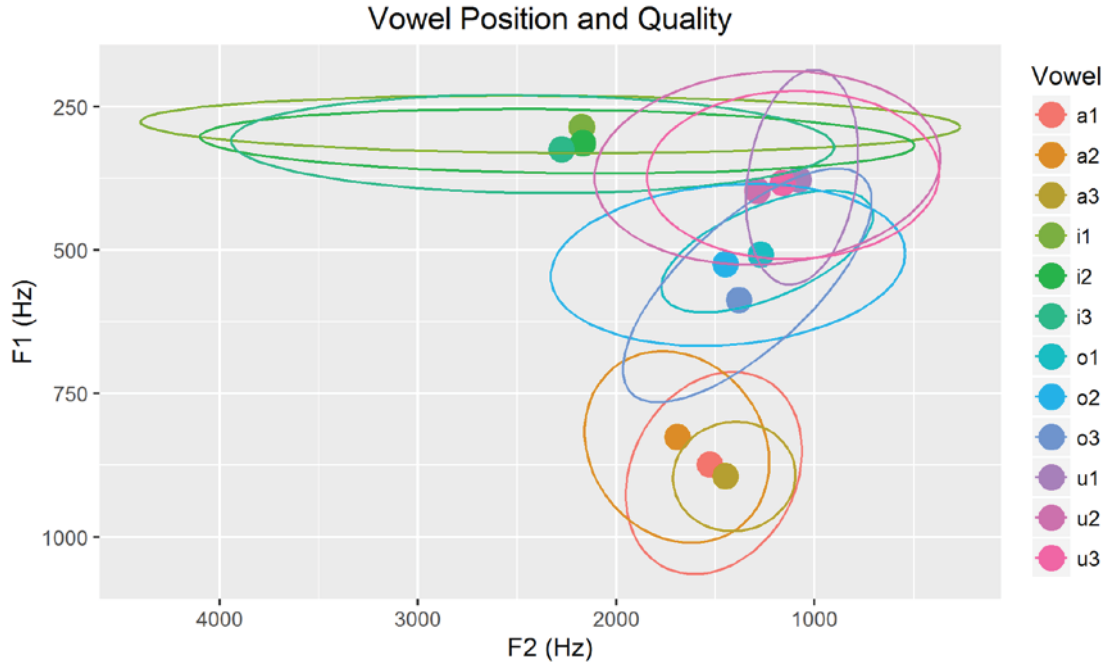


Figure 5. Vowel quality (plotted as F2 vs. F1) in  $CV_1CVC$  vs.  $CVCV_2C$  vs.  $CV_3CəC$

### 3.3.4 F0

F0 was analyzed by comparing F0 contours of CVCVC words and CVCəC words. If the final stress hypothesis is correct, the contours are predicted to be similar. Namely, the F0 maxima and minima are expected to be realized at proportionally similar time locations in the word. If the sonority-driven stress hypothesis is correct, there is expected to be a difference in the F0 contours of the two word shapes. This difference can be realized either as an inversion of the tones assigned to the syllables, or a significant shift in the time locations of the F0 maxima and/or minima.

To ensure minimal effect on vowel duration and F0, the middle and final consonants in both word shapes were nearly always voiceless.

Since speech rate varied from token to token, this was accounted for by time-normalizing the contours using the ProsodyPro script for Praat (Xu 2013).

It is evident in Figure 6 that the F0 contours are identical between the two word shapes.<sup>7</sup> That is, the F0 excursion is the same, and the local minima and maxima are virtually identical between CVCVC and CVCəC words. Due to words with schwa being inherently shorter, CVCəC words have a steeper initial rise in F0, but both word types begin in approximately the same L state and end on the same H state at almost precisely the same time.

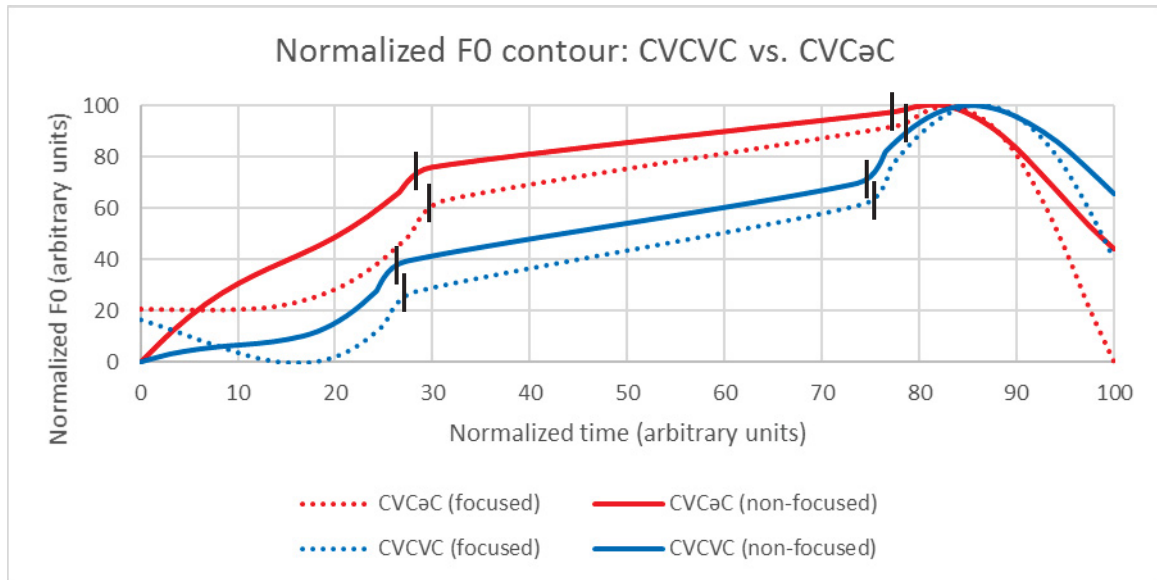


Figure 6. Normalized F0 contours (CVCVC blue, CVCəC red)

<sup>7</sup> The black vertical bars in Figures 6 and 7 demarcate the boundaries of the interpolated linear region between the two vowels in each word shape. This is a non-vocalic region and may be disregarded.

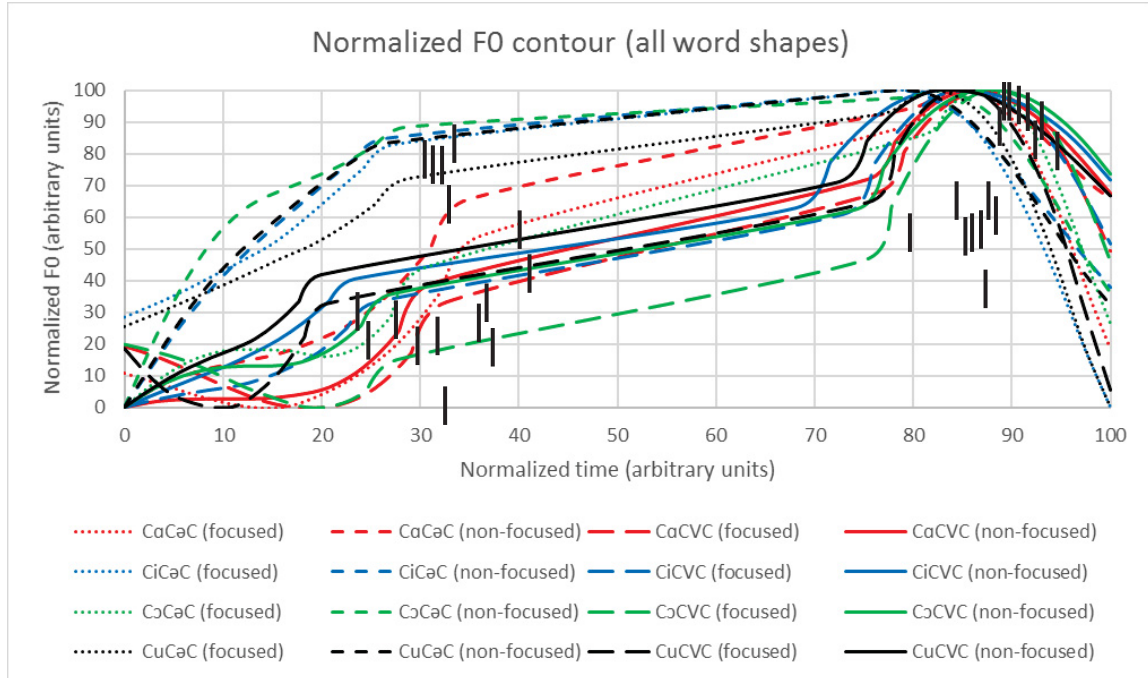


Figure 7. Normalized F0 contours for all word shapes and vowels

As best illustrated in Figure 7, the L and H tones in the F0 excursion that occurs across all word shapes and vowels occupy virtually the same point in time across all word shapes. The same time locus exists for both low and high tones, with normal variation and an overall rise in absolute F0 due to focus. Remaining differences are primarily due to inherent differences in F0 of the various vowel qualities. This accords with the final stress hypothesis, with consistent time loci for the L and H tones across word shapes. The sonority-driven stress hypothesis predicts two distinct time loci and/or tone loci (e.g. HL instead of LH), one for V-final words and one for schwa-final words; this, however, is not consistent with the results.

### 3.3.5 Schwa [ə]

Schwas were realized in two positions: either from high vowel reduction in the first syllable of a CVCVC word, or from epenthesis in a suffixed root /CVC-C/. Both schwas are analyzed here, separate from the full vowels, so as to investigate 1) whether the schwas

behave similarly, and 2) whether their acoustic realization accords to either stress hypothesis.

According to the final stress hypothesis, the two schwas must be distinct in one or more acoustic parameter; on the other hand, the sonority-driven stress hypothesis predicts that both schwas are similar acoustically, notwithstanding unrelated factors (e.g. lengthened duration at the end of a word, domain-initial fortition, and so on).

The durations of the two schwas are significantly different, but the difference is not perceptible (final schwas are roughly 14% longer in duration).

Final schwas are more intense, in accord with the final stress hypothesis. Given significant overlap within one standard deviation of both sample groups, and the lack of a consistent pattern in the intensities of the full vowels, it is not evident that intensity behaves as an acoustic correlate of stress here.

The quality of both schwa types are nearly identical. They occupy the same region of the vowel space, making vowel quality not a correlate of stress (consistent with the pattern in the full vowels). This supports neither stress hypothesis. Although initial schwas are significantly more back than final schwas, geometrically the two overlap. If this is a robust pattern, it may be due to the fact that the initial schwas in the current experiment originate from high vowel reduction (though the height of the two schwas is nearly identical).

The mean pitch of the schwas follows the pattern of both F0 contours examined in the previous section. Namely, there is a low tone on the first vowel, and a high tone on the final vowel. This is in accord with the final stress hypothesis. As shown in the previous section, the range of F0 minima to maxima between the two schwas is compressed,



exhibiting a tighter range of frequencies than that of the tokens composed entirely of full vowels.

(22) Acoustic characteristics of schwa in two positions:  $C\vartheta_1CVC$  vs.  $CVC\vartheta_4C$

	$\vartheta_1$	$\vartheta_4$	Differences
	$C\vartheta_1CVC$	$CVC\vartheta_4C$	$C\vartheta_1CVC$ vs $CVC\vartheta_4C$
Duration (ms)	49.72 (n=120,sd=8.3)	56.77 (n=240,sd=11.4)	$p < 0.001$
Intensity (dB)	73.47 (n=120,sd=4.6)	75.96 (n=240,sd=3.3)	$p < 0.001$
F1 (Hz)	476.6 (n=120,sd=114.8)	467.2 (n=240,sd=90.1)	$p = 0.396$
F2 (Hz)	1960 (n=120,sd=244.4)	1899 (n=240,sd=250.5)	$p = 0.031$
F0 (Hz) [non-focused]	235.3 (n=60,sd=16.9)	270 (n=120,sd=31.7)	$p < 0.001$
F0 (Hz) [focused]	272.2 (n=60,sd=24.2)	307.6 (n=120,sd=31.1)	$p < 0.001$

### Vowel Position and Quality

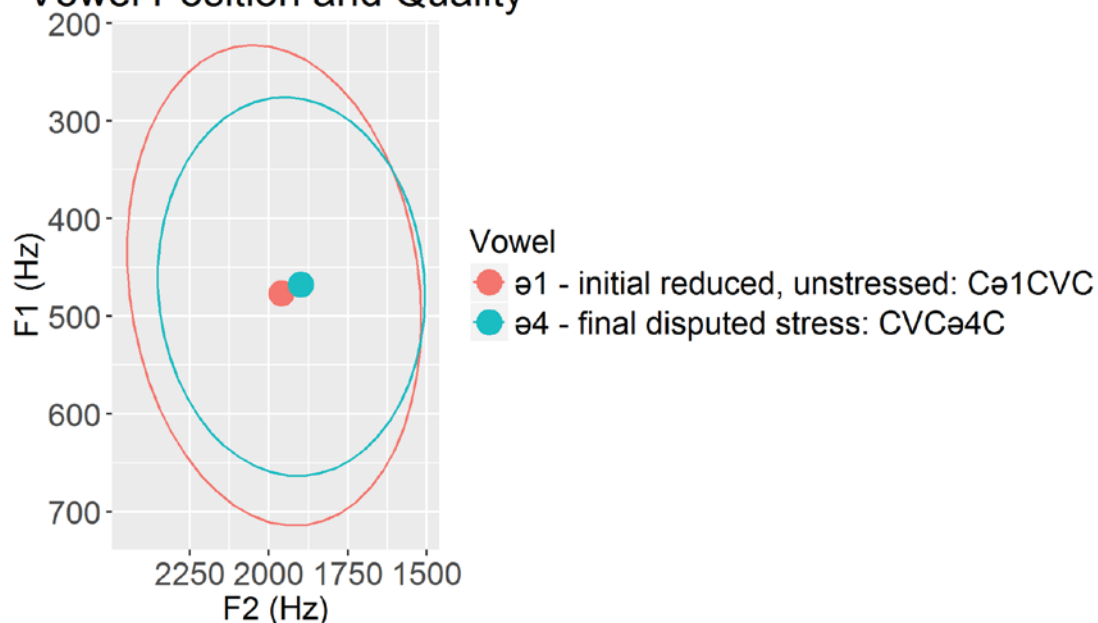


Figure 8. Vowel quality of schwa in two positions:  $C\vartheta_1CVC$  vs.  $CVC\vartheta_4C$

## 4 Discussion

Between the measurements of normalized duration, intensity, F0 and quality for each vowel in each disyllabic stimulus, only F0 showed a consistent and perceptible pattern of interest vis-à-vis the hypotheses presented in section 3.1.

The results are consistent with a hypothesis that there is a high pitch accent on the final vowel of each target word, regardless of vowel quality or sonority. This corroborates the Final Stress Hypothesis, which indicates precisely that Armenian word-level stress is predictably assigned to the final syllable of a word without regard to final vowel quality.

There may be alternative reasons as to why previous descriptions of EA claim that words are stressed on their final full vowel. For instance, the end of a word may be lengthened, as with phrases and utterances (Oller 1973). Yet schwas are inherently shorter than the full vowels. All final full vowels in this study were above the 20% JND for duration over final schwas, with the exception of final [i] which was just shy at 19%. On the same note, Gordon (2011) notes that the perception of stress can potentially be a local phenomenon. That is, for a CVCəC word, since V is virtually always perceptibly longer than ə, V will be perceived to be stressed. This would potentially be exacerbated if EA exhibits shortened duration of vowels in closed syllables.

As far as grammatical descriptions of EA stress being retracted in schwa-final words, this may be the case if the only reference being tested was a set of words with a definite suffix (realized as [-ə] after consonant-final stems). The reason for this is that if the definite marker is not a suffix but a clitic, it may not even be part of the prosodic word and hence not receive any accent, thus giving the semblance of a penult-stressed word. Of course, for any impressionistic description by a non-Armenian speaker, there may have

been significant bias from the authors' native language phonologies (e.g. in English, full vowels consistently attract stress at the expense of schwa). As for the Armenian phonetic study (Khachatryan 1988), it may be that the speaker in the current study behaves differently from those studied in the former study. A follow-up analysis of the other two participants of the current study will hopefully reveal any interspeaker variation, if it be the case. If, however, it turns out that EA speakers consistently accent the final vowel of a word, then alongside the findings of Shih (2015) for Gujarati, this should make phonologists reconsider whether other descriptions of sonority-driven stress systems are actually results of any combination of analytical error, L1 perceptual bias of fieldworkers, and other such factors. At the least this would warrant rigorous experimental work to put such descriptions to the test. Either way the results would be vital, whether in providing confirmation or dismantling faulty descriptions of stress.

Finally, one should ask whether the results for EA warrant the need for metrical structure at all in the language. Absent a full phonological analysis of high vowel reduction/deletion under the paradigm suggested here, it is not clear whether any morpho-phonological or phonological processes necessarily refer to metrical structure. It may be the case that any and every word ends in an LH tone excursion and that acts as a word boundary rather than an active process of metrical assignment. Testing this would require a richer pool of target words, including at the least trisyllabic stimuli as well as stimuli whose endings are possibly extrametrical (such as the previously mentioned definite marker, a potential clitic). On top of this there is the constant potential for interference from intonation. A much-needed addition would be a baseline assessment of the intonational patterns of EA alongside their syntactic structures, so as to improve the design of the

current experiment to avoid the placement of target words in any intonational “hot spots” of activity (e.g. phrasal boundaries, focal positions, and so on).

#### **4.1 Limitations and Future Directions**

Despite the findings, this phonetic study does have its limits.

One is that the form of the experiment does not permit determination of the phrase-level at which the LH\* contour is assigned. In this experiment, LH\* occurred at the end of the target words, but that does not necessarily mean that it appears at the end of every PrWd; it may be the case that Armenian demarcates phrasal boundaries with intonational markers. Syntactically, the stimuli were not at the edge of the determiner phrase they were placed in. However, it would be a worthwhile future research project to pursue this line of thought, experimenting as to whether phrasal boundaries in Armenian are demarcated by way of intonational markers.

In addition, the targets were all disyllabic. The problem with disyllabic words is that the penultimate syllable is also the initial syllable, and initial syllables may be targets of fortition (Cho & Keating 1999), and phonologically privileged, too (Beckman 1998). In the future, I plan to revisit this study with an updated library of target words that span across disyllabic, trisyllabic and perhaps larger words. Although the target words ended in closed syllables, the fact that the word immediately following the target word in either frame began with a voiced stop may have at the least influenced the duration of the final syllable of the target word. This would be improved upon by reimagining the frame sentences to counteract such an effect. Furthermore, a syntactic breakdown of various possible frames would help more accurately specify whether the target is in a position of syntactic focus. Also of interest would be a study specifically designed to analyze

acoustically whether the various sources of schwa in EA differ in their realization; in particular, I would examine schwa from epenthesis, reduction, and lexical schwa, all crossed with varying positions in words (as far as the morphology would allow it).

## **5 Conclusion**

This paper has shown that Eastern Armenian stress is consistently final in the PrWd. This finding contrasts with previous grammatical descriptions as having a stress system conditioned by the presence or lack of schwa in the final syllable of a word. The argument presented was two-fold: 1) the process of high vowel reduction (or deletion) in EA, as used in previous descriptions to reinforce a Sonority-Driven Stress Hypothesis, can be accounted for independently by phonotactic restrictions on schwa, and 2) acoustic data corroborates a Final Stress Hypothesis whereby accent is placed on the final vowel, without regard for its sonority or quality.

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## 7 Appendix

The following table contains all 124 words read by the subject, with filler words highlighted in yellow. Words in Armenian script—presented individually to the subject on a computer monitor—are accompanied by the corresponding pronunciation in standard modern EA.

(23) Stimuli for the experiment, including filler words

Stimuli				Filler	
Armenian	IPA	Armenian	IPA	Armenian	IPA
տատս	ta.təs	գիտս	gi.təs	հաճելի	ha.tʃe.li
տատդ	ta.tət	գիտդ	gi.tət	նյարդ	njart <sup>h</sup>
պապս	pa.pəs	ծիտս	tsi.təs	եկեղեցի	je.ke.ʁe.t <sup>h</sup> si
պապդ	pa.pət	ծիտդ	tsi.tət	զեղեցիկ	ze.ʁe.t <sup>h</sup> sik
պատս	pa.təs	ճիտս	tʃi.təs	համաձայն	ha.ma.dzajn
պատդ	pa.tət	ճիտդ	tʃi.tət	ընկույզ	əŋ.kujz
հատս	ha.təs	միտս	mi.təs	ընտանիք	ən.ta.nik <sup>h</sup>
հատդ	ha.tət	միտդ	mi.tət	ընկեր	əŋ.ker
կապս	ka.pəs	խիտս	xi.təs	ընդհանուր	ən.t <sup>h</sup> a.nur
կապդ	ka.pət	խիտդ	xi.tət	ընդհանրապես	ən.t <sup>h</sup> an.ra.pes
տատիս	ta.tis	գտիս	gə.tis	ցտեսություն	t <sup>h</sup> sə.te.su.t <sup>h</sup> jun
տատից	ta.tit <sup>h</sup> s	գտից	gə.tit <sup>h</sup> s	շնորհակալություն	ʃno.ra.ka.lu.t <sup>h</sup> jun
պապիս	pa.pis	ծտիս	tsə.tis		
պապից	pa.pit <sup>h</sup> s	ծտից	tsə.tit <sup>h</sup> s		
պատիս	pa.tis	ճտիս	tʃə.tis		
պատից	pa.tit <sup>h</sup> s	ճտից	tʃə.tit <sup>h</sup> s		
հատիս	ha.tis	մտիս	mə.tis		
հատից	ha.tit <sup>h</sup> s	մտից	mə.tit <sup>h</sup> s		
կապիս	ka.pis	խտիս	xə.tis		
կապից	ka.pit <sup>h</sup> s	խտից	xə.tit <sup>h</sup> s		
զետս	ge.təs	զետակ	ge.tak		
զետդ	ge.tət	աղքատ	aχ.k <sup>h</sup> at		
կետս	ke.təs	միջատ	mi.t <sup>h</sup> fat		
կետդ	ke.tət	պոչատ	po.t <sup>h</sup> fat		
սեպս	se.pəs	ունչատ	un.t <sup>h</sup> fat		
սեպդ	se.pət	բանակ	ba.nak		
պետս	pe.təs	տեսակ	te.sak		
պետդ	pe.tət	տափակ	ta.p <sup>h</sup> ak		
չոփս	t <sup>h</sup> ʃo.p <sup>h</sup> əs	հաստատ	has.tat		
չոփդ	t <sup>h</sup> ʃo.p <sup>h</sup> ət	զանգակ	zaŋ.gak		
զետիս	ge.tis	ծակոտ	tsa.kot		
զետից	ge.tit <sup>h</sup> s	ցասկոտ	t <sup>h</sup> sas.kot		
կետիս	ke.tis	վախկոտ	vaχ.kot		
կետից	ke.tit <sup>h</sup> s	տախտկոտ	taχt.kot		

սեպիս	se.pis	ձենոնց	dzer.not <sup>h</sup> s
սեպից	se.pit <sup>h</sup> s	բողջոց	boʁ.dʒot <sup>h</sup> s
պետիս	pe.tis	դեղոտ	de.kot
պետից	pe.tit <sup>h</sup> s	Ժանգոտ	ʒaŋ.got
չոփիս	t <sup>h</sup> ʃo.p <sup>h</sup> is	պուտուկ	pu.tuk
չոփից	t <sup>h</sup> ʃo.p <sup>h</sup> it <sup>h</sup> s	գիտուն	gi.tun
մուսս	mu.təs	հատուկ	ha.tuk
մուտդ	mu.tət	մաճուն	ma.tsun
մուկս	mu.kəs	պոչուկ	po.t <sup>h</sup> fuk
մուկդ	mu.kət	մամուկ	ma.muk
սուսս	su.təs	մանուկ	ma.nuk
սուտդ	su.tət	Ժախուկ	ʒa.χuk
սուզս	su.k <sup>h</sup> əs	խոզուկ	χo.zuk
սուզդ	su.k <sup>h</sup> ət	միզուկ	mi.zuk
բուզս	bu.gəs	զատիկ	za.tik
բուզդ	bu.gət	պապիկ	pa.pik
մտիս	mə.tis	տատիկ	ta.tik
մտից	mə.tit <sup>h</sup> s	հատիկ	ha.tik
մկիս	mə.kis	գետիս	ge.tis
մկից	mə.kit <sup>h</sup> s	գետից	ge.tit <sup>h</sup> s
ստիս	sə.tis	կետիս	ke.tis
ստից	sə.tit <sup>h</sup> s	կետից	ke.tit <sup>h</sup> s
սզիս	sə.k <sup>h</sup> is	սեպիս	se.pis
սզիդ	sə.k <sup>h</sup> it	սեպից	se.pit <sup>h</sup> s
բզիս	bə.gis	պետիս	pe.tis
բզից	bə.git <sup>h</sup> s	պետից	pe.tit <sup>h</sup> s