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On affix allomorphy and syllable counting

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1. Introduction[1]

At issue in this paper is the interaction between prosody and morphology; specifically, the way in which metrical structure conditions allomorphy of affixes. I will propose an analysis of various affix allomorphies in Estonian, which are apparently conditioned by the number of syllables in the base to which the allomorphs attach. But as I will show, it is not syllable number that matters, but rather the foot parsing of the complete base-plus-affix combination. This analysis produces new evidence for the relevance of metrical feet to morphology, and for a constraint-based (rather than rule-based) model of the morphology-phonology interface.

The complementary distribution of affix allomorphs can be conditioned by the prosodic structure of the base. Usually one allomorph selects bases of a certain prosodic type, while the other allomorph occurs in the 'elsewhere' case. Prosodic conditioning of allomorphy may take the form of sensitivity to syllable structure (for example, a distinction between bases ending in a consonant and those ending in a vowel, as in Djabugay, discussed below), or sensitivity to base stress (for example, a distinction between bases ending in a stressed syllable and those ending in an unstressed syllable).

As an example of syllable-governed allomorphy, consider the formation of the Genitive in Djabugay (Patz 1991). The Genitive is marked by either:

(1) a. /-n/ after bases ending in a vowel, e.g. guludu 'dove', Gen. guludu-n
b. /-ŋun/ after bases ending in a consonant, e.g. gaɲal 'goanna', Gen. gaɲal-ŋun

The choice of the proper allomorph is partially predictable from CV shape, in particular from the way in which it syllabifies with the base into a PrWd. Djabugay has no syllables that end in a consonant cluster, and therefore the single consonant allomorph -n cannot be attached to a base that is itself consonant-final:

(2)	/-n/	gu.lu.dun	*ga.ɲaln
	/-ŋun/	(?gu.lu.du.ŋun)	ga.ɲal.ŋun

In short, allomorphy never produces ill-formed syllables. Notice that prosody predicts the complementary distribution of both allomorphs only partially, since syllabification alone is insufficient to explain why the allomorph /-ŋun/ cannot be adjoined to vowel-final bases. That is, although the genitive allomorph /-n/ may be for *morphological* reasons preferred over the allomorph /-ŋun/, it may not adjoin when it would violate *prosodic* principles.

In Optimality Theory (Prince & Smolensky 1993, McCarthy & Prince 1993) such prosodically governed allomorphy can be seen as *output optimization* (see McCarthy and Prince 1993, Mester 1994, Bolognesi 1995, Anttila 1995 for similar ideas). For each form the function

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‘*Gen*’ generates all logically possible base-plus-allomorph combinations as *candidate* outputs. Among all candidate outputs the function ‘*Eval*’ selects the *optimal* candidate (c.q. ‘optimal allomorph’) by general output constraints. As always, constraints are *universal,* but *ranked* in a language-specific order. Lower-ranked constraints may be violated in order to satisfy higher-ranked constraints.

Let us see how this model accounts for the Djabugay data. The prosodic constraint at play is *COMPLEX (Prince & Smolensky 1993): “No complex syllable margins”, which is actually unviolated in Djabugay. This constraint dominates the morphological constraint that /-n/ is the ‘best’ genitive allomorph, e.g. GENITIVE=/-n/ (“Genitive is marked by /-n/”)[2]. The constraint ranking *COMPLEX » GENITIVE=/-n/ is illustrated in the tableaux below:

(3)

(i) /gaɲal, Genitive/	*COMPLEX	GENITIVE=/-n/
a. ☞ ga.ɲal.-ŋun		*
b. ga.ɲal-n	*!	

(ii) /guludu, Genitive/	*COMPLEX	GENITIVE=/-n/
a. ☞ gu.lu.du-n		
b. gu.lu.du.-ŋun		*!

It is a language-specific fact that Djabugay happens to have two ‘morphs’ which satisfy the morpho-syntactic specification ‘Genitive’ in the input. But the avoidance of complex onsets is surely a fact of much greater generality - it is a universal markedness constraint that happens to be highly ranked in Djabugay. In sum, prosody-conditioned allomorphy is an instantiation of ‘prosodic morphology’, the domination of prosodic constraints over morphological ones, as summarized in the scheme *Prosody » Morphology* (McCarthy & Prince 1993).

Below I will discuss prosodically governed allomorphy in Estonian, which will provide a strong argument for an output-optimization model of allomorphy.

2. Syllable counting allomorphy in Estonian

Estonian (Mürk 1991) has several morphological categories whose allomorphs depend on the number of syllables of the base. I first discuss the Genitive plural and Partitive plural, and later discuss the less regular allomorphy in the Partitive and Illative singular.

For most declension classes the Genitive plural and Partitive plural are formed on the base of the Genitive singular, a vowel-final stem[3]. Suffix allomorphy is dependent on the number of syllables in this base. The Genitive plural is marked by a suffix /-te/ after bases of two or four syllables, and by a geminate consonant suffix /-tte/ after bases of three syllables (Mürk 1991:281). The Partitive plural is marked by a consonant-initial suffix /-sit/ after bases of two or four syllables, or alternatively, by a mutation of the final vowel of the base (e.g. /a/ → /u/ or /a/ → /e/). It is marked by a vowel-initial suffix /-it/ after bases of three syllables (Mürk 1991:295-296)[4].

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2 Quite plausibly, this constraint might be an instantiation of a universal constraint requiring that morphological categories are marked by minimal means (e.g. the ‘phonologically shortest’ morpheme).

3 Some declension classes exceptionally form their Gen.pl. and Part.pl. on the base of the Part.sg., a stem form that can be consonant-final, see fn. 10.

4 No glosses have been indicated for the Estonian examples since Mürk (1991) does not provide them.

(4)		*Nom.sg.*	*Gen.sg.*	*Gen.pl.*	*Part.pl.*
	2 σ	visa	visa	visa-te	visa-sit *or* vis**u**
		pesa	pesa	pesa-te	pesa-sit *or* pes**i**
	3 σ	paras	paraja	paraja-tte	paraja-it
		raamatt	raamattu	raamattu-tte	raamattu-it
	4 σ	atmiral	atmirali	atmirali-te	atmirali-sit *or* atmiral**e**
		telefon	telefoni	telefoni-te	telefoni-sit *or* telefon**e**

The consonantal length alternations between genitive plural /-te/ and /-tte/ reflect genuine allomorphy rather than a productive phonological process of gemination or degemination. (Although historically, the allomorphy developed from suffixal consonant gradation, cf. Mürk 1991:59[5]). Similarly Estonian has no productive deletion or insertion of /-s-/ that would account for the alternation between partitive plural /-it/ and /-sit/[6].

As a first observation, we note that the allomorphs /-tte/ and /-it/ that follow bases of an odd number of syllables syllabify with the base-final vowel in either of two ways:

(5) a. Stem-final vowel and -t(te) syllabify into a closed syllable: pa.ra.jat.te
 b. Stem-final vowel and -i(t) syllabify into a diphthong: pa.ra.ja͜it

Notice that in both cases, the outcome is a heavy syllable. This observation will be taken up below, after we have looked into the mechnism of syllable counting.

3. How to count syllables?

The question then arises of how to explain the sensitivity of allomorphy to the syllable number of the base. According to a maximally restrictive view, expressed in particular by McCarthy & Prince (1986), grammars do not count syllables, nor segments. The strategy that has proved succesful is to eliminate counting by grouping the 'counted' elements into units at a higher level. Any reference to syllable parity should be reducible to grouping of syllables in *binary feet* (Halle & Vergnaud 1987, Hayes 1995).

In order to check the relevance of feet to allomorphy, we should first look into Estonian stress. Slightly simplified, Estonian has a rightward pattern of syllabic trochees[7]. Primary stress is initial, while secondary stress falls on the third syllable if it is non-final or if it is heavy. Syllable weight is defined as follows. Open short-voweled syllables are light, and syllables that are closed, or contain a long vowel or diphthong, are heavy (Hint 1973, Prince 1980, Hayes 1995, Kager 1994). Example distributions of syllabic trochees, (σ σ) or (**H**), are given below. Feet are marked by parentheses, and PrWds by square brackets:

(6)			
	2 σ	[(ví.sa)]	[(kín.nas)t]
	3 σ	[(pá.ra).ja]	[(pá.ra).(jài)t]
	4 σ	[(át.mi).(rà.li)]	[(pá.ri).(màt.tel)t]

5 Mürk, citing Kettunen (1962), reports that the ending /-tte/ "developed in distemic nominals when the genitive plural was attached to a consonant stem ending in a stop, e.g. **kastek+ten* 'dew' > *kastete* (/kastette/). The genitive /-t/ assimilated the stem consonant and then the resultant geminate /-tt/ was reanalyzed as part of the genitive ending. This spread by analogy to other nominal types."

6 According to Mürk (1991:60) the -s- of the /-sit/ ending is historically "a pleonastic formation resulting from a reanalysis of the regular /-it/ partitive plural form as it appeared on certain stems ending in -s. For example the partitive plural form for a word like *naine* 'woman' in Proto-Finnic was **naisiða*. The -s- is actually part of the stem but this was reanalyzed as belong to the plural ending and hence > -si[t]."

7 This ignores variability of binary and ternary stress intervals, but see below.

As indicated in (6), final consonants are extrametrical, which accounts for the lack of final stress in [(pí.mes).tav], vs. its presence in [(pá.ra).(jài)t]. I will return to extrametricality in section 5 below, where I will replace the notion by a non-finality constraint.

Returning to the distribution of allomorphs, we are now able to state this in terms of the foot structure of the base, without having to count the actual numbers of syllables. 'Even-numbered' bases are those that can be exhaustively parsed by disyllabic feet, while 'odd-numbered' bases are those that cannot be exhaustively parsed by disyllabic feet. This latter result follows from the fact, stated above, that the base (the Gen.sg.) ends in a light syllable (hence cannot form a degenerate foot). The generalisations on the distribution of allomorphs are that 'even-numbered' allomorphs (/-te/, /-sit/) immediately follow a stem vowel that is itself rightmost in its foot (cf. 7a). 'Odd-numbered' allomorphs (/-tte/, /-it/) join the final stem syllable in a secondary stress foot (cf. 7b).

(7)			*Gen.sg.*	*Gen.pl.*	*Part.pl.*
	a.	2 σ	[(ví.sa)]	[(ví.sa).-te]	[(ví.sa).-sit]
		4 σ	[(át.mi).(rà.li)]	[(át.mi).(rà.li).-te]	[(át.mi).(rà.li).-sit]
	b.	3 σ	[(pá.ra).ja]	[(pá.ra).(jà-t.te)]	[(pá.ra).(jà-i)t]

There is additional evidence that feet, rather than raw syllables, are the stuff that the allomorphy is computed on. The first evidence comes from *overlong syllables*, that is, heavy syllables with additional length, Cvvː or CvCː. With exceptions in loan words (to which I will return directly below), overlong syllables occur initially in the word. They form monosyllabic feet (σː) by themselves (Prince 1980, Kager 1994). We therefore make three predictions. The first is that monosyllabic overlong bases should behave with respect to suffix allomorphy as disyllabic (cf. 7a and 8a)[8]. The second prediction is that disyllabic bases whose first syllable is overlong should behave as trisyllabic (cf. 7b and 8b). The third prediction is that trisyllabic bases whose first syllable is overlong should behave as quadrisyllabic (cf. 7a and 8c)[9]. All three predictions are confirmed, as can be seen from the examples in (8)[10]:

[8] Interestingly, some monosyllabic stems may take the 'odd-numbered' Part.pl. allomorph /-it/ as well, but this is accompanied by a shortening of the stem vowel, e.g. *jääː* 'ice Gen.sg.' has both *jä-it* and *jääː-sit* as Part.pl. forms (Mürk 1991:250). In the case of stem shortening, the generalisation on the distribution of allomorphs still holds, since the shortened stem, which is not overlong anymore, has become 'odd-numbered'. That is, *jä-it* behaves like *paraja-it*.

[9] All nouns of this type are loan words whose second syllable contains a rising diphthong. All have an extra Gen.pl. variant based on the Part.sg., which ends in /-t/. E.g., Part.sg. *aatːriumit*, Gen.pl. *aatːriumitte.*

[10] Some overlong monosyllabic stems seem not to behave as predicted. For example, Class-III disyllabic stems (i.e. so-called 'truncated nominatives') consistently select 'even-numbered' allomorphy:

(i)	*Nom.sg.*	*Gen.sg.*	*Gen.pl.*	*Part.pl.*	
	sooːl	soola	sooːla-te	sooːla-sit	sooːl**i**
	arːv	arvu	arːvu-te	arːvu-sit	arːv**e**

However, it should be noted that here the base of the Gen.pl. and Part.pl. is not the Gen.sg. Inherently stressed suffixes (/-likk/ etc.) are in the same Class-III ('compounding suffixes', Prince 1980:542):

(ii)	*Nom.sg.*	*Gen.sg.*	*Gen.pl.*	*Part.pl.*
	(ə́n.ne).(lìk)k	(ə́n.ne).(lìk.ku)	(ə́n.ne).(lìkː.ku)-te	(ə́n.ne).(lìkː.k**e**)
	(hóoːg).(lìk)k	(hóoːg).(lìk.ku)	(hóoːg).(lìkː.ku)-te	(hóoːg).(lìkː.k**e**)

I propose to analyse these by pre-specifying foot structure, accounting for both inherent stress and 'even-numbered' allomorph pattern.

(8)			*Gen.sg.*	*Gen.pl.*	*Part.pl.*
	a.	σː	[(kúuː)] [(téeː)]	[(kúuː).-te] [(téeː).-te]	[(kúuː).-sit] [(téeː).-sit]
	b.	σː σ	[(áasː).ta] [(háaːr).me]	[(áasː).(tà-t.te)] [(háaːr).(mè-t.te)]	[(áasː).(tà-i)t] 'year' [(háaːr).(mè-i)t]
	c.	σː σ	[(áatː).(riù.mi)] [(léeː).(guà.ni)]	[(áatː).(riù.mi).-te] [(léeː).(guà.ni).-te]	[(áatː).(riù.mi).-sit] [(léeː).(guà.ni).-sit]

A second piece of evidence for the claim that output foot structure, rather than raw syllable count, is what counts to allomorphy, resides in a large class of loan words with idiosyncratic non-initial primary stress on an overlong syllable. The generalisation with respect to allomorphy (as stated by Mürk 1991:296) is: "[...] syllable counting begins from the main stressed syllable. Anything preceding the main stress is ignored for the purposes of syllable counting." Consider the following examples[11]:

(9)		*Gen.sg.*	*Gen.pl.*	*Part.pl.*
	a.i	[bü.(róoː)] [di.(néeː)]	[bü.(róoː).-te] [di.(néeː).-te]	[bü.(róoː).-sit] [di.(néeː).-sit]
	a.ii	[in.ter.(vjúuː)] [re.sü.(méeː)]	[in.ter.(vjúuː).-te] [re.sü.(méeː).-te]	[in.ter.(vjúuː).-sit] [re.sü.(méeː).-sit]
	b.i	[or.(késsː).tra] [di.(fúusː).se]	[or.(késsː).(trà-t.te)] [di.(fúusː).(sè-t.te)]	[or.(késsː).(trà-i)t] [di.(fúusː).(sè-i)t]
	b.ii	[hal.le.(lúuː).ja] [ri.go.(róosː).se]	[hal.le.(lúuː).(jà-t.te)] [ri.go.(róosː).(sè-t.te)]	[hal.le.(lúuː).(jà-i)t] [ri.go.(róosː).(sè-i)t]
	c.i	[de.(lúuː).(viù.mi)] [a.(kórː).(diò.ni)]	[de.(lúuː).(viù.mi).-te] [a.(kórː).(diò.ni).-te]	[de.(lúuː).(viù.mi).-sit] [a.(kórː).(diò.ni).-sit]
	c.ii	[a.lu.(míiː).(niù.mi)] [ter.ri.(tóoː).(riù.mi)]	[a.lu.(míiː).(niù.mi).-te] [ter.ri.(tóoː).(riù.mi).-te]	[a.lu.(míiː).(niù.mi).-sit] [ter.ri.(tóoː).(riù.mi).-sit]

If syllable count (rather than foot structure) were relevant, the irrelevance of the portion of the base that precedes the main stress would go unexplained.

4. How to model prosody-dependent allomorphy?

Having shown that affix allomorphy depends on output foot structure and its relationship to the foot structure of the base, I now consider some options in enabling the morphology to look into metrical representations to determine the choice of allomorph.

The first possibility is to set up selection frames of allomorphs that directly refer to the foot structure of the stem. Consider, for example, the selection frames in (10):

(10) a. Gen.pl.: Select /-te/ after a stem ending in a foot. Elsewhere, select /-tte/.
b. Part.pl.: Select /-sit/ after a stem ending in a foot. Elsewhere, select /-it/.

The problem is that this analysis fails to relate the prosodic shapes of allomorphs to their effect on the prosodic structure of the output form. Suppose that the allomorphs would have been

[11] All of these examples have been reconstructed after information on declension class membership that is provided in the *Index of Inflexional Lexicon* in Mürk's study.

reverse (e.g., 'Select /-tte/, /-it/ after bases ending in a foot, and /-te/, /-sit/ elsewhere'), then this situation would be equally natural, hence equally expected under this type of analysis. But this analysis fails to capture the generalisations (cutting across Gen.pl. and Part.pl.) that relate the distribution of specific allomorphs to their prosodic shapes.

In 'even-numbered' bases, we observe that both allomorphs selected (/-te/, /-sit/) have the same consonant-vowel shape: -CV(C). Given a vowel-final base, the prosodic structure of the output (syllabification and foot structure) will closely match its morphological structure. More specifically, the right edge of the base (the Gen.sg.) aligns with the right edge of a foot (the Gen.pl. and Part.pl.). See (11):

(11)			*Gen.pl.*	*Part.pl*	
	a.	2 σ	[(ví.s**a**)-te]	[(ví.s**a**)-sit]	[(ví.s**u**)]
	b.	4 σ	[(át.mi).(rà.l**i**)-te]	[(át.mi).(rà.l**i**)-sit]	[(át.mi)(ràl**e**)]
	c.	σː	[(kú**u**ː)-te]	[(kú**u**ː)-sit]	

The generalisation that the right edge of the stem aligns with the right edge of a foot is not violated by vowel mutation in the Part.pl. Vowel mutation involves allomorphy of the base, since the mutated vowel is stem-specific, hence must be part of the stem. Therefore, the mutated vowel constitutes the absolute right edge of the stem, satisfying alignment.

In outputs based on 'odd-numbered' stems, right stem alignment is necessarily violated due to top-ranking constraints on metrical parsing. These constraints force an output in which the final stem syllable is grouped in a foot together with the affix syllable. Here the best option happens to be attaching allomorphs of the prosodic shapes -CCV (/-tte/) or -VC (/-it/), which syllabify with the base-final vowel into a *stressed heavy syllable.*

(12)	a.	σ σ σ	[(pá.ra).(**jà-t.**te)]	[(pá.ra).(**jà-i**)t]
	b.	σː σ	[(áasː).(**tà-t**.te)]	[(áasː).(**tà-i**)t]

If /-te/ and /-sit/ were selected here, there would not be a heavy syllable in the output, e.g. [(pá.ra).(**jà.-**te)], [(pá.ra).(**jà.-si**)t].

In sum, we find that the choice of allomorph is guided by prosodic targets (right stem alignment, maximizing weight of stressed syllables) in the *output* form, that is, the base-plus-allomorph combination. The selection frame analysis given in (10) cannot capture this fact and therefore leaves an important generalisation unexpressed.

This conclusion provides the central argument for the second option: the evaluation of complete output forms (base-plus-allomorph combinations) by prosodic constraints. Of course this is precisely the optimisation-model that I argued for in Section 1 on the basis of Djabugay allomorphy. But in contrast to the fairly simple situation in Djabugay, where a single prosodic well-formedness constraint *COMPLEX did all the work, the prosodic constraints governing affix allomorphy in Estonian are multiple, and their interactions are slightly more complex. Let us find out what they are.

The distribution of allomorphs is conditioned by four undominated constraints on the form and position of metrical feet, which are stated in (13a-d). The first, FT-BIN (Prince 1980, Prince & Smolensky 1993), is the familiar constraint that feet must be binary. The second, ALIGN-HD-L (McCarthy & Prince 1993:35), serves to place main stress on the initial syllable. The third, GR-BIN (Kager 1994) limits the size of the main stress foot to two grid positions, that is, a single overlong syllable, or two normal (light or heavy) syllables. With Prince (1983), I assume that overlong syllables have two grid positions, while other syllables (light or heavy) have only one each. Crucially, GR-BIN rules out any main stress foot consisting of an overlong syllable plus another syllable. Finally, PARSE-2 (Kager 1994) rules out long lapses (sequences of unparsed syllables), which are never found in Estonian rhythm.

(13) a. **FT-BIN**
Feet are binary under syllabic or moraic analysis.

b. **ALIGN-HD-L**
Align (PrWd, L, Head(PrWd), L) Effect: initial main stress

c. **GR-BIN**
Head(PrWd) has two grid positions. Effect: $(\sigma\text{ː})_{Ft}$

d. **PARSE-2**
One of two adjacent stress units (μ, σ) must be parsed by a foot.

Another major ingredient of the analysis is the constraint that aligns the right edge of the stem with the right edge of a foot. This is ALIGN-ST-R, stated in (14)[12].

(14) **ALIGN-ST-R**
Align (Stem, R, Foot, R)
(“Each right stem edge coincides with a right foot edge.”)

This constraint is violated whenever the rightmost stem segment (in the cases at hand: the rightmost stem vowel) is not foot-final in the output. Moreover ALIGN-ST-R indirectly states a syllabification requirement. Because of the prosodic hierarchy, a segment in foot-final position must also be in syllable-final position. Accordingly ALIGN-ST-R is violated in (pá.ra).(jà-t.te), and similar cases, due to the closure of the stem-final syllable by the suffix-initial consonant. This violation will become crucial in ruling out forms such as (ví.sa-t).te, where misalignment is avoidable by the selection of the non-geminate allomorph (ví.sa).-te.

The actual syllabification of consonants is regulated by two undominated constraints:

(15) a. **ONSET**
Syllables must have onsets.

b. ***μ-ONS**
Onsets are non-moraic.

These constraints figure in the choice of allomorphs in the following way. ONSET (15a) is the constraint that forces the syllabification of a vowel-initial affix (e.g. /-it/) with the final base vowel in pa.ra.jai̯t etc. The other, *μ-ONS (15b), has the function of forcing the syllabification of the geminate (moraic) consonant in /-tte/ with the preceding stem vowel in pa.ra.jat.te etc.

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12 This generalisation may actually reflect a requirement of prosodic paradigm regularity: elements at the right edge of the base should be in a prosodically identical position in the derived form (foot-final, etc). Elaboration of this idea would require two extensions of correspondence theory (McCarthy & Prince 1994): (i) setting up correspondence constraints that evaluate the identity between a derived form and its base (as in Benua 1995), and (ii) setting up correspondence constraints that measure prosodic identity of two strings, e.g. ANCHOR-R-FT (McCarthy 1996), which requires that correspondent segments agree in being foot-final (or not).

(i) **ANCHOR-R-FT**
If α is foot-final in S_1, and $\alpha\Re\beta$, then β is foot-final in S_2.

In this definition S_1 is the base, while S_2 is the affixed form. The expression ‘$\alpha\Re\beta$’ states that the two segments α and β are in a correspondence relationship.

Given the undominated position of prosodic well-formedness constraints (on footing 13a-d, and syllabification 15a-b), it is clear that Align-St-R cannot always be satisfied. More specifically, right stem alignment is necessarily violated in output forms whose base is ‘odd-numbered’. As I observed earlier for (12a-b), such forms contain allomorphs (/-tte/, /-it/) that syllabify into the syllable of the stem-final vowel, rendering it heavy. There is a clear bonus to adding weight to this syllable, since by its (odd-numbered) position in the word, it will always be stressed. The specific constraint that favours syllable weight in stressed syllables is known from other languages. It is Pk-Prom (Prince & Smolensky 1993), stated in (16). Literally it requires that prominence peaks must be located on elements of maximal intrinsic sonority (for example, on heavy syllables).

(16) **Pk-Prom**
Peak(x) › Peak(y) if |x| > |y|.

There is independent evidence for Pk-Prom in Estonian from *preferences* in optionally binary versus ternary rhythmic patterns (Hint 1973). That is, rhythmic patterns are preferred in which stressed syllables are heavy, e.g. [(*pá.rat*).*ta*.(*màt.tu*)*s*] ‘inevitability (Iness.sg.)’ is preferred over [(*pá.rat*).(*tà.mat*).*tus*][13]. As it turns out, Align-St-R and Pk-Prom are never in direct competition - hence it is impossible to determine their relative ranking.

Lexical representations of the affix and stem allomorphs are given in (17). Notice that the Gen.pl. allomorphs /-te/ and /-tte/ are distinct by having a nonmoraic vs. a moraic initial consonant. As I argued earlier, general considerations of Estonian phonology show that for the allomorph /-tte/, the moraic consonant must be inherent.

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(17)  a.   Gen.Pl.      μ                          μ μ
                        |                          | |
                       t e    /-te/       vs.      t  e    /-tte/

      b.   Part.pl.     μ                          μ
                        |                          |
                       s i t  /-sit/      vs.      i t     /-it/

      c.   Stems, e.g.  μ μ                        μ μ
                        | |                        | |
                       visa   /visa-/     vs.      visu    /visu-/
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4.1 Even-numbered bases

The Gen.pl. allomorph in words based on even-numbered bases is /-te/. The analysis predicts this correctly since Align-St-R is easily satisfied by selecting the allomorph /-te/, but would be impossible with /-tte/. Undominated prosodic constraints (Ft-Bin, Align-Hd-L, Onset, *μ-Ons) rule out any attempt to ‘save’ /-tte/ in a way that satisfies Align-St-R[14]:

[13] For arguments that ternary rhythm (the former type of case) involves medial unparsed syllables, see Hayes (1995) and Kager (1994).

[14] Henceforth I will mark evaluations by Pk-Prom by indicating the weight of all stressed syllables for each candidate (L for light, H for heavy, and H^+ for overlong syllables).

(18) /visa, {-te, -tte}/	FT-BIN	ALIGN-HD-L	ONSET	*µ ONS	ALIGN-ST-R	PK-PROM
a. ☞ [(ví.sa)-te]						L
b. [(ví.sa-t).te]					*!	L
c. [(ví.sa).-tte]				*!		L
d. [vi.(sá-t.te)]		*!			*	H
e. [(ví).(sà-t.te)]	*!				*	L, H

(19) /atmirali, {-te, -tte}/	FT-BIN	ALIGN-HD-L	ONSET	*µ ONS	ALIGN-ST-R	PK-PROM
a. ☞ [(át.mi).(rà.li)-te]						H, L
b. [(át.mi).(rà.li-t).te]					*!	H, L
c. [(át.mi).ra.(lì-t.te)]					*!	H, H
d. [(át.mi).(rà.li)-tte]				*!		H, L

The same allomorph /-te/ is selected in words that have monosyllabic overlong bases:

(20) /kuuː, {-te, -tte}/	FT-BIN	GR-BIN	ALIGN-HD-L	ONSET	*µ ONS	ALIGN-ST-R	PK-PROM
a. ☞ [(kúuː)-te]							H^+
b. [(kúuː-t).te]						*!	H^+
c. [(kúuː)-tte]					*!		H^+
d. [(kúuː-t.te)]		*!				*	H^+

Proceeding to the Part.pl., we must address the fact that two allomorphs are possible, i.e. either /-sit/ or stem vowel mutation. Since, as shown in (11), both lead to ouput forms that satisfy ALIGN-ST-R, what determines the choice between these?

Interestingly we find lexical variation, depending upon stem. Some stems allow both forms (e.g. visa allows both visa-sit and visu), while other stems allow only one, either the affixed form (e.g. kogu, kogu-sit) or the mutation form (e.g. maja, maju). It is clear that each of the two forms has a specific advantage over the other. Forms that contain the Part.pl. affix /-sit/ mark a morphological category by an overt affix. However, they achieve this aim at the expense of containing an unparsed syllable. The alternative form, a bare stem allomorph with a mutated vowel, has no unparsed syllables. But this goes at the expense of affix-marking of the Part.pl. morphology. To account for this lexical variation, I propose that the ranking between the following constraints is lexically determined by stem:

(21) a. **PARSE-SYLL**
All syllables must be parsed by feet.

b. **PARSE-AFF**
A morphological category must be marked by an overt affix.

This is illustrated in the tableaux below, where '*?' indicates a violation that is dependent on lexically-determined ranking of constraints. In both cases in (22-23), the ranking between PARSE-SYLL and PARSE-AFF can actually be left unspecified (i.e. free), since both stems occur with either stem vowel mutation or the affix /-sit/. In the tableaux, I have marked violations of constraints that are freely ranked with respect to one another by '#':

(22) /{visa-, visu-}, {-sit, -it}/	Ft-Bin	Align-Hd-L	On-set	Align-St-R	Pk-Prom	Parse-Syll	Parse-Aff
a. ☞ [(ví.s**u**)]					L		#
b. ☞ [(ví.sa)-sit]					L	#	
c. [(ví.sa-i)t]				*!	L		
d. [(ví.sa).-it]			*!		L	*	
e. [vi.(sá-i)t]		*!		*	H		
f. [(ví).(sà-i)t]	*!			*	L, H		

(23) /{atmirali, atmirale}, {-sit, -it}/	Ft-Bin	Align-Hd-L	On-set	Align-St-R	Pk-Prom	Parse-Syll	Parse-Aff
a. ☞ [(át.mi).(rà.l**e**)]					H, L		#
b. ☞ [(át.mi).(rà.li)-sit]					H, L	#	
c. [(át.mi).(rà.li-i)t]				*!	H, L		

Overlong bases select the same allomorphs as disyllabic bases. This equavalence is due to Gr-Bin, which requires that the primary stress foot must have precisely two grid positions, and thus restricts the size of this foot to a single overlong syllable, or two regular syllables. (In tableau 24, this is not crucial since Align-St-R would, by itself, already rule out the rivalling candidate 24c; Gr-Bin will become crucial for longer forms in tableaux 27-28 below.)

(24) /kuuː, {-sit, -it}/	Gr-Bin	Ft-Bin	Align-Hd-L	On-set	Align-St-R	Pk-Prom	Parse-Syll	Parse-Aff
a. ☞ [(kúuː)-sit]						H^+	*	
b. [(kúuː).-it]				*!		H^+	*	
c. [(kúuː-i)t]	*!				*	H^+		

4.2 Odd-numbered bases

As I explained above, Align-St-R cannot be satisfied in odd-numbered bases, because doing so would necessarily violate an undominated prosodic well-formedness constraint, such as Ft-Bin, Align-Hd-L or *μ-Ons. Where misalignment is forced, Pk-Prom selects the allomorphs that syllabify with the final-stem vowel, since this maximizes the weight of a stressed syllable. These allomorphs are Gen.pl. /-tte/ and Part.pl. /-it/:

(25) /paraja, {-te, -tte}/	Ft-Bin	Parse-2	Align-Hd-L	On-set	*μ-Ons	Align-St-R	Pk-Prom
a. ☞ [(pá.ra).(jà-t.te)]						*	L, H
b. [(pá.ra).(jà-te)]						*	L, L!
c. [pa.(rá.ja)-te]			*!				L
d. [(pá.ra).ja-te]		*!				*	L
e. [(pá.ra).(jà)-te]	*!						L, L
f. [(pá.ra.ja)-te]	*!						L

(26) /paraja, {-sit, -it}/	FT-BIN	PARSE-2	ALIGN-HD-L	ON-SET	*μ-ONS	ALIGN-ST-R	PK-PROM
a. ☞ [(pá.ra).(jà-i)t]						*	L, H
b. [(pá.ra).(jà-si)t]						*	L, L!
c. [(pá.ra).(jà-.i)t]				*!		*	L, L
d. [pa.(rá.ja)-sit]			*!				L
e. [(pá.ra).ja-sit]		*!				*	L
f. [(pá.ra).ja-it]		*!				*	L
g. [(pá.ra).(jà)-sit]	*!						L, L
h. [(pá.ra.ja)-sit]	*!						L

The same allomorphs /-tte/, /-it/ are selected in forms whose bases have an overlong syllable plus another syllable. Observe that GR-BIN is crucial in ruling out the candidates (27e) and (28f), both of which satisfy ALIGN-ST-R. As in tableaux (25-26) above, PK-PROM selects candidates that contain a heavy syllable (rather than a light one) in the secondary stress foot:

(27) /aasːta, {-te, -tte}/	GR-BIN	FT-BIN	PARSE-2	ALIGN-HD-L	ON-SET	*μ-ONS	ALIGN-ST-R	PK-PROM
a. ☞ [(áasː).(tà-t.te)]							*	H^+, H
b. [(áasː).(tà.-te)]							*	H^+, L!
c. [(áasː).ta-te]			*!				*	H^+
d. [(áasː).(tà)-te]		*!						H^+, L
e. [(áasː.ta)-te]	*!							H^+

(28) /aasːta, {-sit, -it}/	GR-BIN	FT-BIN	PARSE-2	ALIGN-HD-L	ON-SET	*μ-ONS	ALIGN-ST-R	PK-PROM
a. ☞ [(áasː).(tà-i)t]							*	H^+, H
b. [(áasː).(tà-si)t]							*	H^+, L!
c. [(áasː).(tà.-i)t]					*!		*	H^+, L
d. [(áasː).ta-it]			*!				*	H^+
e. [(áasː).ta-sit]			*!				*	H^+
g. [(áasː).(tà)-sit]		*!						H^+, L
f. [(áasː.ta)-sit]	*!							H^+

This analysis of Estonian allomorphy leads to two conclusions. First, the choice of the Gen.pl. and Part.pl. allomorphs is predictable from the prosody of the output. Second, this observation can be captured adequately in an 'optimal allomorphy' model in OT.

5. Partitive singular

Estonian has another morphological category that displays syllable-counting allomorphy. The Partitive singular, which again takes the Gen.sg. as its base, is realised after vowel-final stems (Mürk 1991:52-54) in two ways. After even-numbered bases, we find a zero allomorph, or a single consonant allomorph /-t/, the latter occuring in monosyllables only. After odd-numbered bases, the Part.sg. is marked by a geminate consonant allomorph /-tt/.

(29) 'Even-numbered bases' 'Odd-numbered bases'

σː	maaː-t	'land'	σː σ	aasːta-tt	'year'
	kuuː-t			haaːrme-tt	
2 σ	visa-∅		3 σ	paraja-tt	
	ema-∅	'mother'		raamattu-tt	'book'
4 σ	atmirali-∅	'admiral'	5 σ	haavalumikku-tt	'Admiral butterfly'
	telefoni-∅	'telephon'		numismaatikku-tt	'numismatics'

Again, the generalisation is that in even-numbered bases, ALIGN-ST-R is satisfied, either by a zero allomorph, or by the 'extrametrical' single consonant allomorph /-t/ (see 30a). And again, the allomorph for odd-numbered bases produces a stressed heavy syllable (see 30b). Here this effect is due to an allomorph that has a moraic consonant /-**t**/, which adds weight to stem-final syllable. Since it is heavy, the final syllable can be parsed as a monosyllabic heavy foot. Footed structures are below, where boldface /-**t**/ indicates a moraic consonant (written earlier as /-tt/):

(30) a.

σː	[(máaː)-t]
2 σ	[(ví.sa)]
4 σ	[(át.mi).(rà.li)]

b.

σː σ	[(áasː).(tà-**t**)]
3 σ	[(pá.ra).(jà-**t**)]
5 σ	[(háa.va).(lù.mik).(kù-**t**)]

The mora in /-**t**/ must be parsed by a syllable because of top-ranked PARSE-μ (31a). The 'extrametricality' of non-moraic consonants is due to another constraint NON-FINAL-WD (31b), prohibiting final consonants from being syllabified. This is a member of the *Nonfinality* family (cf. Hung 1994).

(31) a. **PARSE-μ**
Input moras must be parsed by syllables.

b. **NON-FINAL-σ**
A syllable must be non-final in the PrWd.

Given a ranking PARSE-μ » NON-FINAL-σ, the proper effects are obtained as illustrated in the tableaux below.

(32a) /ta**t**/	PARSE-μ	NON-FINAL-σ
a. ☞ $(\text{ta}\mathbf{t})_{\sigma}]_{\text{Wd}}$		*
b. $(\text{ta})_{\sigma}\mathbf{t}]_{\text{Wd}}$	*!	

(32b) /tat/	PARSE-μ	NON-FINAL-σ
a. ☞ $(\text{ta})_{\sigma}\text{t}]_{\text{Wd}}$		
b. $(\text{tat})_{\sigma}]_{\text{Wd}}$		*!

The remaining question is that of the complementary distribution of the /-t/ allomorph, which occurs after overlong bases, and the zero allomorph, which occurs after all other 'even-numbered' bases. I have no satisfactory explanation for this distribution. It can be observed, however, that allomorphs resemble those found in the Part.pl. (even-numbered bases select the full affix /-sit/ or participate in stem vowel mutation). The fact that stem vowel mutation is not available in the monosyllabic forms may be an effect of paradigm regularity: the main stressed vowel must be identical throughout the paradigm (Alderete 1995).

To wind up this section, I summarize the syllable counting allomorphs in Estonian.

(33)		*Even-numbered* (align stem)		*Odd-numbered* (make weight)
	Gen.pl.	**-te**		**-tte**
	Part.pl.	**-sit**	or V stem mutation	**-it**
	Part.sg.	Ø		**-tt**

6. Illative singular

The final syllable-counting allomorphy of Estonian that I will discuss (somewhat speculatively) is the Illative singular. This category is formed by the suffix /-sse/, regardless of syllable count. It is reported by Mürk (1991:55) that certain derivational affixes (e.g. /-lise/) optionally select a truncated form (e.g. /-li/) before the Ill.sg. suffix /-sse/ when they occur with even-numbered bases: "With stems containing an even number of syllables containing derivative suffixes whose genitive form ends in *-se*, the stem is contracted with the addition of *-sse*. Thus, *roheline* 'green', genitive *rohelise* has the regular illative form *rohelisesse* as well as a contracted form *rohelisse*."

(34)	*Nom.sg.*	*Gen.sg.*	*Ill.sg.*		
	rohe-li-ne	rohe-li-se	rohe-li-se-sse	*or*	rohe-li-sse

The complex derivational suffix whose Gen.sg. form is /-li-se/, is optionally truncated to /-li/ before the Ill.sg. suffix /-sse/. Truncation satisfies a prosodic target in the output, or rather a combination of targets, since the truncated form comes to satisfy both PK-PROM and PARSE-SYLL. The cost of the truncation is a violation of PARSE-AFF with respect to the 'morph' /-se/, a part of the complex suffix /-li-se/. This may be tabulated as follows:

(35)			
	a.	[(ro.he)-(li-s.se)]	Satisfies PARSE-σ, PK-PROM, violates PARSE-AFF in *-se*
	b.	[(ro.he)-(li-se-s).se]	Satisfies PARSE-AFF in *-se*, violates PARSE-σ, PK-PROM

As earlier, I assume that variability is formally expressed by equally ranked constraints. Equal ranking between the constraints in (35) provides the basis of an 'optimization' approach to truncation.

7. Conclusion

The analysis of prosodically governed allomorphy in Estonian which I have proposed in this paper has a number of theoretical consequences. First, by having shown that syllable-counting allomorphy is an output-oriented phenomenon, I have demonstrated a specific property of the phonology-morphology interface. That is, morphology may be sensitive to prosodic properties of the output, the complete base-plus-affix structure. This property is predicted by Optimality Theory, a theory in which the output level is the locus of explanation, and where phonological and morphological constraints can be ranked with respect to another to produce effects of kinds that I have discussed. Rule-based theories such as 'cyclic' Lexical Phonology predict that derived prosodic properties of the base may govern affix allomorphy, but do not allow for an evaluation of the complete output (and are actually incapable of expressing this).

Another result of this paper is a deep similarity between allomorphy and reduplication, an 'emergence of the unmarked' (McCarthy & Prince 1994). This is a situation in which well-formedness constraints, which are dominated by faithfulness constraints in a language-specific hierarchy, become active (in the same language) in situations where the faithfulness constraints are 'turned off' (as is the case in reduplication, where 'unmarked' prosodic structures typically arise). Given the chance, the grammar will produce prosodically unmarked structures. Applied to Estonian, we find that the preference for stressed syllables to be heavy, which we witness in the selection of allomorphs, is surely 'universal' in the sense that in some languages PK-PROM is phonologically active. Yet, Estonian does not allow the addition of weight (by productive consonant gemination, or other means) in violation of higher-ranked faithfulness constraints. Prosodically governed allomorphy produces an emergence of the unmarked: where the lexicon supplies different allomorphs (hence faithfulness can be by-passed in the sense that there is no fixed input), the allomorphs are selected that best fit the otherwise suppressed requirements of prosody.

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