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0. Introduction

Recent studies on variation (Kiparsky 1993, Nagy & Reynolds 1997, Anttila 1997) have argued that free variation, including quantitative preferences, derive from partially ranked constraints in Optimality Theory (OT, Prince & Smolensky 1993). This paper provides new evidence for this hypothesis from prosodic morphology, more specifically, allomorph selection in Greek material suffixes and Finnish nominalizers. In both languages, allomorph selection aims at creating a perfectly rhythmic alternation of maximally and minimally prominent syllables or perfect prosodic words. We will argue that when prosodic principles conflict, variation and morpholexically conditioned allomorph selection arise. This is modeled as partial constraint ranking.

Within OT, the ranking schema *Prosody >> Morphology* is definitional for Prosodic Morphology (McCarthy & Prince 1993a,b). When a prosodic constraint dominates a morphological one, the prosodic constraint will control the outcome. Prosodically conditioned allomorphy is a case of Prosodic Morphology where the selection of allomorphs is conditioned by the prosodic structure of the base, such that one allomorph occurs with bases of a certain prosodic type, while the other allomorph occurs with bases of all other prosodic types. The reverse ranking, *Morphology >> Prosody*, characterizes plain or non-prosodic morphology. In this case the P-constraints have no influence on the outcome, and only the dominant M-constraint can have a visible effect.

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(i.i) is among the worst trochees possible. Variation occurs when rhythmic principles are too weak to decide on a single output: (*kora*)(*lénjos*) (perfect PrW) vs. *ko*(*ráli*)*nos* (perfect trochee). In the next section, the systematic gaps and systematic preferences reviewed here are accounted for by means of the partial constraint ranking model.

1.2. Analysis

Greek is a bounded language with a three-syllable-window. This means that the scope of primary stress is limited to the last three syllables of the word (ENDRULE-R; Prince 1983, Prince & Smolensky 1993). Feet are trochaic and quantity-insensitive (FOOTTYPE: Trochee; Malikouti-Drachman & Drachman (MD&D) 1989, Drachman & Malikouti-Drachman (D&MD) 1996). Accentuation is mainly dependent on lexical accents (FAITH(accent); Revithiadou 1999). In the absence of accents, stress is by default on the antepenultimate syllable. The allomorphs at issue have inherent accentual properties. The /-inos/ suffix has a floating accent that lodges on some syllable of the preceding morpheme, / ´-inos/, but never on the sponsoring morpheme itself (cf. Revithiadou 1999 for details). The /-énjos/ suffix is accented. FAITH(accent) is high-ranking in the system, therefore outputs like *roðínos* and *korálenjos* are always ruled out.

Following previous analyses of Greek allomorphy (MD&D 1994, Drachman, Kager & Malikouti-Drachman (DKM) 1997), we argue that allomorphic selection conspires towards prosodic output targets, e.g. the coincidence of morphological and prosodic edges, faithfulness to lexical stress requirements, and so on. However, our analysis focuses on the variable aspect of allomorph selection. More specifically, we propose that the driving force of variation is the competing desire to create words that have perfect prosodic structure or perfect rhythm. The constraints that determine allomorph selection are part of the general accentuation system in Greek. They are mostly responsible for the rhythmic properties of stress, therefore they rank relatively low in the constraint hierarchy. These constraints, however, play a vital role in 'material' and other types of allomorphic formation (DKM 1997).

(3) The Constraints

a. ALIGN-L(PrW, L, Ft, L): Align the left edge of a prosodic word with the left edge of a foot.

b. ALIGN-R (PrW, R, Ft, R): Align the right edge of a prosodic word with the right edge of a foot.

c. TROCHAIC PROMINENCE ALTERNATION (TPA):[1] Maximize the contrast between the prominent and non-prominent part of the foot, *(i.i) >> *(o.i) >> *(a.i).
(For similar proposals, see (i) *(L'H) Kager 1989, Hanson & Kiparsky 1996, Elenbaas 1999; (ii) The Stress and Length Principle; Revithiadou & van de Vijver 1997, van de Vijver 1998.)

[1] TPA is responsible for vowel raising/deletion in Northern Greek dialects as well as high vowel deletion in fast speech in many varieties of Standard Greek (MD&D 1981, Revithiadou & van de Vijver 1997, but cf. Arvaniti 1991 for a different view).

Our analysis must be able to capture categorical and variable distinctions as well as preferences. More specifically, it must account for (i) the variation with a quantitative preference for *-inos* in monosyllabic roots; (ii) the variation with a quantitative preference for *-énjos* in polysyllabic roots; (iii) the absence of *-inos* in polysyllabic i-roots.

Recent work on variation models systematic preferences as partial constraint ranking (Anttila 1997). Here we propose an analysis along these lines. First, we assume that both alternants of material suffixation are listed in the lexicon (cf. Kager this volume). Each carries the meaning "made of material X". Roots are subcategorized for /-inos/ as well as /-énjos/ and the selection of the proper allomorph rests totally upon the rankings of prosodic constraints. Second, we assume that the prosodic constraints have free ranking. This means that six total orders are possible, each promoting a unique winner. We further hypothesize that the number of rankings that generate each outcome is proportional to the relative frequency of this form.

An example is shown in (4). In monosyllabic roots of type *xart-í* 'paper', *-inos* wins by 2/3 and /-énjos/ by 1/3 of the rankings. In disyllabic roots of type *korál-i* 'coral', *-énjos* wins by 2/3 and *-inos* by 1/3 of the rankings.

(4) Corresponding Total Orders and Winners

i. AL >> AR >> TPA	(xárti)**nos**			(kora)(lénjos)
ii. AL >> TPA >> AR	(xárti)**nos**			(kora)(lénjos)
iii. AR >> AL >> TPA		xar(ténjos)		(kora)(lénjos)
iv. AR >> TPA >> AL		xar(ténjos)		(kora)(lénjos)
v. TPA >> AL >> AR	(xárti)**nos**		ko(ráli)**nos**	
vi. TPA >> AR >> AL	(xárti)**nos**		ko(ráli)**nos**	

The shift in preferences from *-ínos* to *-énjos* is due to the fact that in forms based on disyllabic roots, such as *ko(ráli)nos* vs. (kora)(lénjos), *-énjos* is desirable because achieves perfect alignment, whereas in forms based on monosyllabic roots, such as *(xárti)nos* vs. *xar(ténjos)*, this does not happen.[2]

According to the model advanced here, preferences arise if the partial order is too weak to select a unique winner, but strong enough to leave its statistical fingerprint on the output. The *xártinos* candidate beats *xarténjos* quantitatively by winning in a greater number of tableaux (4 out of 6). The representative tableaux in (5) show the selection of different winners by different total orders.

[2] The analysis predicts that the difference in preferences corresponds to the difference between roots with odd vs. even number of syllables. Given the small data base, we have so far not been able to properly test this prediction.

(5)
T.i output=xártinos

xart-, -inos~-énjos	AL	AR	TPA
☞ a. (xárti)nos		*	
b. xar(ténjos)	*!		*

T.iii output=xarténjos

xart-, -inos~-énjos	AR	AL	TPA
a. (xárti)nos	*!		
☞ b. xar(ténjos)		*	*

As evident from the examples in (1), there are bases that allow both allomorphs, *xártinos/xarténjos*, and bases that allow only one allomorph, *ðáfninos/*ðafnénjos*. To account for this lexical variation, we propose, following Kager 1996, that different roots can lexically select different rankings. More specifically, roots of the *ðáfninos/*ðafnénjos* group are associated with the orders {i,ii,v,vi}, stylistically marked roots (*skaténjos/*skátinos*) are associated with the orders {iii,iv}, whereas roots like *xártinos/xarténjos* permit all possible orders.

Turning to polysyllabic roots now, we see that the favorite allomorph is again the one that wins in most tableaux. Here, however, the constraints conspire in favor of the *-énjos* suffix. More importantly, the effects of TPA in output formation are more transparent. The *-inos* allomorph is strongly preferred with a-roots and completely disallowed with i-roots. Once again, we have a case in which quantitative preferences are closely dependent on the degree of support a particular candidate receives from prosodic constraints. As shown in (6), perfect alignment is achieved when alignment constraints are high ranking, whereas rhythmically well-formed outputs arise when TPA dominates alignment.

(6)
T.iii output=koralénjos

koral-, -inos~-énjos	AR	AL	TPA
a. ko(ráli)nos	*!	*	
☞ b. (kora)(lénjos)			*

T.vi output=korálinos

koral-, -inos~-énjos	TPA	AR	AL
☞ a. ko(ráli)nos		*	*
b. (kora)(lénjos)	*!		

Interestingly, the same rankings lead to categorical selection. This happens when the prosodic constraints point to a single winner, as the tableaux in (7) demonstrate.

(7)

T.iii output=lastixénjos

lastix-, -inos~-énjos	AR	AL	TPA
a. la(stíxi)nos	*!	*	*
☞ b. (lasti)(xénjos)			*

T.vi output=lastixénjos

lastix-, -inos~-énjos	TPA	AR	AL
a. la(stíxi)nos	*	*!	*
☞ b. (lasti)(xénjos)	*		

As in monosyllabic roots, polysyllabic roots have lexically predetermined rankings. The form *kriθarénjos/*kriθárinos* is associated with perfect alignment rankings: {i-iv}. The pair *koralénjos/korálinos* is associated both with perfect alignment as well as perfect trochee rankings: {v-vi}. From tableaux (7), it is easy to see that **la(stíxi)nos* is an 'eternally doomed' candidate: it can never win, no matter what ranking. Note that this holds even given our assumption that different roots can lexically select different rankings. No matter what ranking /lastix-/ may wish to select, it will not be able to select one that would yield the ill-formed **la(stíxi)nos*. The general point is that prosodic well-formedness sets firm limits to the outcomes of lexical selection, which defuses the possible objection that lexically selected rankings would make the theory vacuous by allowing any pattern whatsoever to be described. In sum, the model succeeds in capturing the statistical preference for *-énjos* and the optionality of *-inos* with certain types of roots.

Before closing up this section, a final issue needs to be addressed, namely the categorical selection of the *-inos* suffix by archaic roots. We claim that the archaic stratum is associated with a plain derivational (non-allomorphic) ranking (M >> P). Material formation was non-allomorphic in older forms of Greek; it used *-inos* as its only formative. Archaic roots remain therefore faithful to their inheritance and do not participate in allomorphic formation. For these roots the selection of the suffix is completely controlled by morphology. Being faithful to the morphologically assigned suffix is more important than having prosodic constraints select a suffix that creates a prosodically or rhythmically optimal output. However, archaic roots that have acquired demotic counterparts submit to allomorphic formation. They participate in a grammar in which prosodic constraints play a vital role in the selection of the proper suffix. For example, the archaic root *molívð-* exclusively chooses *-inos*, *molívðinos* (non-allomorphic stratum), but its demotic counterpart *moliv-* selects *-énjos*, *molivénjos* (allomorphic stratum).

2. Finnish Nominalizing Allomorphy

We now turn to the prosodically conditioned nominalizer allomorphy in Finnish which reflects a complex interaction of stress, syllable weight and vowel sonority; all three aspects of syllable prominence. As in Greek, the selection is categorical in the prosodically clear cases, but becomes subject to lexical conditions if the prosodic conditions are weak.

2.1. The Facts

Finnish has a nominalizing suffix with three allomorphs: /-nti/, /-nto/ and /-nta/ whose distribution is partly prosodically, partly lexically conditioned. Consider the representative examples in (8). Primary stress falls on the initial syllable and secondary stress on every second syllable after that, with the proviso that a light syllable is skipped if a heavy syllable immediately follows.

(8)

a.	júo-n.ti	'drink-nom'	'drinking'
	sí.jai-n.ti	'locate-nom'	'location'
	ár.vi.òi-n.ti	'estimate-nom'	'estimation'
	fór.ma.li.sòi-n.ti	'formalize-nom'	'formalization'
b.	lúo-n.to	'create-nom	'nature'
	pýy-n.tö	'request-nom	'request'
	lás.ke-n.to	'count-nom'	'elementary arithmetic'
	lú.e-n.to	'read-nom'	'lecture'
	á.su-n.to	'inhabit-nom'	'apartment'
	ús.ko-n.to	'believe-nom'	'religion'
c.	lú.e-n.ta	'read-nom'	'reading'
	lás.ke-n.ta	'count-nom'	'counting'
	án. sai-n.ta	'earn-nom'	'earning'
	pá.hek.sù-n.ta	'disapprove-nom'	'disapproval'
	é.leh.dï-n.tä	'gesture-nom'	'gesticulation'
	vé.te.lèh.dï-n.tä	'loiter-nom'	'loitering'

The basic phonological generalization evident from the above data goes as follows: /-ntí/ attaches to heavy syllables, /-nta/ attaches to light syllables, and /-nto/ attaches to either. The mutual distribution of /-ntí/ and /-nta/ is thus purely phonological and the allomorphs do not differ in meaning. The suffix /-nto/ is different in two ways: it does not appear to have any prosodic limitations, but freely occurs after both heavies and lights, and it is clearly lexicalized: besides being unproductive, it is typically associated with unpredictable meanings. Consequently, many stems have both a semantically transparent /-nti, -nta/ nominalization and a lexicalized /-nto/ nominalization. The following doublets are typical:

(9)

Transparent		Lexicalized	
lúo-nti	'creating'	lúo-nto	'nature'
lúe-nta	'reading'	lúe-nto	'lecture'
láske-nta	'counting'	láske-nto	'elementary arithmetic'
hálli-nta	'governing'	hálli-nto	'government'
ístu-nta	'sitting'	ístu-nto	'session'
kúki-nta	'flowering'	kúki-nto	'blossom'
pálki-nta	'rewarding'	pálki-nto	'prize'

In addition, stress also seems to correlate with allomorph selection: /-nti/ is extremely common after stressed heavies, but only marginally found after unstressed heavies, the only case being *sí.jai-n.ti* 'location'; /-nta/ is usually found after unstressed lights, although allowed after light syllables that bear secondary stress: *pá.hek.sù-n.ta* 'disapproval'. This may simply reflect the general fact that stress and weight tend to go together in Finnish (Hanson & Kiparsky 1996, Anttila 1997). Be that as it may, the best descriptive generalization is clearly weight-based. This is easy to see based on the data in *Nykysuomen sanakirja* (NS) [Dictionary of Modern Finnish, type frequencies] (Sadeniemi 1973) and *Suomen Kuvalehti* 1987 (SK) [all the 52 issues of a Finnish weekly magazine from 1987, token frequencies].

(10)	NS:	H́ _	H _	Ĺ _	L _	SK:	H́ _	H _	Ĺ _	L _
	/-nti/	591	1	0	0	/-nti/	167	1	0	0
	/-ntO/	7	4	1	66	/-nto/	4	3	26	94
	/-ntA/	1(?)	1	30	534	/-nta/	0	0	1	147

To explain these distributional facts, we assume that weight, stress and vowel sonority all contribute to syllable prominence: stressed is more prominent than unstressed (X́ >> X), heavy is more prominent than light (H >> L) and low vowels are more prominent than mid vowels which are more prominent that high vowels (/a, ä/ >> /o, ö/ >> /i/) (Anttila 1997). In addition, we assume a principle which we dub *Generalized Prominence Alternation* (GPA) and state informally as follows: "Maximize prominence differences between adjacent syllables if you can." The nominalizer allomorphy provides an opportunity for this principle to apply: /-nti/ with a high vowel is chosen after heavy (and typically stressed) syllables, /-nta/ with a low vowel is chosen after light (and typically unstressed) syllables.

Finally, we note that despite its clearly phonological nature, the generalization we have proposed only emerges in the nominalizer allomorphy: nonderived stems like *Ís.lan.ti* 'Iceland', *sé.kun.ti* 'second' and *súun.ta* 'direction' survive phonology intact and do not become **Ís.lan.ta*, **sé.kun.ta* or **súun.ti*, respectively. This implies that the markedness constraints responsible for GPA emerge in nominalizations, but are incapacitated in nonderived stems. The observation that roots are more faithful than affixes is a familiar one (McCarthy & Prince 1995).

2.2. Analysis

As a modest first approximation of the GPA, we will assume the constraints (11a-b), a special case of the GPA, and the faithfulness constraint (11c):

(11)	The Constraints	
a.	*L.i >> *L.o >> *L.a	Light syllable followed by /i/ is worse than ...
b.	*H.a >> *H.o >> *H.i	Heavy syllable followed by /a/ is worse than ...
c.	FAITH	Be faithful to the underlying form

As for inputs, we assume that the Finnish lexicon contains three allomorphs: /-nti/, /-nto/, /-nta/. Each carries the basic meaning 'nominalizer'. As for outputs, we only consider [-nti], [-nto] and [-nta]. (Other forms such as [-nte], [-nty], etc. could be considered, but they would lose out in any case.) We start by picking an input and a ranking at random: for the input we choose /L-nti/ (e.g. /laske-nti/ 'calculate-nom' and for the ranking we choose L.i >> FAITH >> *L.o >> *L.a.

(12)

/L-nti/	*L.i	FAITH	*L.o	*L.a
a. L-nti	*!			
b. L-nto		*	*!	
☞ c. L-nta		*		*

The result is the emergence of the unmarked allomorph: /-nti/ is neutralized to /-nta/ after a light syllable. If we now proceed to try the remaining two inputs, we find that underlying /-nto/ and /-nta/ are faithfully realized.

(13)

/L-nto/	*L.i	FAITH	*L.o	*L.a
a. L-nti	*!	*		
☞ b. L-nto			*	
c. L-nta		*!		*

/L-nta/	*L.i	FAITH	*L.o	*L.a
a. L-nti	*!	*		
b. L-nto		*!	*	
☞ c. L-nta				*

If we lower the ranking of FAITH by one step, we only get [-nta]: both /-nti/ and /-nto/ neutralize to [-nta] after a light syllable.

(14)

/L-nti/	*L.i	*L.o	FAITH	*L.a
a. L-nti	*!			
b. L-nto		*!	*	
☞ c. L-nta			*	*

/L-nto/	*L.i	*L.o	FAITH	*L.a
a. L-nti	*!		*	
b. L-nto		*!		
☞ c. L-nta			*	*

/L-nta/	*L.i	*L.o	FAITH	*L.a
a. L-nti	*!		*	
b. L-nto		*!	*	
☞ c. L-nta				*

We now compute the outputs for all inputs (3 possibilities), all rankings (4 possibilities), and both markedness hierarchies (2 possibilities). The results are summarized below.

(15)	/L-nti/	/L-nto/	/L-nta/
1. FAITH >> *L.i >> *L.o >> *L.a	L-nti	L-nto	L-nta
2. *L.i >> FAITH >> *L.o >> *L.a	L-nta	L-nto	L-nta
3. *L.i >> *L.o >> FAITH >> *L.a	L-nta	L-nta	L-nta
4. *L.i >> *L.o >> *L.a >> FAITH	L-nta	L-nta	L-nta

(16)	/H-nti/	/H-nto/	/H-nta/
1. FAITH >> *H.a >> *H.o >> *H.i	H-nti	H-nto	H-nta
2. *H.a >> FAITH >> *H.o >> *H.i	H-nti	H-nto	H-nti
3. *H.a >> *H.o >> FAITH >> *H.i	H-nti	H-nti	H-nti
4. *H.a >> *H.o >> *H.i >> FAITH	H-nti	H-nti	H-nti

The following two problems now present themselves: (i) Explain why the prosodic restriction is only found in the nominalizer morpheme, but not in nonderived stems; (ii) Explain the categorical limitations on the distribution of suffixes:

(17)	*lú.e.-nti	lú.e-nto	lú.e-nta	/lue-/	'read'
	lúo-n.ti	lúo-n.to	*lúo-n.ta	/luo-/	'create'

These facts are easily captured if we follow Itô & Mester 1995, 1998 in assuming that subregularities arise from ranking FAITH at different levels. The two categorical regularities (*L-nti, *H-nta) follow if we assume that, in the "nominalizer phonology", FAITH is dominated by the topmost markedness constraints, i.e. {*L.i, *H.a} >> FAITH, and in the "nonderived stem phonology" FAITH may dominate all markedness constraints, and for this reason no neutralization takes place, hence *Ís.lan.ti* 'Iceland', *sé.kun.ti* 'second' and *súun.ta* 'direction'.

We may also have uncovered the reason why exactly /-nto/ has fallen prey to lexicalization, having been the productive action nominalizer in the 19th century (Ahlqvist 1877). Given the phonological system of present-day Finnish, associating lexicalized meanings with /-nti/ or /-nta/ would be pointless because the distinction is obliterated by neutralization in virtually all environments, i.e. the allomorphs are in a phonologically complementary distribution. In contrast, /-nto/ is allowed to surface as [-nto] in all environments, contrasting with both /-nti/ and /-nta/, and phonological contrasts are well-known for their usefulness in making meaning distinctions.

Finally, if we consider the output space defined by the available rankings and the available inputs, it is easy to see that [-nta] is numerically the preferred choice after light syllables (9 cells out of 12), [-nto] is the next best choice (2 cells out of 12) and [-nti] is tolerated in exactly one case: when the input is /-nti/ and FAITH ranks on the top. After heavy syllables, the mirror image of this situation obtains. Now, if we take seriously the hypothesis that the number of available phonological systems (rankings, ranking/input pairs) has a quantitative empirical interpretation (Anttila 1997), we would expect to find an appropriately skewed statistical distribution in a corpus (token frequencies) or in the dictionary (type frequencies). This is indeed what we seem to find. The following preliminary numbers are based on a pseudo-random 2,578 word sample of the Finnish lexicon, more precisely the nominal lexical entries from A to F in *Nykysuomen sanakirja*, including nonderived stems. This is approximately 6% of the stems in the dictionary. H= superheavy, H = heavy, L = light.

(18)	Stem-final V/Penult	H́ _	H _	H́ _	H _	Ĺ _	L _
	/i,u,y/ %	85	80	75	71	49	30
	/o, ö/ %	2	8	11	13	15	25
	/a, ä/ %	13	12	14	16	36	45
		100	100	100	100	100	100

The general tendency of high vowels to occur after prominent syllables and low vowels after nonprominent syllables suggests that the lexicon is a random sampling of the space of phonological possibilities: the phonologically best areas of the lexicon are more densely populated than the phonologically worse areas. In addition, we find that derived words (e.g. Finnish nominalizations) are particularly keen on migrating towards the less marked areas, while the phonological outliers are mostly nonderived words. This can be captured by limiting the nominalizers to the area defined by the subgrammar *L.i, *H.a >> FAITH.

3. Main conclusions

In this paper, we examined prosodically conditioned allomorph selection in Greek and Finnish. We argued that, in both languages, if the phonological conditions are strong (all constraints converging on one alternative, Prosodic Constraints dominating Faithfulness) the conditioning is *total*, resulting in a categorical pattern. If the phonological conditions are weak (conflicting prosodic requirements, Faithfulness dominating some Prosodic Constraints) the prosodic conditioning is only *partial*. We further argued that partial conditioning results in outcomes of two kinds: free surface variation with quantitative phonological preferences (roots of different lengths in Greek) and morphological/lexical conditioning with quantitative phonological preferences (lexically selected rankings in Greek, Finnish nominalizations vs. nonderived forms, the quantitative structure of the lexicon). We showed that an analysis that assumes the presence of several constraint rankings within the same language naturally accounted for both variation and morphological/lexical subregularities, as well as various quantitative facts.

The differences between Greek and Finnish allomorphy also serve to show that allomorph selection makes use of the prosodic principles already available in the language. In Greek, a quantity-insensitive language, we find that allomorphy is driven by the desire for perfect alignment of feet with word edges and the desire to form perfect trochees by synchronizing strong and weak beats with low and high vowels, respectively. No weight effects are present. In Finnish, a quantity-sensitive language, we find weight-based allomorphy. In addition, Finnish provides evidence for a principle we dubbed Generalized Prominence Alternation (GPA): "Maximize prominence differences between adjacent syllables if you can", where prominence is defined as a combination of stress, weight and vowel sonority. The best known instantiation of the GPA is foot rhythm (e.g. TPA), statable as "Maximize prominence differences between stressed and unstressed syllables within a foot." The Finnish data suggest that the GPA applies across the weight-sonority dimension as well.

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