Revisiting binary features: The case of Greek front high vocoids*

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Περίληψη

Στο παρόν άρθρο εξετάζεται η σχέση μεταξύ των πρόσθιων υψηλών φωνηεντοειδών της Ελληνικής και προτείνεται μια ανάλυση που καλύπτει τόσο τις σταθερές πραγματώσεις όσο και τις περιπτώσεις ελεύθερης ποικιλίας. Στο πλαίσιο των Διαβαθμισμένων Συμβολικών Αναπαραστάσεων (Smolensky και Goldrick 2016) υποστηρίζεται ότι το υποτεμαχιακό χαρακτηριστικό [φωνηεντικό], όπου έγκειται η ελάχιστη διάκριση μεταξύ των φωνημάτων /i/ και /j/, δεν είναι δυαδικό, αλλά διαθέτει στην υποκείμενη δομή διαβαθμισμένο επίπεδο ενέργειας, το οποίο κυμαίνεται μεταξύ του 0 και του 1. Με βάση τη συγκεκριμένη υπόθεση, η ελεύθερη εναλλαγή [i]~[J] ερμηνεύεται ως επιλογή μεταξύ δύο ισοαρμονικών εξαγόμενων συνδεόμενων με το εισαγόμενο /$i_{[x\varphi\omega\nu]}$/, όπου $0<x\leq 1$.

Λέξεις-κλειδιά: ημίφωνο, υψηλό πρόσθιο φωνήεν, ελεύθερη ποικιλία, Νέα Ελληνική, Διαβαθμισμένες Συμβολικές Αναπαραστάσεις

1 Greek front high vocoids

Glides comprise a class of segments which have posed great challenges to phonological analyses cross-linguistically, since they are known to pattern both with consonants and vowels (Levi 2004, 2011, Nevins and Chitoran 2008, Padgett 2008). There has been a long-lasting debate among scholars concerning the phonological status and the exact representation of these puzzling segments, which can be either allophones of vowels or distinct phonemes.

Three main hypotheses have been put forward to capture the interplay between the front high vocoids (FHV) of Standard Modern Greek (henceforth Greek), i.e. the vowel *i* and the glide *j*,[1] and to account for their underlying representation. First, it has been argued that Greek has a single phoneme /i/, that has a non-vocalic allophonic variant (henceforth [J]) in syllable margins; in other words, glide formation is seen as a hiatus resolution strategy (Kazazis 1968, Malavakis 1984, Warburton 1976, Holton et al. 2012, Arvaniti 2007). Counter-proposals suggest that output glides correspond to a separate phoneme /j/ (Mirambel 1959, Householder 1964, Setatos 1974, Nyman 1981, Baltazani and Topintzi 2012, Topintzi and Baltazani 2016). In a different vein, accounts adopting a stratified view on phonology posit two parallel phonological systems bearing different pragmatic information: the [–learned] stratum has an underspecified archiphoneme /I/, which surfaces as either [i] or [J] depending on its position in the syllable, while the [+learned] stratum has a fully specified /i/, which is always realized as [i] (Malikouti-Drachman 1987, Malikouti-Drachman and Drachman 1990, Soultatis 2013).

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[1] For a discussion on the back vowel /u/ and the peripheral vocoid [w] in Greek see Apostolopoulou (2018).

I concur with the view that there exists a phonological distinction between the two FHV in Greek. More specifically, the Greek inventory is taken to include two phonemes /i/ and /j/, both specified as [–consonantal], that contrast minimally with respect to the feature [vocalic], i.e. /i$_{[+\text{voc}]}$/ vs. /j$_{[-\text{voc}]}$/ (Baltazani and Topintzi 2012, henceforth B&T 2012; Topintzi and Baltazani 2016, henceforth T&B 2016).

There is ample evidence bearing testament to the phonological distinction between /i/ and /j/. The argument that is most often employed in order to confute the allophony hypothesis is the existence of minimal pairs:[2]

(1)	a.	ópio	'opium'	vs.	ópJo	'whichever'
	b.	míðia	'Medea'	vs.	míðJa	'mussels'

The trisyllabic window for stress (Malikouti-Drachman and Drachman 1989, Revithiadou 1999) offers additional evidence supporting the phonemic distinction between /i/ and /j/. A first example comes from the emergence of secondary stress in nominal possessives (B&T 2012). When a post-tonic post-vocalic FHV is found in the penultimate syllable, two patterns arise. If the FHV at hand is [+voc], it counts as syllabic; thus, the stress is on the antepenult. This entails that the presence of the possessive clitic will trigger post-lexical stress on the final syllable of the nominal host (2a).[3] On the other hand, a non-vocalic element cannot serve as a syllable nucleus; instead, it is syllabified in the coda of the –stressed– penult. In this case, the trisyllabic window is not violated when a possessive clitic is attached, hence the absence of enclitic stress (2b).

(2)	a.	/psaroka**i**ko mu/	[psa.ro.kà.**i**.kó.mu] *[psa.ro.ká**J**.ko.mu]	'my fishing boat'
	b.	/ga**j**da mu/	[gá**j**.da.mu] *[gà.**i**.dá.mu]	'my bagpipes'

Similar patterns are observed in verbs that contain a FHV in the antepenult in the past tense.[4] To illustrate, consider the verbs [ɣo?tévo] and [cela?ðó], where [?] denotes an ambiguous FHV. In the present, it remains unclear whether [?] corresponds to a vocalic or a non-vocalic phoneme. In the past, though, the distinct phonological properties of /i/ and /j/ come to light: the former can occur in a nucleus and receive stress (3a)[5], while the latter cannot (3b) (see also Soultatis 2013: 279).

(3)	a.	ɣo.**í**.tef.sa	*ɣó**J.**tef.sa	→ /ɣo**i**tevsa/	'I charmed'
	b.	ce.lá**J**.ði.sa	*ce.la.**í**.ði.sa	→ /kela**j**ðisa/	'I chirped'

Based on the above data, I conclude that hiatus is not obligatorily resolved in Greek: /i/ can be realized as [i], regardless of the phonological environment it appears in (cf.

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[2] Unless specified otherwise, the examples are taken from Apostolopoulou (2018). (1a) is drawn from B&T (2012: 153).
[3] Example (2a) is taken from B&T (2012: 154).
[4] Note that in the past tense the stress falls mandatorily on the antepenult (Spyropoulos and Revithiadou 2009, van Oostendorp 2012).
[5] The underlying representations are simplified.

Warburton 1976).[6] Moreover, /j/ always retains its non-vocalic status in the output next to a vowel.[7]

Interestingly, there are cases where [i] and [J] stand in free variation, the vast majority of them being recent loans from English. The variable phonological behavior is illustrated in (4) (the abovementioned criteria related to stress are employed):

(4)	a.	[ne.rà.**i.**ðá.mu]	~	[ne.rá**J.**ða.mu]	'my fairy'
	b.	[te.l**í.**o.sa]	~	[té.l**J**o.sa]	'I finished'
	c.	[pè.**i**.pér.mu]	~	[pé**J.**per.mu]	'my scientific paper'
	d.	[er.ko.dì.s**i.**ón.mu]	~	[er.ko.dí.s**J**on.mu]	'my air-conditioner'
	e.	[va. **í.**ba.ra]	~	[vá**J**.ba.ra]	'I felt the vibe'

2 Analyses within Optimality Theory

A comprehensive analysis of the FHV should be able to account for both categorical and variable realizations. If we assume a single representation for each variably realized word, the task of yielding the two variants is passed on to the grammar. Within a constraint-based model such as *Optimality Theory* (OT, Prince and Smolensky 1993/2004), the interplay between /$i_{[+voc]}$/ and /$j_{[-voc]}$/ is formalized as the interaction of (a) a *faithfulness* constraint penalizing input-output discrepancies regarding the value of [voc], i.e. IDENT[voc] (McCarthy and Prince 1995), and (b) a *markedness* constraint *VV prohibiting vowel sequences (McCarthy 1993). Given the ranking IDENT[voc] >> *VV, both /Vi/[8] (Tableau 1) and /Vj/ (Tableau 2) are realized faithfully, even at the expense of markedness, since a change in the value of [voc] fatally violates the high-ranking IDENT[voc].[9]

		/Vi/	IDENT[voc]	*VV
☞	a.	Vi		*
	b.	VJ	*!	

Tableau 1

		/Vj/	IDENT[voc]	*VV
	a.	Vi	*!	*
☞	b.	VJ		

Tableau 2

Free variation is captured by means of constraint reranking, i.e. *VV >> IDENT[voc], that is associated with a specific set of lexical forms containing a /Vi/ sequence in their

[6] Instances of variation attributed to fast-speech (Theofanopoulou-Kontou 1973) or stylistic variation (Rytting 2005, Markopoulos and Apostolopoulou 2020) are not taken into consideration.

[7] In particular, a post-vocalic /j/ surfaces as an approximant [j], taken to be [–cons]. Pre-vocalically, onset strengthening is observed, as /j/ is realized as a palatal consonant [j, ç, c, ɟ, ʎ, ɲ], depending on the preceding segment (T&B 2016, see also Bateman 2007). Furthermore, it becomes [$i_{[+voc]}$] in the absence of an adjacent vowel (Apostolopoulou 2018) or where a non-vocalic realization violates specific phonotactics, e.g. *CrJ (see Soultatis 2013, T&B 2016). Pursuing a more detailed discussion on the realizations of /j/ exceeds the scope of the current investigation.

[8] In all examples the FHV are postvocalic. The same analysis applies to prevocalic FHV.

[9] The [i]~[J] distinction analyzed here is based on phonological grounds (see, for example, the criteria related to APU stress). Further discussion about the phonetics-phonology interface and the mappings of the phonological outputs into articulatory/auditory forms falls beyond the scope of the present paper.

underlying structure and favors the candidate in which the hiatus has been repaired in the output:

	/Vi/	*VV	IDENT[voc]
	a. Vi	*!	
☞	b. VJ		*

Tableau 3

Extensions of the standard model have also aimed at accounting for variable patterns. For example, it has been argued that variation arises from the *crucial nonranking* of the relevant constraints (Kiparsky 1993, Reynolds 1994, Anttila 1997). Thus, both candidates can be deemed grammatical under the respective total ranking:

	/Vi/	IDENT[voc]	*VV
☞	a. Vi		*
☞	b. VJ	*	

Tableau 4

IDENT[voc] >> *VV
***VV >> IDENT[voc]**

Moreover, an analysis along the lines of Coetzee (2006) would treat variation as selection among candidates that violate only constraints which are ranked below a critical *cut-off* point and do not decide on grammaticality.[10] As illustrated in Tableau 5, candidates *c* and *d* are eliminated as ungrammatical by constraints above the cut-off, i.e. MAX and DEP,[11] respectively. On the other hand, candidates *a* and *b* are both possible.

	/Vi/	DEP	MAX	IDENT[voc]	*VV
☞	a. Vi				*
☞	b. VJ			*	
	c. V		*!		
	d. VCi	*!			

Tableau 5

According to the aforementioned OT-based analyses, invariable patterns are captured by means of strict domination (see Tableaux 1–2). However, we need to employ at least two different grammars for the same language, as a single hierarchy does not suffice to accommodate all the patterns.

In order to develop an analysis that enjoys empirical adequacy without postulating multiple grammars, we can combine the *Pseudo-Optionality* approach (following Müller 1999) with a lexicalist point of view (Ralli 2005, Bermúdez-Otero 2013). Greek lexicon would then be taken to include simply stored stems that correspond to categorical realizations (5a–b) and multiple stems for each case displaying variation (5c–d). A single ranking, where faithfulness dominates markedness, i.e. IDENT[voc] >> *VV, would evaluate all inputs and select a single winner (see Tableau 1–2). According to such an analysis, variation is viewed as free choice between winners.

[10] According to Coetzee, the constraints below the cut-off point "impose a harmonic rank-ordering on the candidates, thereby determining the relative frequency with which they will be observed as variant outputs." (2006: 342).

[11] MAX penalizes deletion and DEP penalizes epenthesis (McCarthy and Prince 1995).

(5)	a.	/ɣa**j**ðaros/	→	[ɣá**j**.ða.ros]	‘donkey’[12]
	b.	/psarokai**i**ko/	→	[psa.ro.ká.**i**.ko]	‘fishing boat’
	c.	/nera**i**ða/	→	[ne.rá.**i.**ða]	‘fairy’
		/nera**j**ða/	→	[ne.rá**J.**ða]	
	d.	/pe**i**per/	→	[pé,**i**.per]	‘scientific paper’
		/pe**j**per/	→	[pé**J.**per]	

In this light, as Anttila (2002) points out, competition does not take place in phonology at all: variation is namely reduced to optionality at the point of lexical insertion. However, making this choice independent from grammar comes to contradiction with the general observation that grammar-related factors do emerge in phonological variation either categorically or gradiently; essentially, under this approach, these effects are impossible to model (Anttila 2002: 218). Moreover, such an account entails a significantly increased burden for the lexicon, especially if we consider the amount of borrowed words that are supposed to be stored twice when they enter the lexicon.

3 The proposal

The goal of the present paper is to account for all the attested patterns by means of a single computation system while keeping the lexicon as parsimonious as possible. I propose that the key to explaining variation does not lie in the architecture of the grammar but in the representation of the segments involved. The analysis builds on *Gradient Symbolic Representations* theory (GSR, Smolensky and Goldrick 2016, Faust and Smolensky 2017, Revithiadou et al. 2019). In a nutshell, underlying elements have a gradient *activity level* (AL) ranging between 0 and 1. The AL in the output must be equal to 1 (cf. Zimmerman 2018). Should an element have an underlying AL lower than 1, additional activity must be provided by the grammar in order for it to get realized. Otherwise, the non-fully active element is silenced.

The proposed account places the “defectiveness” of /i/ at the subsegmental level (Rosen 2016, Walker 2019 and references therein; cf. Smolensky and Goldrick 2016). The feature [voc] is taken to be privative.[13] Specifically, the binary values [+] and [–] are replaced with AL values [1] and [0], respectively. An immediate consequence is that intermediate AL values [*x*] are predicted. The contrast between vocalic and non-vocalic is captured by the presence vs. absence of a specific AL for [voc].

In this light, Greek /j/ is specified as [0voc] and contrasts minimally with /$i_{[x\text{voc}]}$/, where $0<x\leq 1$. When /i/ is fully active regarding [voc], full activity is guaranteed also in the output, i.e. [$i_{[1\text{voc}]}$]. If, though, [voc] has a gradient AL, its realization depends on the grammar: unless it is less costly to provide the required activity, the AL of [voc] becomes 0; thus, an output glide [$J_{[0\text{voc}]}$] is generated.[14]

For the phonological computation I employ *Gradient Harmonic Grammar* (GHG, Smolensky and Goldrick 2016). In Harmonic Grammars (Legendre et al. 1990), constraints are not strictly ranked with respect to each other, but weighted. As a result,

[12] B&T (2012: 154).

[13] See Lombardi (1991, 2001) on the privativity of laryngeal features.

[14] The assumption of impoverished underlying elements finds further empirical support in cases of [i]~[J] alternation in particular derivational suffixes, e.g. /-ianos/, /-iazo/. For a detailed analysis see Apostolopoulou (2018).

the relationship between a dominant and a subordinate constraint in OT is translated into a GHG constraint *A* that bears a relatively greater weight than a GHG constraint *B*.

The penalty a candidate yields on a constraint is calculated by multiplying the number of violations with the weight of the specific constraint. The sum of penalties each candidate incurs corresponds to its *harmony* (*H*). The winning candidate is the one with the highest *H*-value. Tableau 6 illustrates the evaluation process in GHG (the violations are given with negative numbers; the rightmost column presents the *H*-value for each candidate).

		/ai/	**MAX** *4*	**IDENT** *3*	***VV** *2*	***H***
☞	**a.**	**ai**			–1 × 2 = –2	**–2**
	b.	**aj**		–1 × 3 = –3		**–3**
	c.	**a**	–1 × 4 = –4			**–4**
	d.	**aa**		–1 × 3 = –3	–1 × 2 = –2	–3 – 2 = **–5**

Tableau 6

As in OT, the core of the GHG analysis of the Greek FHV is the interaction between a faithfulness constraint disfavoring changes from the input to the output on the one hand and a markedness constraint penalizing vowel sequences, i.e. *VV, on the other hand. Crucially, in GHG, IDENT[voc] fails to capture the gradient nature of the change in the AL from the input to the output. Therefore, it is decomposed into (a) MAX[voc], which militates against deletion of the underlying AL in the output, and (b) DEP[voc], which penalizes the addition of activity.[15]

MAX[voc] and DEP[voc] are assigned a relatively greater weight (=2 each)[16] than *VV (=1), mirroring the domination of faithfulness over markedness in OT (see section 2). *VV is violated categorically, i.e. once for each two-vowel sequence in the output. The violations of MAX[voc] and DEP[voc], though, depend on the AL of the element that surfaces unfaithfully, i.e. [voc]. More precisely, if the feature is silenced, the underlying AL that is lost is multiplied by the weight of MAX[voc]. The assumption follows that, if [voc] has underlying AL=1, then in [$J_{[0voc]}$] we have full subtraction of this AL, i.e. a full violation on MAX[voc]. If, however, [voc] has a lower AL, a lesser penalty is assigned. In the same vein, if the underlying activity of [voc] is lower than 1, yet the feature eventually makes it to the output, then the numerical value corresponding to the additional activity that was provided is multiplied by the weight of DEP[voc]. The lower the underlying AL of [voc] is, the greater the violation of DEP[voc] is. The calculation of the violations of the faithfulness constraints is illustrated in Table 1:

	Input	***Output***	***Violation of faithfulness***	
			MAX[voc]	**DEP[voc]**
AL of [voc]	1	1	0	0
	0	0	0	0
	1	0	1	0
	0	1	0	1
	x	1	0	1–*x*
	x	0	1–*x*	0

Table 1

[15] See McCarthy and Prince (1995); Lombardi (2001) and references therein.

[16] For the purposes of the present paper, there is no reason to postulate different weight values for MAX[voc] and DEP[voc].

The analysis of the variable and the invariable manifestations of the FHV in a hiatus environment is detailed below. First, let us examine a toy input /$Vi_{[1voc]}$/, where the /i/ is fully active with respect to [voc]. Given the weighted constraints presented above, the faithful candidate *a* is preferred despite containing a marked structure, as its violation of *VV (weight=1) has a smaller impact on the total *H*-value in comparison to candidate *b*, which violates MAX[voc] (weight=2). Since a single winner arises from this competition, no variation is observed.

/$Vi_{[1voc]}$/	DEP[voc] *2*	MAX[voc] *2*	*VV *1*	*H*
☞ a. Vi			–1 × 1 = –1	**–1**
b. VJ		–1 × 2 = –2		**–2**

Tableau 7

Consider now an input /$Vi_{[0.75voc]}$/, i.e. containing an /i/ that is weak with respect to [voc]. Because [voc] is no longer fully active (AL=0.75), changing /i/ into [J] yields a lesser violation of MAX[voc] than the same process did in Tableau 7. More specifically, for the calculation of the violation incurred by candidate *b* with respect to MAX[voc], the weight of the constraint has to be multiplied by –0.75 instead of –1, as less of activity needs to be subtracted in order for the AL of [voc] to reach 0. Therefore, candidate *b* has now a *H*-value equal to –1.5 instead of –2. As for candidate *a*, retaining a positive value for [voc] now does not come for free: the required activity insertion of 0.25 so that the AL of [voc] reaches 1 violates DEP[voc] by –0.5 (versus the zero violation in Tableau 7). At the same time, candidate *a* violates also *VV. The sum of the penalties for both candidates ends up equal (–1.5). In other words, we get balanced *H*-values among the two possible outputs, which allows the two forms to alternate freely.

/$Vi_{[0.75voc]}$/	DEP[voc] *2*	MAX[voc] *2*	*VV *1*	*H*
☞ a. Vi	–0.25 × 2 = –0.5		–1 × 1 = –1	–0.5 –1 = **1.5**
☞ b. VJ		–0.75 × 2 = –1.5		**–1.5**

Tableau 8

4 Conclusions

In the proposed analysis of the Greek FHV, phonological variation was associated with weak representations. Instead of a stem-listing solution, which entails increased storage requirements and reduces variation to lexical selection, an impoverished vowel with respect to the AL of a privative [voc] was postulated. I posited a single computational system within GHG (cf. multiple OT grammars) and argued that the invariable manifestations are associated with a fully active /$i_{[1voc]}$/ that always surfaces faithfully. On the other hand, the underlying representation of lexical items exhibiting variation contain a gradiently active /$i_{[x\text{voc}]}$/ and thus incur gradient violations of faithfulness constraints. Consequently, the competition between markedness and faithfulness may reach a fine line so that more than one isoharmonic outputs may be selected by the grammar.

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