Misbehaved PWs: A Harmonic Grammar account of gradient sandhi in Greek

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Two major kinds of arguments have been proposed for recursion at the PW level. The first type of argument is morphosyntactic in nature and reflects primarily the view advocated in Selkirk (1995: 458–460), who proposes that nested syntactic structures are translated by phonology into a PW-Rec, e.g. $_{V}$[$_{V}$[need] 'm]] $_{PW}$[$_{PW}$[need] 'm]. In this case, phonology mirrors morphosyntactic embededness by respecting the prosodic boundaries of the lexical word, i.e., the verb (due to a high-ranked alignment constraint which requires edges of the morphological word to be matched by a PW boundary). However, it is well grounded that isomorphy is not always respected at the interfaces. The second line of argument removes the motivation for the recursive prosodic tree as a reflection of morphosyntactic structure. PW-Rec are not replicas of morphosyntactic recursivity but rather instantiations of different levels of the PW that offer various possibilities for the prosodification of functional elements (clitics, particles, determiners, etc.) at the post-lexical level (Booij 1995, 1996; Peperkamp 1997; Vigário 1999, among others). Itô & Mester (2007, 2009, 2013), in particular, keep the number of prosodic categories low, i.e. PW and PPh, but proliferate their layers through *prosodic adjunction*. More specifically, a PW has several instantiations within a projection, among them a *maximal* (PW^{max}, a PW not dominated by another PW) and a *minimal* one (PW^{min}, a PW that does not dominate another PW). Domain-sensitive phonological processes can target specific subcategories of a recursive structure, i.e. maximal or minimal projections. More importantly, each prosodic layer finds support in phonological evidence, such as the blocking or the optional application of a phonological process that (obligatorily) applies at the lower layer (e.g., the failure of prevocalic schwa deletion in proclitics in Dutch, e.g., /də avɔnd/ $_{PW\text{-}Rec}$[də $_{PW}$[avɔnt]]/*[davɔnt] 'the afternoon', as opposed to enclitics, e.g., /haldə ɪk/ $_{PW}$[haldɪk] 'I took', is taken by Booij (1996) as evidence for prosodic adjunction). However, a serious drawback of the phonological approach to recursion is that it does not take into consideration the variability that exists especially within the lowest domains; often differences across lexical items are captured by proposing the existence of a further layer of prosodic structure. Crucially, however, this assumption is not always corroborated by the data. Below we explicate the nature of the problem and propose a solution within the weighted constraint framework of *Gradient Harmonic Grammar* (GHG, Smolensky & Goldrick 2016) in which representations contain gradiently active symbols.

Kainada (2009) has shown that the distribution of voicing assimilation in nasal-stop sequences between a function word and a lexical word in Greek cannot be fitted into neatly distinct categories of the domain in which the phenomenon is allowed and the domain in which it is blocked, as would be Itô & Mester's expectation. In a perception experiment she conducted, she observed differences across lexical items on how many times they voice within a specific domain, with some items voicing more and some fewer times. For instance, voicing occurred in all instances containing the negative particle [ðen] and the determiners [ton/tin] 'the-MASC/FEM.ACC.SG', as opposed to the other negative particle [min], which triggered voicing only 50% of the times, showing optionality. In sharp contrast, the complementizers [ˈan] 'if' and [ˈotan] 'when' blocked voicing, which we take to also be the case with the determiner [ton] 'the-GEN.PL':

(1) *Variability in nasal-stop voicing assimilation in* $_{PW}^{max}$*[fnc* $_{PW}$*[word]]*

a.	/ðen pirazis/	[ðe ^{m}biˈɾazis]	'don't tease-2SG'
b.	/min pirazis/	[mi ^{m}biˈɾazis] ~ [min piˈɾazis]	'don't tease-2SG'
c.	/ton patera/	[to ^{m}baˈteɾa]	'the-ACC.SG father-ACC.SG'
d.	/ton pateron/	[ton paˈteɾon]	'the-GEN.PL father-GEN.PL'

The assumed prosodic structure for determiners and negation particles is PW^{max}: $_{PW}{}^{max}$[ton $_{PW}$[patera], whereas for stressed complementizers and the following lexical word is the PPh: $_{PPh}$[$_{PW}$[ˈotan] $_{PW}$[piˈrazis]] (Revithiadou & Spyropoulos 2008). Apparently, some functional items behave phonologically as if they form PPhs with their host, which is bizarre given their lack of PW-status (i.e., they are unstressed). To conclude, nasal-stop voicing seems to send the wrong signals for the prosodification of fnc-word strings (see also Hsu 2019) challenging the importance of phonological evidence for the identification of prosodic units.

The problem described above can be easily addressed if the exceptional prosodic behavior of the data in question is linked to the underlying properties of certain misbehaved lexical items. In the spirit of Smolensky & Goldrick (2016) and related work (Rosen 2016; Faust & Smolensky 2017ab; Zimmermann 2018), we take input structures to have gradient *activity level* (AL) values ranging from 0 to 1. Only elements with output activity 1 are pronounceable; those with inherent AL lower than 1 are silenced, unless they are reinforced during phonological computation. The idea is that word-final nasals come in different strengths depending on the lexical item they belong to. For instance, /n/ of the gen.pl det is strong (AL:1), whereas /n/ in the acc.sg det and the neg /ðen/ is much weaker (AL: 0.4). In order to be realized, /n/ chooses to coalesce (in violation of UNIF) with the voiceless stop into a prenasalized voiced stop (Kong et al. 2007).

The tableau in (2) provides the GHG for the phonological process of nasal-stop voicing (*NT) and place assimilation (*NP) in the same prosodic environment, the PW^{max}. The violation of DEP is proportional to the amount of activity that needs to be added in order for the segment to reach activity 1. For cand-2ib, for instance, this penalty is tantamount to the weight of the constraint (w=–5) multiplied by the added activity: –5 x 0.6 = –3. The violation of MAX is calculated in a similar way; it is proportional to the underlying activity of a segment that does not make it to the surface. For cand-2ic the penalty of MAX equals the weight of the constraint (w=–15) times the lost (non-pronounced) activity: –15 x 0.4 = –6. Interestingly, because gradient activity contributes to the total *harmony* (H) of each candidate, we expect outputs with either merged or faithful /n/s, depending not on the prosodic structure per se but on the lexical item that participates in a structure. To explain, within the PW^{max}, /ton$_{1.0}$/(gen.pl) fails to merge with the following stop, whereas in the same domain /ton$_{0.4}$/(acc.sg) does merge. Similarly, neg /min$_{0.6}$/ exhibits variation as a result of its slightly higher AL on word-final /n/ compared to neg /ðen$_{0.4}$/ (see 2-i for /ton$_{0.4}$/ (acc.sg)).

(2)	DEP w: –5	MAX w: –15	UNIF w: –4	*NT w: –1	*NP w: –1	H	
i. /ton$_{0.4}$ patera/ (acc.sg)							
a. $_{PW}{}^{max}$[to $_{PW}$[^{m}baˈtera]]			1			–4	☜
b. $_{PW}{}^{max}$[ton$_{1}$ $_{PW}$[paˈtera]]	(1 – 0.4 =) 0.6			1	1	–5	
c. $_{PW}{}^{max}$ [ton$_{0}$ $_{PW}$[paˈtera]]		0.4				–6	
ii. /ton$_{1.0}$ pateron/ (gen.pl)							
a. $_{PW}{}^{max}$[to $_{PW}$[^{m}baˈteron]]			1			–4	
b. $_{PW}{}^{max}$[ton$_{1}$ $_{PW}$[paˈteron]]				1	1	–2	☜
c. $_{PW}{}^{max}$ [ton$_{0}$ $_{PW}$[paˈteron]]		1				–15	
iii. /min$_{0.6}$ pirazis/ (neg)							
a. $_{PW}{}^{max}$[mi $_{PW}$[^{m}biˈrazis]]			1			–4	☜
b. $_{PW}{}^{max}$[min$_{1}$ $_{PW}$[piˈrazis]]	(1 – 0.6 =) 0.4			1	1	–4	☜
c. $_{PW}{}^{max}$ [min$_{0.6}$ $_{PW}$[piˈrazis]]		0.6				–9	

To conclude, approaches based solely on recursive prosodic constituents are not able to explain the attested variation in sandhi phenomena. We thus propose that phonological processes are sensitive not only to the prosodic structure but also to the gradient strength of the lexical items' segmental representation.