

Derived Environment Effects and Consistency of Exponence

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1 Coloured Containment

1.1 Consistency of Exponence

In this article, I defend the assumption that the generator function Gen of Optimality Theory should be restricted by a principle called *Consistency of Exponence* and I show how this assumption helps us understand so-called Derived Environment Effects.¹

Consistency of Exponence was introduced almost in some of the earliest work on Optimality Theory (McCarthy & Prince, 1993, 1994) as a reasonable restriction on the way the phonology works, and in particular on the way it interacts with the lexical specification of morphemes.² Over the course of the past 15 years, very few explicit arguments have been provided against it — those that have will be discussed in section 1.3 — and we will show in section 1.2 that several well-known families of constraints are dependent on it. Nevertheless, the principle never received the attention it deserved. Here is the original definition:

(1) *Consistency of Exponence*

“No changes in the exponence of a phonologically-specified morpheme are permitted.” (McCarthy & Prince, 1993, 1994)

¹Thanks are due to Ben Hermans, Anthi Revithiadou, Christian Uffmann, the audiences at my talks in Tromsø, August 2005 and London, December 2005 and the reviewers and editors. All errors are mine.

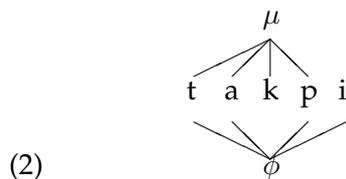
²The idea of Containment predates Consistency of Exponence, as it is found already in Prince & Smolensky (1993). The term Containment is from McCarthy & Prince (1993, 1994).

The principle was explained by McCarthy & Prince (1993, 1994) in the following way:

“[Consistency of Exponence] means that the lexical specifications of a morpheme (segments, prosody, or whatever) can never be affected by Gen. In particular, epenthetic elements posited by Gen will have no morphological affiliation, even when they lie within or between strings with morphemic identity. Similarly, underparsing of segments — failure to endow them with syllable structure — will not change the make-up of a morpheme, though it will surely change how that morpheme is realized phonetically. Thus, any given morpheme’s phonological exponents must be identical in underlying and surface form.”

Underlying this is an important assumption on what Gen can do to morphology: it can only concatenate morphemes, it cannot change the morphemes themselves to something completely different. Phonologically, we are free; we can spread features from one morpheme to another, insert various types of material and decide not to pronounce other parts; but this will never affect the morphological status of the phonological material involved. If we decide not to pronounce the final *t* of *cat*, or if we insert a vowel at its end ([kætə]), this does not change the fact that the morpheme is /kæt/.

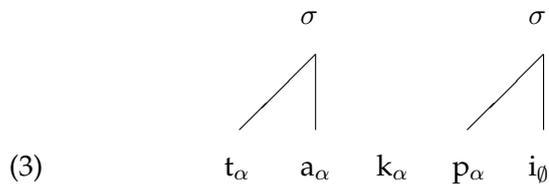
It may be instructive to consider an example. Let us consider a hypothetical input morpheme /takp/ in some language L; and let us furthermore assume that this morpheme would be pronounced as [tapi] in isolation. Consistency of Exponence gives the following output representation:



In this picture, the μ denotes the morphological structure: there is one morpheme, which ‘consists’ of the segments /t, a, k, p/, and will always consist of these segments. Φ denotes the phonological structure, which does not include the deleted /k/, but it does contain a segment [i], which is phonologically present.

In van Oostendorp (2005), I propose a slightly different notation, one which is based on colours — reproduced here as subscripts:³

³See Blaho & Bye (2005) for a partially similar approach, rooted in Correspondence Theory.



Every morpheme has its own colour which is distributed over all segments and other material — features, mora's, etc. — which make it up. In this simple example, there is only one morpheme with the 'colour' α . The epenthetic segment does not have any morphological colour, denoted here by giving \emptyset as its subscript. In terms of colours, Consistency of Exponence states that Gen cannot change the colour of any phonological element: it cannot give colour to epenthetic material, and it cannot alter the colours of underlying material.

A second principle restricting Gen in McCarthy & Prince (1993, 1994) is called *Containment*. This can be seen as a special case of Consistency of Exponence in most cases:⁴

(4) *Containment*

No element may be literally removed from the input form. The input is thus contained in every candidate form.

This is a special case of Consistency of Exponence, since also the latter principle says that everything which is part of a morpheme should stay part of that morpheme. We thus do not need Containment independently of Consistency of Exponence, but it is useful to have a separate name for it, since Containment refers to one of the more controversial aspects of Consistency of Exponence.⁵

Prince & Smolensky (1993) have implemented the idea of Containment in one specific way, the so-called PARSE & FILL Model, named after the two constraints which take care of the most important aspects of faithfulness theory, deletion and insertion respectively:

- (5) a. PARSE: 'Every phonological element needs to be parsed into the prosodic structure.' (I.e. deleted elements are 'not parsed' in the phonological structure.)

⁴A third principle governing Gen is *Freedom of Analysis*: "posit any amount of structure". Freedom of Analysis can hardly be seen as a restriction on Gen.

⁵Logically speaking, there are a few cases where the two principles work differently. Consider for instance the case of an underlying segment without morphological affiliation – in other words an 'underlying epenthetic segment' (this point has been brought to my attention by Curt Rice, p.c.). Containment would disallow deletion of such a segment, whereas Consistency of Exponence would not. It is unclear, at present, whether such devices as underlying epenthetic segments are ever really needed in phonological analysis, and thus, whether an independent status for Containment is warranted.

- b. FILL: ‘Syllable positions are filled with segmental material.’ (I.e. inserted segments are ‘empty’.)

The PARSE & FILL Model is fraught with problems, in particular with respect to the theory of epenthesis, i.e. the FILL component (van Oostendorp, 2005). For instance, inserted segments have to be ‘empty’ in order to be recognizable as inserted at all: if we would allow non-empty epenthetic segments, the constraint FILL would not be violated, and hence we would have no theoretical device to prevent gratuitous epenthesis in all languages of the world. We thus have to prevent features from being inserted or from spreading into epenthetic vowels if we use FILL. This means for instance that we can have no phonological analysis of vowel harmony to epenthetic vowels, clearly an undesirable result.

Instead of this particular implementation of Containment, van Oostendorp (2005) therefore proposes an alternative implementation, called *Coloured Containment*, of which the most important constraints are:

- (6) a. PARSE- $\phi(\alpha)$: The morphological element α must be incorporated into the phonological structure. (No deletion.)
 b. PARSE- $\mu(\alpha)$: The phonological element α must be incorporated into the morphological structure. (No insertion.)

As in the PARSE & FILL Model, we assume that underlying material which is not pronounced, is still present — it just fails to be incorporated into the prosodic structure. The phonetics will only pronounce the material that is prosodically parsed and leave the rest behind (‘Stray Erasure’).

PARSE- $\phi(\alpha)$ forces everything to be in the phonological structure, and thus counts as a constraint against ‘deletion’. PARSE- $\mu(\alpha)$, inversely, disallows any material which is not part of a morpheme. Since something can only be part of a morpheme when it is underlying, this forbids epenthesis (cf. Golston, this volume, for a proposal which integrates epenthetic segments into the input). Since faithfulness violations can always be decomposed into deletion + insertion, this gives us the machinery needed to describe the relations between lexicon and the phonetic output.

Notice that we have so far not really introduced anything new into the theory. Given Consistency of Exponence, the relevant properties of a theory of faithfulness theory follow for free, and the enrichment with Correspondence Theory seems largely superfluous.

Correspondence Theory is a more powerful theory of faithfulness than Containment-based models, involving more abstract relations (the correspondence relations between input and output), and allowing for analyses which are unavailable in Containment — such as unbounded metathesis and changing the morphological affiliation of segments. It remains to be seen whether we need this power independently, but this is not the goal of this paper. The

literature so far has not given uncontested evidence to this effect (see van Oostendorp, 2005, for more discussion).

The structure of the argumentation is as follows. I will first set out to show that Consistency of Exponence is implicit in much of the current literature: people routinely invoke constraints which assume that the morphological affiliation of phonological material cannot be changed (section 1.2); and furthermore, the only published attacks on Consistency of Exponence, proposing to make it a violable constraint rather than a restriction on Gen, are not successful (1.3). Having thus established that Consistency of Exponence seems to be a principle restricting Gen, I turn to derived environment effects and show how these can be captured in a model which takes Consistency of Exponence seriously. It will turn out that we can formulate the relevant constraint without problems, assuming that morphological affiliation is a visible property.

1.2 The need for colours

Consistency of Exponence is not often referred to in the literature, but there are a few exceptions. In the first place, there is a fairly large amount of literature which refers to the morphological colours implicitly, using constraints which do not make sense if we can freely change the morphological status of morphemes. In the second place, there are a few more explicit rejections of Consistency of Exponence in the literature.

Among the examples of constraint families which crucially use the unchangeability of morphological affiliation are positional faithfulness constraints such as FAITH-root and FAITH-affix. McCarthy & Prince (1995a) cite several examples of this:

- (7) a. *Turkish vowels are distinctively [\pm back] in roots, but not in affixes*
 $\text{IDENT}_{\text{Root}}(\text{back}) \gg *[\text{back}] \gg \text{IDENT}_{\text{Affix}}(\text{back})$
 b. *Sanskrit roots contain onset clusters, but affixes do not*
 $\text{MAX}_{\text{Root}} \gg *[\text{COMPLEX}] \gg \text{MAX}_{\text{Affix}}$
 c. *Arabic roots contain pharyngeals, but affixes do not*
 $\text{IDENT}_{\text{Root}}(\text{Place}) \gg *[\text{Pharyngeal}] \gg \text{IDENT}_{\text{Affix}}(\text{Place})$

In Dutch (as in most Germanic languages), inflectional affixes only contain coronal consonants, whereas in roots we can distinguish three places of articulation (coronal, labial, velar). This could be described in terms of the following ranking:

- (8) $\text{IDENT}_{\text{Root}}(\text{Place}) \gg *[\text{velar}], *[\text{labial}] \gg \text{IDENT}_{\text{Affix}}(\text{Place}) \gg *[\text{coronal}]$

Yet if Gen could freely change the morphological status of segments, it could change every root consonant into an affix consonant, and then reduce it; this

would actually be the preferred winner (in the following tableau the subscript ‘r’ stands for ‘root’ and ‘a’ for ‘affix’; I assumed the nonsensical suffix $-/p/$ for illustrative purposes):

(9)

/spɛm/ ‘to spam’ -/p/ 3SG	IDENT _R	*[labial]	IDENT _A	*[coronal]
s _r p _r ɛ _r m _r p _a		*!*		*
✗ s _r p _r ɛ _r m _r t _a		*!*	*	**
s _r t _r ɛ _r n _r t _a	*!*		*	****
☞ s _a t _a ɛ _r n _a t _a			***	****

In this tableau, **✗** marks the candidate which should win; however, it is bested in this analysis by the candidate marked with **☞**, in which all segments have turned affixal.

A potential way out of this would be to have root and affix faithfulness constraints refer to the *underlying* morphological status of phonological material only. Under such assumptions, which can be implemented in Correspondence Theory, the morphological status no longer has to be visible in the output form in the form of colours. But constraints would still be sensitive to colours in the input.

This means that, even if we allow our Gen function to change the morphological status of segments, we have to restrict our theory such that only the underlying morphological status is visible for the constraints. The changes that Gen makes to this are thus vacuous, since they are never going to affect constraint violation. In other words, the constraints only see *consistent* exponence of morphemes. Consistency of Exponence is thus still satisfied: since containment follows logically from this, correspondence theory is thus superfluous.

Another example is provided by the FAITH-Noun constraint family of Smith (2001) and related work. Smith observes that nouns usually allow for more contrasts than other categories, and she implements this by having a special faithfulness constraint on nouns. But again, if Gen is allowed to change the label “Verb” into the label “Noun” for free, FAITH-Noun cannot do any work.

Finally, also constraints aligning morphological to phonological structure such as ALIGN-(M, Φ) (sometimes referred to as ANCHOR) have to rely on a stable morphological affiliation of phonological material during the phonological derivation. In German and (The Netherlands) Dutch, prefix-stem boundaries cannot be crossed by syllable boundaries, so that a Dutch form like *op+eet* ‘eat up’ is pronounced as [ɔp.et], not as *[ɔ.peat] (McCarthy & Prince, 1995b).⁶ A constraint aligning the lefthand side boundary of stems to

⁶See Noske (2005) for an argument that in Flanders syllables may cross morpheme

the lefthand side boundary of phonological word ($\text{ALIGN}(\mathbf{R}, \omega)$) may be considered responsible for this. Again, if we would be allowed to freely change the status of morphological material, this would change the analysis completely:

(10)

/op/ + /et/	ALIGN(\mathbf{R}, ω)	ONSET
$\times \text{ə}_a \text{p}_a \cdot \text{e}_r \text{t}_r$		*!
$\text{ə}_a \cdot \text{p}_a \text{e}_r \text{t}_r$	*!	
$\text{ə}_r \text{p}_r \text{e}_r \text{t}_r$		

Whether or not we want to be able to formalize all these distinctions, is an empirical matter; but we can only formalize them if we keep track of the morphological status of segments. Of course there is one alternative to restricting Gen by Consistency of Exponence, and this is by introducing a violable constraint into CON which does the same job: this constraint would be high ranked in the cases just discussed. We will turn to this alternative now.

1.3 Attacks on Consistency of Exponence

Even though Consistency of Exponence is usually ignored in the literature, the only explicit attacks against it of which I am aware are Walker & Feng (2004) and Łubowicz (2005a). These authors suggest that Consistency of Exponence is not a restriction of Gen, but a set of violable constraints in CON, controlling the output of Gen. Gen will be able to change the morphological affiliation of phonological material, but in many cases these constraints will filter out candidates with those changes. The argumentation in favour of such a position should be that Consistency of Exponence is sometimes violated by a winner candidate in some natural language; this is the type of argument Walker & Feng provide.

The data are from Anxiang, a Chinese dialect spoken in the Hunan Province in central China. In this dialect, a diminutive is formed of a noun by adding Cə_r , where C is a copy of the stem consonant, and ə an epenthetic vowel.

(11)

Stem	Diminutive	Gloss
$\text{p}^h \text{a}$	$\text{p}^h \text{ə}_r \text{p}^h \text{ə}_r$	'claw'
ke	$\text{k} \text{ə}_r \text{k}$	'square'
to	$\text{t} \text{ə}_r \text{t}$	'pile'
$\text{p}^h \text{w} \text{u}$	$\text{p}^h \text{w} \text{ə}_r \text{p}^h \text{w}$	'shop'
$\text{p}^h \text{a} \text{u}$	$\text{p}^h \text{ə}_r \text{p}^h \text{a} \text{u}$	'bulb'

The diminutive form thus consists of the stem, a copy of the consonant of the stem, a schwa and an /r/. Since the schwa may be considered an epenthetic boundaries.

vowel, Walker & Feng assume that the underlying structure of the diminutive suffix is /r/.

Walker & Feng (2004) argue that we need two constraints for our analysis of these facts. First we have the following constraint on the morphology-phonology interface:

- (12) ALIGN[σ]: ‘Each morpheme should occupy exactly one syllable and vice versa’

This constraint is argued to be a very general one on the phonology-morphology interface in this dialect of Chinese in which every morpheme has the size of exactly one syllable — and every syllable therefore corresponds to exactly one morpheme.

Next to this well-formedness constraint, Walker & Feng (2004) propose the following faithfulness constraint, which is essentially a violable version of Consistency of Exponence:

- (13) IDENT-MM: ‘Let α be a morpheme in the input, and β be its correspondent morpheme in the output. If α has phonological content ϕ , then β has phonological content ϕ and vice versa.’

In order to show that IDENT-MM is not a restriction on Gen, we need to show that it is sometimes violated in the winning candidate. This is exactly what happens in Anxiang, according to Walker & Feng (2004), as illustrated by the following tableau:

(14)

	ke_1, r_2	ALIGN[σ]	IDENT-MM
a.	$[ke]_1[r]_2$	*!	
b.	$[ke]_1kə[r]_2$	*!	
☞ c.	$[ke]_1[kəʀ]_2$		*

The winning candidate here is the one in which the ‘copied’ consonant and the epenthetic vowel have become part of the morpheme on the surface. This would prove that Consistency of Exponence is indeed violable.

Yet very much depends on our interpretation of the constraint ALIGN[σ]. Under one interpretation, we could argue that this constraint is violated in (14a) both by the morpheme *ke-* and by the morpheme *-r* — because neither corresponds exactly to one syllable —, so that this form has 2 violations of that constraint. On the other hand, (14b) has only 1 (for *r*, but not for *ke*). This means that even if we do not take (14c) into consideration — because this is not generated under Consistency of Exponence — the correct surface string *kekəʀ* would still win:

	ke_1, r_2	ALIGN[σ]	IDENT-MM
(15)	a. $[ke]_1[r]_2$	**!	
	b. $[ke]_1k\emptyset[r]_2$	*	

Although it is a little less explicit, another proposal for a violable interpretation of Consistency of Exponence can be found in Łubowicz (2005a), who analyses phenomena in Palauan and Akkadian, and argues that these should be understood as the result of ‘morpheme absorption’: infixed elements become part of the morphological stem. I will discuss the Palauan facts here, but I believe a similar reanalysis can be made for Akkadian.

In Palauan, then, there is a morpheme / m (\emptyset)/ which behaves sometimes as a prefix and sometimes as an infix; the status of the schwa is irrelevant. Łubowicz (2005a) argues that the choice between these two options is non-phonological and made on morphological grounds only:

(16)	Prefixation	dakt	‘fear’	mə-dakt	‘be/get fearful’
		rur	‘shame’	mə-rur	‘be/get ashamed’
	Infixation	lájəl	‘crying’	l-m-ájəl	‘cry’
		rurt	‘running’	rə-m-urt	‘run’

The prefix and the infix behave differently with respect to one phonological phenomenon: (long distance) dissimilation. If the verb already contains a labial consonant, the infix nasal turns into a rounded vowel [u], whereas the prefix nasal is not affected:

(17)	Prefixation	dub	‘poison’	mə-dub	‘be/get poisoned/bombed’
		kimud	‘cut hair’	mə-rur	‘been cut (hair)’
	Infixation	rəbət	‘action of falling’	r-u-əbət	‘fall (from)’
		ʔárm	‘suffering’	ʔ-u-árəm	‘suffer’

Łubowicz (2005a) claims that the relevant constraint is a version of the OCP indexed for morphological category:

- (18) OCP_{root}(C-lab): Avoid more than one labial consonant in the root domain.

The idea is that this constraint is violated in the infixed cases, but not in the prefixed cases. But this idea only makes sense if the infix is part of the root — it has been ‘absorbed’ by it —, whereas the prefix stays outside.

In order to get this effect, Łubowicz (2005a) invokes two constraints: one is a violable version of Consistency of Exponence, which she dubs MORPHEME-DEPENDENCE (M-DEP), and another constraint MORPHEME-LOCALITY (M-LOC) which disallows discontinuous morphemes:

- (19) a. M-DEP: Let M_i be a morpheme and S_j be a phonological element in two related morpho-phonological representations, M_1 and $S_1 \in \text{Input}$, M_2 and $S_2 \in \text{Output}$, $M_1 \mathcal{R} M_2$, and $S_1 \mathcal{R} S_2$. If $S_2 \in M_2$, then $S_1 \in M_1$.
- b. M-LOC: Let M be a morpheme, and xyz be segments, where $xyz \in \text{Output}$: If xyz are adjacent, and $x \in M \wedge z \in M$, then $y \in M$

A ranking $M\text{-LOC} \gg M\text{-DEP}$ gives the right morphological parsing (given that the status of the morpheme as an infix is predetermined by the morphology):

- (20) a.
- | /l-m-atk/ | M-LOC | M-DEP |
|-----------|-------|-------|
| ☞[lmatk] | | * |
| [l[m]atk] | *! | |
- b.
- | /m-dakt/ | M-LOC | M-DEP |
|-------------|-------|-------|
| ☞[mə][dakt] | | *! |
| [mədakt] | | |

In (20a), the morphology has decided that /m/ is an infix; however, M-LOC does not like to see infixes at the surface, and it therefore turns the segment into a part of the stem, creating a violation of M-DEP. On the other hand, there is no potential problem with M-LOC in (20b), so that in this case M-DEP (=Consistency of Exponence) decides.

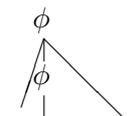
This analysis has to determine the placement of affixes as infix or prefix *before* any phonology can take place. The reason for this is that in the output form [lmatk], the morphology would no longer be able to check that /m/ has indeed turned into an infix: as a matter of fact the relevant adjectivising suffix has become completely invisible, since it is ‘absorbed’ by the stem. This means that morphological constraints can no longer be operative at this level. This implies a type of serialism however — doing morphology before phonology — which runs counter to one central tenet of classical OT, where the placement of affixes can be determined by the interaction of phonological and morphological constraints (Prince & Smolensky (1993); see also Golston (1995)).

Given this architecture of the grammar, it is furthermore unclear why we need to have morphological structure in the output of the phonological module at all. The morphological constraints are no longer operative at this level, so why would we need to see the difference between stems and affixes at all? The answer to this is: because phonological constraints like $OCP_{root}(C\text{-lab})$ need to see them. But this actually turns the root in these cases into a purely prosodic category, which is only there to establish the domain of phonological phenomena.

If that is the case, however, we might just as well abandon the problematic assumption that morphological grammar precedes phonological grammar, and reformulate the OCP constraint directly into prosodic terms:⁷

- (21) OCP_{PW}(C-lab): Avoid more than one labial consonant in the phonological word.

In this case, we will have to make sure that infixes become part of the phonological word, whereas prefixes stay outside. We do not need to relativize Consistency of Exponence for this, however. Under the assumption that embedded phonological word structures such as (22a) are universally impossible, we only need a constraint for Alignment of phonological and morphological categories. And even if we would allow Gen to produce structures such as this, we could still have a high-ranking constraint against such center-embedding phonological structures, paralleling Łubowicz (2005a)'s M-LOC.

- (22) a.  *lmatk
 b. Φ-LOC: Phonological words must be contiguous (=M-LOC, applied to phonological words).
 c. ALIGN: The edges of a morpheme should correspond to the edges of a phonological word.

We can now build exact parallels to the structures in (20):

- (23) a.

/latk/+/m/	Φ-LOC	ALIGN
⊖(lmatk)		**
(l(m)atk)	*!	
- b.

/dakt/+/m/	Φ-LOC	ALIGN
⊖(mə)(dakt)		
(mədakt)		*!

The first candidate in (23a) violates ALIGN since there is a morpheme boundary which does not correspond to a phonological word boundary – as a matter of fact there are two such ‘illicit’ boundaries (both before and after the

⁷I am not claiming that the OCP could not refer to roots in some cases, but only that it does not need to refer to the morphological category of a root in cases like this, where it could also refer to the prosodic word.

morpheme). Yet there is no way to not violate ALIGN in this case, without violating higher-ranking Φ -LOC. In the case of (23b), on the other hand, we can satisfy both constraints by keeping the prefix and the stem separate, following a strong cross-linguistic trend for boundaries between prefixes and stems to have strong phonological correlates (Booij & Rubach, 1984; Rubach & Booij, 1990).⁸

I believe that this analysis is not just a notational variant of the one which turns Consistency of Exponence into a violable constraint; it is conceptually superior to it on the grounds of interleaving morphological and phonological constraints in a way which is well-established and of not using morphological categories as phonological diacritics. Instead of this, it uses the category of the phonological word, which is independently needed. We just see that neither Walker & Feng (2004)'s nor Łubowicz (2005a)'s attempt to turn Consistency of Exponence into a violable constraint is very successful. From this we conclude that its status as a restriction on Gen is uncontested.

2 Derived environment effects and colouring

2.1 Some examples of derived environment effects

One important aspect of the phonology-morphology interface which has been discovered in the second half of the twentieth century, is that some phonological processes only apply in derived environments, that is to say they do not apply to underlying monomorphemic forms (Kiparsky, 1973, 1993; Kenstowicz & Kisseberth, 1977; Anttila, 2005). Traditionally, two types of derived environment are recognized: phonologically and morphologically derived environments. Morphologically derived environments consist of material from more than one morpheme; phonologically derived environments can be monomorphemic, but at least one of the elements has to be created by an earlier phonological rule or process. In as far as these effects are real, phonological theory needs to account for them, and I propose that Coloured Containment is optimally suitable for that.

In order to illustrate this point, I will consider five rather well-known instances of Derived Environment Effects (DEE), from Korean, Turkish, Finnish, Polish and Tuscan Italian.

Korean has a rule of *palatalisation*, affecting coronal stops before front high vowels, roughly formulated as in (24a) and illustrated in (24b). This rule only applies across morpheme boundaries however; it does not apply in the form in (24c), where the /t/ and /i/ are already adjacent at the underlying

⁸Notice that it has to be assumed here, as in Łubowicz (2005a) that independent, higher-ranking and purely morphological constraints decide that the morpheme is an infix in (23a) and a prefix in (23b).

level (Iverson, 1993; Polgárdi, 1998; Rhee, 2002, to mention just a few recent sources).

- (24) a. $t, t^h \rightarrow tʃ, tʃ^h / _ i$
 b. $hæ \text{ tot}+i \rightarrow hæ \text{ dođi}$ ‘sunrise-NOM’
 c. $mati \rightarrow madi$ ‘knot’

The second example comes from Vowel Harmony in Turkish. As is widely known, Turkish has both backness and roundness harmony (subject to different phonological constraints) (25a). Roots can be disharmonic; although the forms in (25b) are of foreign etymology, they have integrated into the Turkish phonology in other respects. (25c) shows that epenthetic vowels are sensitive to vowel harmony.

- (25) a.

	<i>nom.sg.</i>	<i>gen.sg.</i>	<i>nom.pl.</i>	<i>gen.pl.</i>
‘rope’	ip	ipin	ipler	iplerin
‘girl’	kız	kızın	kızlar	kızların
‘face’	yüz	yüzün	yüzler	yüzlerin
- b. *vali* ‘governor’, *kitap* ‘book’, *hareket* ‘movement’, *hesap* ‘bank account’, *bobin* ‘spool’
- c.

	<i>careful form</i>	<i>colloquial form</i>
‘fettors’	pranga	pıranga
‘cruiser’	kruvazör	kuruvazör

We can see this blocking of productive harmony to roots as a DEE; the fact that a vowel within a root can be subject to harmony only if it is epenthetic lends further credence to such a view.

A third example of a DEE comes from Colloquial Helsinki Finnish Vowel Coalescence, as has been recently demonstrated by Anttila (2005). This particular dialect of Finnish has a rule of Vowel Coalescence, which turns /makea/ ‘sweet’ for instance into [má.ke:]; the rule is optional, so that [má.ke.a] is also possible. I assume that in vowel coalescence, all the features of one vowel spread onto the other vowel position.

Anttila (2005) notes that Vowel Coalescence is subject to a quantitative DEE effect:

- Vowel Coalescence is categorically blocked in **non-derived environments** if the structural change is highly marked. If the structural change is unmarked, it may apply.
- Vowel Coalescence is quantitatively dispreferred in **derived environments** if the structural change is highly marked. If the structural change is unmarked, it is quantitatively preferred.

All in all, we will thus find more vowel coalescence in derived environments; there is vowel coalescence in underived environments as well, but it is much

by ALTERNATION. In the form on the lefthand side, on the other hand, the two elements which are linked have different colours, hence the association line is allowed.

Similarly, it becomes quite clear what happens in Finnish once we draw the right association lines. Remember that we are dealing in this case with vowel coalescence, and we are assuming that this means that all features of one vowel spread onto the other vocalic position:

$$(31) \quad \begin{array}{cccccccc} l_a & a_a & s_a & i_a & a_b & *r_c & a_c & s_c & i_c & a_c \\ & & & \diagdown & / & & & & \diagdown & / \\ & & & i_a & & & & & i_c & \end{array}$$

Again, the preferred structure is characterized by new association lines linking elements of different colours, whereas the dispreferred has a new link between material which is already underlyingly present in the same morpheme.

The situation is a bit complicated in this case by the fact that we are dealing with statistical preferences rather than an absolute categorical distinction. Anttila (2005) proposes to deal with these preferences by way of variable constraint ranking. Suppose we have three constraints \mathcal{C}_1 , \mathcal{C}_2 and \mathcal{C}_3 . These constraints can be ranked in six different ways. Suppose furthermore, that given an input α , four of these rankings give an output β , whereas the remaining two rankings give an output γ . We predict that this will correspond to twice as many β than γ in the input.

In this case, it could be the constraint ALTERNATION which is ranked in a variable way. If it is ranked very low, vowel coalescence will be allowed both in derived environments and in non-derived environments. If it is ranked very high, it will block coalescence in non-derived environments but not in derived environments. This is how we get a difference in preference.⁹

In this approach, there thus is no qualitative difference between phonologically and morphologically derived environments. In both cases there is a difference in colour; in phonologically derived environments since one of the elements is epenthetic, i.e. colourless, and in morphologically derived environments since different morphemes each contribute their own colour.

The situation is a little more complicated for the case of Polish spirantisation. In the examples just discussed, a whole segment was 'new', either because it was phonologically derived or because it belonged to a different morpheme. In Polish, this is not the case: the difference between [rozek], *[rojek] and [br̥jek] is not that the former contains a new segment in any

⁹This sketches only a rough approximation of the relevant facts. See Anttila (2005) for a more precise approach, which can easily be made compatible with the present proposal.

sense in which the latter does not. The difference is that the former contains a segment which has been *changed*.

In order to describe this properly, then, we need to resort to Feature Geometry and assume that ALTERNATE works at a subsegmental level in this language.

An independent advantage of introducing Feature Geometry, may be that it allows us to express the intimate connection between [continuant] and Place. Within other approaches to the Polish facts (such as Łubowicz, 2002, 2005b) it is essentially a coincidence that the derived environment for spirantisation — a change in [continuant] — is created by palatalisation — a change in Place feature specification. However, it is well known that there is an intimate connection between these features, which has been expressed in various ways; here we will choose the analysis of Padgett (1991), according which [continuant] depends on the Place features (so it can be a daughter of Coronal, Velar or Labial).

A few more representational assumptions are in order. In line with a very long-standing tradition, we assume that palatalisation is ‘assimilation’ with the vowel on the righthand side. With Rubach (1984) we also assume that the relevant context for spirantization is the lefthand side, since it happens after vowels and sonorants, but not after obstruents:

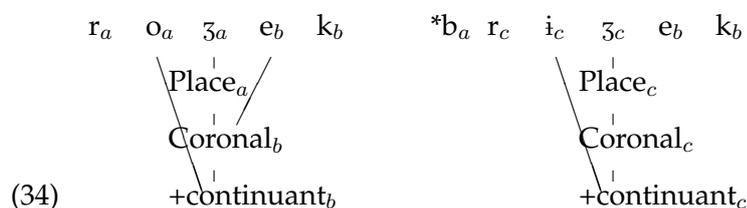
- (32) a. róg ‘horn’ → ro[ʒ]ek (DIM), potęga ‘power’ → potę[ʒ]ny (ADJ),
 b. skarga ‘complaint’ → skar[ʒ]yć ‘complain’

I will assume that this is progressive assimilation of continuancy (cf. Mascará, 1983; Harris, 1984)

To fully understand what happens in Polish, it is useful to first study the structure of these two words when only palatalisation has applied:

- (33)
$$\begin{array}{cccccc} r_a & o_a & ʒ_a & e_b & k_b & & b_a & r_c & i_c & j_c & e_b & k_b \\ & & \text{Place}_a & / & & & & & \text{Place}_c & & & \\ & & \text{Coronal}_b & & & & & & \text{Coronal}_c & & & \end{array}$$

In the case of /rog+ek/, the Coronal feature will spread from the /e/ to the /g/, perhaps because of a constraint which disallows a configuration of a non-palatalized velar consonant followed by a front vowel. This spreading conforms to the constraint ALTERNATION. For /brɨjek/, no change is necessary, since the structure already conforms to all well-formedness constraints. Now we extend the structure and look at the interaction of this with spirantisation.



Spirantisation is allowed in [roʒek], since the feature [continuant] links to a feature [Coronal] which has a different colour. Spirantisation is not allowed in [briʒek], on the other hand, since the place feature and [continuant] have the same colour in this case.

We have thus seen that all cases of DEE from the previous section are the result of implementing a feature spreading analysis in a Coloured Containment frame. It remains to be seen whether this is true for all DEE, and if not, how other cases are to be analysed. This also requires a theory of faithfulness to association lines, possibly one which is based on Turbidity Theory (Goldrick, 2000); see Revithiadou (this volume).

2.3 Comparison to other models

Hitherto, various analyses have been proposed to deal with DEE within Optimality Theory, usually based on Correspondence models of faithfulness. We will briefly discuss these alternatives, in order to compare them with the analysis just proposed. By necessity, all these models share some mixing of faithfulness and markedness: we are talking about derived environments, hence phonological environments which are derived (faithfulness) and require some phonological process to apply (markedness).

The most well-known analysis of DEE within OT is couched in terms of Constraint Conjunction (Łubowicz, 2000). Under this approach, DEE are seen as the result of conjunction of Faithfulness and Markedness constraints. For the Polish case we have discussed, this is [$*\text{ɕ}\&\text{IDENT}[\text{CORONAL}]$]_{segment}, i.e. a markedness constraint requiring spirantisation which is coupled with a faithfulness constraint on palatalisation: if this constraint is high-ranked, only those instances of [ɕ] which are the result of palatalisation (hence, which invoke a violation of IDENT-[coronal]) will be subjected to this constraint.

Several objections can be raised against this account. We have already pointed out that the linking of spirantisation and palatalisation is purely accidental for this account, since any two constraints could be linked. In as far as these processes are indeed intimately linked, the explanation should come from outside the theory of constraint conjunction — possibly from some form of phonetic grounding, although it is not clear how grounding could interact with a purely formal operation such as constraint conjunction. In the

Coloured Containment model, only features which are linked in the Feature Geometry can establish a relation of this type.

Further, Constraint Conjunction did not have a theory of locality its original formulation. There is no principled reason why it refers to a violation of $*\zeta$ and of IDENT-[coronal] within the same segment. This unrestrictiveness predicted unattested long-distance effects. For instance, if we assume that $[*\zeta \& \text{IDENT-}[\text{CORONAL}]]_{\text{word}}$ would be conjoined within the domain of the word in some language, we would get the effect that palatalisation of a consonant at the end of the word could cause spirantisation of a consonant at the beginning of the word. We thus could get derivations of the following type:

(35) $\zeta\text{em}+\text{ik}+\text{ek} \rightarrow \text{zemi}\check{\text{c}}\text{ek}$

These derivations seem unattested, however, and we therefore want to rule them out. A proposal to this effect is provided by Łubowicz (2005b) using McCarthy (2003)'s idea of a so-called *locus function*. The details of this are not important here, but essentially this minimizes the domain of all constraints to the segment: only segments can violate constraints. This restriction seems too general: it is certainly incompatible with the assumption of autosegmental representations. On the other hand, within Coloured Containment, the locality comes for free: palatalisation of one segment in a word will have no representational effect on another palatal in the same word, so a derivation as in (35) can never be derived.

A second approach to DEE in the existing literature, is *Comparative Markedness* (CM, McCarthy, 2003). Like Coloured Containment, CM refers to differences between 'old' and 'new' material, but it is couched in a Correspondence framework. The central idea of CM is that markedness constraints can refer to 'old' violations — those already underlyingly present — vs. 'new' violations — those created by Gen. To be precise, for every traditional markedness constraint, CM posits two versions: one referring only to old violations, and one only to new violations. In the case of Polish, this would involve for instance a high ranking constraint $*\zeta_{\text{New}}$: old / ζ / is unaffected by this constraint, but those instances of [ζ], for instance created by palatalisation, are ruled out by it.

CM is in a certain sense a Correspondence sister (or historically and genetically, a mother) of Coloured Containment theory. Like Constraint Conjunction, CM is however crucially based on the Locus function, which, as we have seen, is incompatible with autosegmental representations. Opinions may of course differ as to whether this is a positive or a negative aspect of the theory, but in the presence of an overwhelming amount of evidence in favour of autosegmental representations, we consider it wise to be conservative.

Furthermore, in order to describe cases of morphologically DEE, CM has to refer to a very special version of 'newness', viz. $\text{Output-Output}_{\text{New}}$, satisfied if the violation was not yet there in the underived word. However,

introduction of such a constraint type implies simultaneous introduction of a constraint referring to Output-Output_{Old}, i.e. violations which only count if there is a base form in which they are already present. This has the undesirable result of deriving anticyclicity. For instance, we predict a language like Turkish*, which is like Turkish, except that we find spreading of [-back] only in embedded domains:

- (36) a. Underived form for /kitap/ 'book': *kitap*
 b. Derived form: *kitep-lar* (SPREAD_{Old} applies to stem element, which has a base, but not to suffix, which is new).
 c. Derived form: *kitep-ler-an* (SPREAD_{Old} applies to *kitepler*, which has a base, but not to the whole word)

Patterns like this have not been attested, and this seems an undesirable result of CM.

A third approach, *Root Faithfulness* is proposed as a device to describe Derived Environment Effects in Anttila (2005). This gives very similar effects as Coloured Containment; for instance, both suffix vowels and epenthetic vowels in Turkish are not part of the root. If we assume FAITH-Root \gg SPREAD, this is why they can both assimilate, whereas vowels in the root are blocked from doing so.

It comes as no surprise that the two approaches yield similar results; we have seen in section 1.2 that Root Faithfulness constraints need an idea of morphological colour for their implementation. Inversely, Coloured Containment can be seen as an implementation of Root Faithfulness. It is not clear, however, how we could derive the phonological derived environment effects of Polish in a Root Faithfulness approach, without taking recourse to more sophisticated phonological representations, since [\pm continuant] and [Coronal] represent different dimensions in an autosegmental approach.

3 Conclusions

In this article, I have defended the classical assumption that Consistency of Exponence restricts the Generator function; I have shown that this assumption is needed in the interpretation of various constraints which are available in the literature, and that objections which have recently been raised to it are not strong enough to abandon this assumption.

Consistency of Exponence expresses a generalisation about the interaction between phonology on the one hand and morphology and syntax on the other which seems quite strong: phonology cannot influence morphology or syntax. Phonology can decide to interpret morphemes in some way, but it cannot decide that the vowel at the end of one syntactic word will be at the beginning of the next syntactic word instead.

It should be noted that it follows from Consistency of Exponence that Correspondence is probably superfluous. The output representations are already very rich under Consistency of Exponence, so that we do not need to refer to overly abstract correspondence relations with an independent input representation. Certain types of opacity also follow from containment. Consistency of Exponence thus leads us to adapt a purely monostratal model, one in which all constraints refer to one representation only.

An important goal of this article was to argue that Derived Environment Effects are basically expected under Coloured Containment, at least in as far as they can be seen as involving the spreading of features.

A final important note is that none of these claims can be evaluated without some basic assumptions about phonological representations. Since we are dealing with a monostratal model, we will have to read off the faithfulness status of a given segment from its representation. Whereas a Correspondence-based model of faithfulness is basically independent from the internal structure of the input and output representations — the only requirement is that the representations consist of discrete elements which can be related to each other. This is not true for Containment models, where there is an intimate link between markedness and faithfulness. It is this link which allows us to express Derived Environment Effects, but it is also this link which makes a very precise reconsideration of representations necessary. We consider this to be a positive aspect, since it makes the theory into a tighter unit, where subtle changes in one assumption will have implications for many other aspects of the analysis. Phonological analysis becomes more difficult because of this, but that is not necessarily a bad thing.

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