

Restricting Repairs

Abstract

The problem of Too Many Repairs (Steriade, 2001, TMR) affects many theories of phonology: why are certain unwellformed, or less preferred, structures repaired in one and the same way in language after language, while typologically many options are available? In this paper we study two cases of the TMR problem, instantiated by final devoicing and clusters of nasals plus voiceless obstruents. We argue that the problem arises within OT when the theory of faithfulness is too unrestricted. We propose that Correspondence Theory be replaced with Containment Theory to get a more restrictive theory. This proposal is illustrated by a range of Romance and Germanic dialects.

1 Introduction

Steriade (2001) raises an important issue for current phonological theory: the problem of Too Many Repairs (TMR). If phonological processes are driven by markedness, we observe that certain types of markedness requirements may be repaired in a variety of ways. For instance, the relative markedness of hiatus may be repaired by deleting a vowel, by gliding, by epenthesis of a consonant, by choosing a different allomorph, etc. Yet sometimes the phonological toolbox seems too large.

Steriade (2001) mentions final devoicing, which is attested in many languages.¹ The following example presents a few well-known cases:

- (1) a. Catalan:
 i. *gris* 'grey (M)' - *grizə* 'grey (F)'
 ii. *gos* 'dog (M)' - *gosə* 'dog (F)'
 b. Dutch:

¹Lombardi (2001) independently makes a similar observation; we will discuss aspects of Steriade (2001)'s proposal in section 4.1, and of Lombardi (2001) in section 4.2.

- i. *kwaa*[t] ‘angry (PRED.)’ - *kwadə* ‘angry (ATT)’
- ii. *laat* ‘late (PRED.)’ - *latə* ‘late (ATT)’
- c. German:
 - i. *blin*[t] ‘blind (PRED.)’ - *blində* ‘blind (ATT)’
 - ii. *bunt* ‘colourful (PRED.)’ - *buntə* ‘colourful (ATT)’
- d. Polish:
 - i. *klup* ‘club’ - *klubi* ‘clubs’
 - ii. *trup* ‘corpse’ - *trupi* ‘corpses’
- e. Russian:
 - i. *knik* ‘book (GEN.PL.)’ - *kniga* ‘book (NOM.SG.)’
 - ii. *sok* ‘juice (NOM.SG.)’ - *soka* ‘juice (GEN.SG.)’

The examples in (i) in each case give an alternating pair: a voiceless obstruent at the end of a syllable (or of the stem in all these cases), shows up as voiced when it occurs with an inflectional suffix starting with a vowel — in other words, if it appears in an onset. The examples in (ii) show that this voicing alternation cannot be due to intervocalic voicing in these languages, since there are other stems ending in voiceless obstruents which do not show a similar alternation.

It is commonly assumed that these alternations are due to some type of markedness, although the specific formulation of markedness may vary (see Hall, 1992; Lombardi, 1999; Iverson and Salmons, 2003, 2007; Blevins, 2004; Kiparsky, 2006, and references cited there for a variety of contrasting views). Since we assume that it is largely irrelevant for our present purposes, we will adopt the following formulation here:

- (2) * $[+voice]/_]_{\sigma}$: No voiced segments at the end of the syllable.

The TMR problem is that there are potentially many ways in which an underlying structure — say, /tæb/ — violating (2) could be repaired. Devoicing is only one of many logically possible options, but it happens to be the one that is always chosen in cases where * $[+voice]/_]_{\sigma}$ becomes high-ranking.

Steriade (2001) lists the following logically possible solutions, of which only the first one is found in languages of the world, according to her:

- (3)
- | | | | |
|-------------------|-------|---|--------|
| Devoicing: | /tæb/ | → | /tæp/ |
| Nasalisation | /tæb/ | → | /tæm/ |
| Lenition: | /tæb/ | → | /tæj/ |
| C Deletion: | /tæb/ | → | /tæm/ |
| Segment reversal: | /tæb/ | → | /bæt/ |
| Feature reversal: | /tæb/ | → | /dæp/ |
| V insertion: | /tæb/ | → | /tæbə/ |

It should be noted that each of the processes listed in (3) are attested as repairs to other problematic structures, but somehow they do not seem to be used to satisfy the requirements of $*[+voice]/_]_{\sigma}$.

It is in the nature of OT to distinguish formally between ‘targets’ (violations of well-formedness conditions) and ‘repairs’ (operations on structures which may solve the problem). However, in certain cases, it seems that only one repair is possible. That is the TMR problem. It has been observed (Blumenfeld, 2006) that this problem is not exclusive to OT. Exactly the same problem arises in rule-based phonology — and it might actually be more difficult to solve there —, in which we could pose the question why natural languages often show the rule in (4a), but never the one in (4b).

- (4) a. $C \rightarrow [-voice] / _]_{\sigma}$
 b. $C \rightarrow [+nasal] / _]_{\sigma}$

Targets and repairs are not very intimately linked in the rule formalism either. Each of the variables α, β, γ is independent from the others in a rule scheme $\alpha \rightarrow \beta/\gamma$, even if there are certain measures of rule complexity, counting the number of symbols which are used.

In this article, I propose that the solution to the TMR problem needs to be found in a severe restriction of the notion of possible repairs, which is formalised within OT by our theory of faithfulness. I argue that the current view of faithfulness in terms of Correspondence Theory is too unrestrictive, and there are independent reasons to prefer a more restrictive version of the theory. I then present such a theory in section 2, and show how it can be applied to restricting this instance of the TMR problem in section 3.

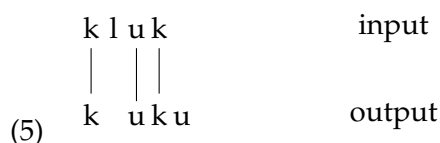
This paper is not the first one to deal with Steriade’s problem. In section 4, I compare the approach presented here to those alternatives of which I am aware. Finally, section 5 deals with the issue of conspiracies, in particular with the well-known conspiracy involving $*NC_{\sigma}$ clusters; it seems that in this case many more possibilities are actually attested, and I discuss possible reasons for this. The last section is devoted to a conclusion.

2 The theory of faithfulness

Two general families of theories of input-output relations (‘faithfulness’) have been proposed within OT. I will call them theories of *correspondence* and theories of *containment*.

Theories of correspondence are the most popular since their introduction in McCarthy and Prince (1995). These authors assume that there are two representations, an input and an output, and there are ‘correspondence’ relations between the elements of those representations.

Suppose we have an input /kluk/, realised as [kuku]. In a correspondence framework, this looks as follows:



Candidate structures consist of two complete phonological representations within correspondence theory: an input and an output. Elements of these representations may or may not be linked to each other by so-called correspondence relations. Basic faithfulness constraints check the relations between the two representations:

- (6) a. *Constraints against deletion* are constraints which require elements in the output to have input correspondents.
 b. *Constraints against deletion* are constraints which require elements in the input to have output correspondents.

Correspondence theory is a very powerful theory of faithfulness: any input representation can be related to any output representation in this theory, and the number of possible correspondence relations beyond the basic ones in (6) is very large (see Potts and Pullum, 2002). Beyond basic deletion and insertion, we can have one segment in the input corresponding to two segments in the output (creating a violation of INTEGRITY) or vice versa, creating a UNIFORMITY violation. Yet another possibility is that two input elements α, β correspond to output A, B respectively but α precedes β in the input, whereas B precedes A in the output; these create violations of LINEARITY.

Steriade (2001)'s argumentation is based on this theoretical framework, and the TMR problem she observes is a consequence of the excessive power of Correspondence Theory. All of the repairs for FINDEV mentioned by Steriade correspond to a different faithfulness constraint:

- (7) a. **Devoicing:** IDENT-[voice] (corresponding segments are identically specified for Voice)
 b. **Nasalisation:** IDENT-[Nas] (corresponding segments are identically specified for Nasal)
 c. **Lenition to glide:** IDENT-[cons] (corresponding segments are identically specified for Consonantal)
 d. **C-deletion:** MAX-C (A consonant in the input needs to have a correspondent in the output)
 e. **Segment reversal:** LINEAR-SEG (If segments x, y in the input correspond to a, b in the output, and x precedes y , then a precedes b)
 f. **Feature reversal:** LINEAR-F (If features x, y in the input correspond to a, b in the output, and x precedes y , then a precedes b)

- g. **V-insertion:** DEP-V (A vowel in the output needs to have a correspondent in the input)

Since all of these constraints are independent, they can be independently ranked, and we are facing a factorial typology with a TMR problem. We need a more restrictive theory of faithfulness in order to solve this problem, and we can find this restrictiveness in Containment theory, which was first proposed in Prince and Smolensky (1993). However, this theory had several severe shortcomings, which were repaired only recently. The theory has therefore seen a revival in recent years (Revithiadou, to appear; van Oostendorp, 2005, to appear; Eychenne, 2006; Uffmann, 2007).

Containment theories are monostratal, in the sense that there is only one phonological representation to be evaluated. Yet this single representation contains both phonological and morphological information, since the generator function is restricted by the following principle:

- (8) **Consistency of Exponence (CoE)** ‘No changes in the exponence of a phonologically-specified morpheme are permitted.’ (McCarthy and Prince, 1993, 1994)

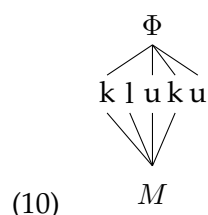
CoE restricts the operation of phonology. It implies that lexical specifications can never change; phonological material which belongs to a morpheme will always be part of that morpheme in the surface representation. Inversely, epenthetic segments can never become part of a stem or an affix. The principle was explained in the following way by McCarthy and Prince (1993, 1994) (both works contain the same explanation in the same words):

- (9) “[CoE] 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.”

As far as I can see, a substantial amount of work within Optimality Theory — also within Correspondence views of faithfulness — is based on the silent assumption of Consistency of Exponence. Work on stem alignment and anchoring, for instance, assumes that boundaries of stems cannot be changed by Gen — we cannot turn affix material into stem material —, and so does most work based on differences between root and affix faithfulness. There

have been very few attempts to define CoE away, or turn it into a violable constraint.²

Our example in (5) above looks as follows in CoE (Φ is a shorthand for the phonological tree of syllables, feet, etc; M is a shorthand for the morphosyntactic tree of stems, words, phrasal constituents, etc.):

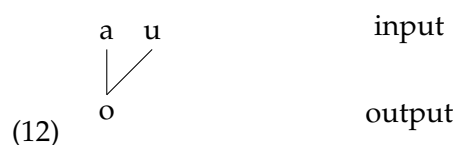


Material which is underlying will always be ‘parsed’ into the morphosyntactic tree, but if it is not pronounced, it will not be part of the phonological tree. On the other hand, material which is pronounced will always be parsed into the phonological tree – but if it is epenthetic, it can never be part of the morphological tree, which only contains lexical material, due to CoE.

We can thus read off from this representation both which material is ‘deleted’ (not phonetically realized) and which material is ‘inserted’ (not morphologically realized). The basic faithfulness constraints are therefore symmetric in nature and of the following type:

- (11) *Faithfulness constraints* (Containment version)
- a. $\text{PARSE-}\phi(x)$: The morphological element x must be incorporated into the phonological structure. (No deletion.)
 - b. $\text{PARSE-}\mu(x)$: The phonological element x must be incorporated into the morphological structure. (No insertion.)

Furthermore, every ‘change’ from input to output can only be seen as a involving a combination of $\text{PARSE-}\phi$ and $\text{PARSE-}\mu(x)$ violations. For instance, fusion of segments can be seen as involving violation of exactly one constraint in correspondence theory:



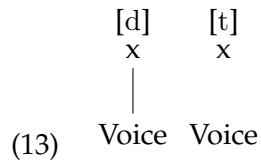
Within a containment approach, such a straightforward analysis is not possible: both /a/ and /u/ need to be present at the surface, as must all of

²The arguments against CoE (or to be more precise, in favour of a violable CoE) of which I am aware are Walker and Feng (2004) and Łubowicz (2005). See van Oostendorp (to appear) for discussion and refutation of these arguments.

their features; but some of the features of the one may have spread to the other (say, spreading roundness to /a/), while the segment itself will be left unparsed. We thus predict that fusion will always have some of the properties of segment deletion, and hence we restrict the number of possibilities (if deletion is out of the question, so will be fusion). Whether this is empirically correct for all cases, remains to be tested, obviously; here we will explore the consequences of this approach for solving the TMR problem.

3 Restricting the number of repairs

Let us consider the effects of a high-ranking constraint FINDEV within Containment Theory. The preferred choice always is a devoiced segment, i.e. a segment which leaves the final [voice] unparsed.



This means that the faithfulness constraint PARSE-Voice will be violated in case FINDEV is satisfied:

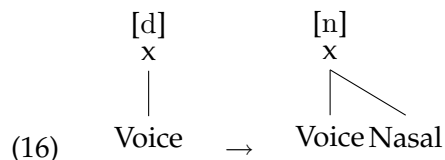
(14) PARSE- ϕ (Voice): The feature Voice needs to be parsed into the phonological tree.

(15)

/kwa:d/	FINDEV	PARSE- ϕ (Voice)
kwa:d	*!	
↵kwa:t		*

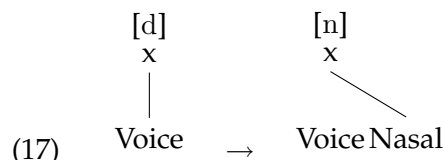
The two constraints in this tableau give us the relevant factorial typology; languages without final devoicing have FINDEV \gg PARSE- ϕ (Voice), whereas languages with final devoicing have PARSE- ϕ (Voice) \gg FINDEV.

We now turn to the other solutions in Steriade (2001)'s list in (3). First, let us consider nasalisation. Suppose we turn an /d/ into a nasal [n] by adding a feature [Nasal]:



This does not solve the problem posed by FINDEV in (2), however: a final voiced [n] will still have a feature [Voice] violating the constraint.

Since voicing is non contrastive on sonorants in many languages, including Dutch, we might therefore choose another option, and also delete the voicing specification:



Yet both (16) and (17) will never be able to win, since they violate a constraint against insertion of [nasal], and will be harmonically bounded by non-nasalised candidates:

(18) PARSE- μ (Nasal): The feature [nasal] needs to be parsed into the morphological tree (hence, may not be epenthesized).

(19)

/kwa:d/	FINDEV	PARSE- ϕ (Voice)	PARSE- μ (Nasal)
kwa:d	*!		
\rightarrow kwa:t		*	
kwa:n (16)	*!		*
kwa:n̥ (17)		*	*!

No matter how we rank the constraints, no form with a nasal will ever be able to win: (16) will always lose from [kwa:d], and (17) from [kwa:t]. Nasalisation thus does not count as a valid repair, and we have reduced the TMR problem by one repair.

Notice that this does not mean that voiced obstruents in codas cannot turn into nasals. If a feature [nasal] is already present in the underlying representation for some independent reason, PARSE- μ (Nasal) becomes irrelevant: the nasal can dock onto the obstruent. This indeed happens in Vimeu Picard, a Romance dialect spoken in parts of the north of France and the south of Belgium (José and Auger, 2004):

(20) *Vimeu Picard*

- a. Voiced stops nasalise in coda: *rudemint* /rydmɛⁿ/ → [rynmɛ̃] ‘roughly’ (cf. *rude* ‘rough’ [ryd]), *gamme* /gaⁿb/ → [gãm] ‘leg’ (cf. *gamber* ‘kicking a leg’ [gãbe])
- b. Voiceless stops do not nasalise in coda: *lampe* /laⁿp/ → [lãmp] ‘lamp’
- c. There is no final devoicing: *tube* /tyb/ → [tyb] ‘pipe’

Vimeu Picard thus presents an instance of underlying nasal features attaching to underlyingly voiced obstruents. What explains the restriction of nasalisation to underlyingly voiced obstruents? José and Auger (2004) suggest that

this a type of ‘grandfather effect’ (McCarthy, 2003a) of final devoicing: although underlying voiced consonants are allowed, the phonology is not able to create such consonants. We can easily replicate this finding in the framework presented here.

Given that Vimeu Picard does not have Final Devoicing, we know that $\text{PARSE-}\phi(\text{Voice}) \gg \text{FINDEV}$ in this language. Suppose, plausibly, that there is a constraint which says that nasal consonants need to be voiced (21a), and suppose that the floating nasal feature in /gaⁿb/ and /laⁿp/ prefers to be docked to both elements of the rhyme (21b):

- (21) a. [nasal] ⊃ [voice], (Itô et al., 1994)
 b. DOCK: Nasal features on a vowel need to be supported by nasal features on the rhyme.

Ranking [nasal] ⊃ [voice] and DOCK below FINDEV gives the grandfather effect: voiced consonants in coda seem to be allowed, except that we do not allow new voiced (nasal) obstruents to be formed:

(22) a.	ga ⁿ b	PARSE- ϕ (Voice)	FINDEV	[nasal] ⊃ [voice]	DOCK
i.	gãb		*		*!
ii.	gãm		*		
iii.	gãm̩	*!		*	
b.	la ⁿ p	PARSE- ϕ (Voice)	FINDEV	[nasal] ⊃ [voice]	DOCK
i.	lãp				*
ii.	lãm		*!		
iii.	lãm̩			*!	
c.	tyb	PARSE- ϕ (Voice)	FINDEV	[nasal] ⊃ [voice]	DOCK
i.	tyb		*		
ii.	typ	*!			

Except in situations in which [nasal] is underlyingly present, we thus predict that nasalisation cannot be an option. In a similar way, we can rule out lenition. Here, we have to change the consonantality of the /d/ and lose voicing, ensuing again in a situation of harmonic bounding:

- (23) a. $\begin{array}{c} [d] \\ x \\ | \\ \text{Voice} \end{array} \rightarrow \begin{array}{c} [j] \\ x \\ \diagdown \\ \text{Voice} \end{array} \text{Vocalic}$
- b. PARSE- μ (Vocalic): The feature [nasal] needs to be parsed into the morphological tree (hence, may not be epenthesized).

c.

/kwa:d/	FINDEV	PARSE- ϕ (Voice)	PARSE- μ (Vocalic)
kwa:d	*!		
\rightarrow kwa:t		*	
kwa:j		*	*!

The previous two analyses could to some extent probably be replicated within Correspondence theory: the main idea is that neither nasalisation nor lenition will be enough in itself to satisfy FINDEV, and an extra change is needed.

Now consider deleting the whole offending consonant. The two approaches start to diverge here. Within Correspondence Theory, changing a feature results in an IDENT-F violation whereas deleting a segment will violate MAX. These are independent constraints, hence they can get independent ranking; that is why we have the unwanted repair of consonant deletion.³

However, consonant deletion and feature deletion are both instances of non-parsing: something will be left out of the phonological tree. Given a plausible definition of parsing, this results in a situation of harmonic bounding. If the segment is not parsed into the tree, neither will any of its features: deletion of a whole segment will trigger faithfulness violations also for its features. Hence, it will be better to delete a feature, if possible:

- (24) PARSE- ϕ (C): Consonants need to be parsed into the phonological tree.

(25)

/kwa:d/	FINDEV	PARSE- ϕ (Voice)	PARSE- ϕ (C)
kwa:d	*!		
kwa:		*	*!
\rightarrow kwa:t		*	

The next two possibilities on Steriade's list involve reversal or metathesis. While Correspondence Theory allows for this process freely, this is not true

³As a matter of fact, Lombardi (2001) analyses this phenomenon in terms of Correspondence Theory, using MAX-feature rather than IDENT-F. The idea is that a MAX-segment violation will also result in a MAX-feature violation. However, it is not straightforward to implement this idea, since MAX-feature approaches presuppose an autosegmental view of phonology. In that case, it is possible however to have a floating feature. This does not give a MAX-feature violation, since the feature is still present on the surface, even if it is not pronounced. Lombardi unfortunately does not discuss this issue.

for Containment. Under the latter theory, the input has to be contained in the output, so that metathesis involves a rather complicated machinery. First consider metathesis of segments, for instance changing /tab/ to [bat]. This could be represented in Correspondence Theory as follows:

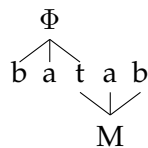
(26) *Metathesis Correspondence Style*



Special ‘linearity’ constraints on respecting the linearity of input in the output will take care of this (cf. (7e)), but such constraints are violable by definition.

On the other hand, all aspects of the input need to be present in the output in a Containment model, including the underlying linearity. This means that metathesis is possible in principle, but it comes at a very heavy cost. One possible phonological structure for a /tab/ → [bat] metathesis is the following:

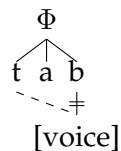
(27) *Metathesis Correspondence Style*



Clearly, this structure requires quite some epenthesis of segmental material, plus copying of features from one position to the other. If this is at all possible — which might not be the case, given plausible autosegmental assumptions — (27) will be harmonically bounded by other forms.

In particular, notice that the underlying voicing of the final instantiation of /b/ will show up on the first segment. [voice] will thus have ‘moved’ from one position to the other. But this also happens in an alternative repair from Steriade (2001)’s list: /tab/ → [dap/. We could represent this as follows:

(28) *Featural movement*



Structures like the one in (28) typically are interpreted in a derivational way, where the dashed line is seen as a ‘new’ line (it is ‘inserted’), and the strikes through a line represent the fact that it is underlyingly present, but no longer audible on the phonetic surface (it is ‘deleted’).

Notice that this structure is phonologically undistinguishable from a simply devoiced structure: [voice] is phonologically present on a vowel, but since vowels are already voiced by definition, there is usually no phonetic effect. Yet this potentially introduces a difference between ‘voiced’ and ‘voiceless’ vowels in the phonology, and we may wonder whether natural languages ever show empirical evidence for structures such as (30).

The answer may be found in those theories which claim that the feature [voice] is the same formal object as the Low Tone (Kaye et al., 1985; Bradshaw, 1999). This feature — called L/[voice] by Kaye et al. (1985); Bradshaw (1999) — can give a coherent account for the recurrent interaction between voicing on obstruents and low tones on sonorants and vowels, for instance in Bantu languages where voiced obstruents act as ‘depressor’ (i.e. lowering consonants). Under this theory, then, we expect final devoicing to sometimes show up as a low tone on the preceding vowel, as in (30).

A case of this type is attested. Franconian dialects of West-Germanic display a limited amount of lexical tone, which can be described as a difference between a Low tone and no tone⁴; phonetically, this will be usually realized as a level high tone vs. a falling tone:

(31)	<i>falling tone</i>	<i>level high tone</i>
	mîn ‘minus’	mín ‘vile’
	dǎèn ‘fir’	dǎén ‘then’
	klám̃ ‘trap’	klám̃ ‘hardly’
	bî ‘bee’	bí ‘with’
	zî ‘side’	zí ‘she’
	pîp ‘to squeak’	píp ‘pipe’

In most Franconian dialects, the tonal contrast only occurs on long vowels or on short vowels followed by sonorant consonants. Short vowels followed by obstruents are only relevant in a limited number of dialects.

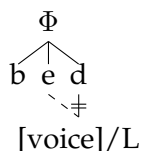
One example of a variety of the latter type is the Moresnet dialect (Jongen, 1972). The tone is falling in this dialect if the vowel is followed by voiced obstruent, but level if followed by a voiceless obstruent. Thus, in a word like *bedde* ‘bed-PL’ the first vowel has a falling tone, whereas in words like *teppich* ‘carpet’ and *kes* ‘casket’ it is level.

Interestingly, words that are devoiced by Final Devoicing have a falling tone, according to Jongen. Thus, *bet* ‘bed-SING’ has a falling tone. This seems to suggest that the tone of the short vowel is determined at the underlying level. That is, since *bet* has a voiced consonant underlyingly, the vowel preceding it has a falling tone, even at the surface level.

⁴See for instance Hermans and van Oostendorp (2001); and see Gussenhoven (2000) for a different view.

Under the view that Low tone and [+voice] are the same object, the tonal shift could be represented in a way which would be completely in line with (30):

(32) *Local movement*



We thus see that local movement of a feature will harmonically bound non-local movement. This means that from the original list in (3), we are left with only two possible repairs, each with their own specific constraint violation profile:

- (33) a. **Devoicing:** $\text{PARSE-}\phi(\text{[voice]})$: The feature voice needs to be incorporated into the phonological structure.
 b. **V-insertion:** $\text{PARSE-}\mu(\text{V})$: Vowels should be part of the morphological structure.

Since these constraints can be independently ranked, we predict a three-way factorial typology:

(34) *Factorial typology*

- a. $\text{PARSE-}\phi(\text{[voice]}), \text{PARSE-}\mu(\text{V}) \gg \text{FINDEV}$: Voiced coda obstruents are allowed
 b. $\text{PARSE-}\mu(\text{V}), \text{FINDEV} \gg \text{PARSE-}\phi(\text{[voice]})$: Final devoicing
 c. $\text{PARSE-}\phi(\text{[voice]}), \text{FINDEV} \gg \text{PARSE-}\mu(\text{V})$: Vowel epenthesis after voiced obstruents

(35)

/tab/	FINDEV	$\text{PARSE-}\phi(\text{[voice]})$	$\text{PARSE-}\mu(\text{V})$
tab	*		
tap		*	
tabə			*

The third type of language would give [tabə] as an output for /tap/. It has been suggested that language varieties of this type do indeed exist. Itô and Mester (2003) mention two potential cases. First, in second language acquisition of speakers of a FD language trying to learn a non-FD language such as English, we sometimes find epenthesis of exactly this type. The problem with this type of evidence is that we know that there is something special about the second language acquisition process in the sense that epenthesis is more generally preferred as a repair strategy than deletion (see for instance Escudero,

2005, and references cited there). On the other hand, to the extent that second-language acquisition does provide us with insight into the way in which natural language works, this evidence may not be discarded out of hand.

The second type of evidence offered by Itô and Mester (2003) is more promising. They note that in the history of German — or, we could add, the history of West Germanic more generally —, a process of schwa apocope has applied, turning e.g. the adjective *süsse* ‘sweet’ into *süss*. One of the factors in this change was the voicing of final obstruents: stems ending in such an obstruent resisted apocope for a longer time than stems ending in other segments, so that even in present day German we still have forms such as *leise* ‘quiet’, *böse* ‘angry’ and *träge* ‘slow’.

Diachronic blocking of apocope obviously is not the same thing as synchronic epenthesis, but the situation is very similar. In particular, West Germanic dialects which are in a stage in which apocope has applied to all or some of the stems with final voiceless obstruents, but to none with voiced obstruents, such a stage can be described exactly by a grammar such as (34c).

Some Flemish dialects spoken in the border region between the provinces of East-Flanders and Brabant come quite close to this. This can be shown by consultation of the data in the so-called Goeman/Taeldeman/Van Reenen Database of Dutch dialects, which is freely available at <http://www.meertens.knaw.nl/mand/>. This is true, for instance, in the town of Buggenhout in the eastern part of the province of East Flanders. In the dialect spoken in this town, forms end in an underlyingly voiceless plosive, or in a voiced plosive plus a schwa⁵ (we simplified some of the irrelevant details of the narrow transcriptions in the database):

- (36) a. *een baard* ‘a beard’ [nənbɔ:t] - *baarden* ‘beards’ [bɔ:tɪ], *een schaap* ‘a sheep’ [ənsxɔ:p] - *schapen* ‘sheep’ [sxɔ:pən], *een vat* ‘a barrel’ [ənvət] - *vaten* ‘barrels’ [vɔ:tɪ]
 b. ‘*n bed* ‘a bed’ [əmbɛrə] - *bedden* ‘beds’ [bɛrəs], ‘*n rib* ‘a rib’ [əmrɛbə] - *ribben* ‘ribs’ [rɛbɛrɪ]

The orthographic form in italics in every case represents the Standard Dutch form. As can be seen from the word for ‘beards’, this form sometimes has a voiced plosive in Dutch. As far as I can tell, there are no cases where a word ends in an (underlyingly) voiced plosive, or for that matter in a voiceless plosive plus schwa.

One slightly problematic case in the Buggenhout dialect is *een hoed* ‘a hat’ [nənhut] - *hoeden* ‘hats’ [ujəs], since here we find a [j] as the correspondent of the singular [t], and lenition to [j] is otherwise usually restricted to underlying /d/’s in Dutch (Zonneveld, 1978). This /d/ is also there in Standard

⁵The situation is different for fricatives, which have a different voicing system in most varieties of Dutch anyway; cf. Iverson and Salmons (2003).

Dutch and other varieties, as the orthography indicates. However, lenition of intervocalic /d/ seems to lead to [r] in Buggenhout (see also the word for *bed* in (36b)), and furthermore, the diminutive form of ‘hat’ is transcribed as [utəkən] rather than [udəkən], where -[əkən] is the diminutive suffix, which usually preserves underlying voicing. All of this suggests that the plural form [ujəs] is really lexicalized and not indicative of the underlying status of the stem-final segment.

In the case of sonorants, there is variation however (which might be partially regulated by other factors such as vowel length):

- (37) *een boom* ‘a tree’ [nənbu:əm] - *bomen* ‘trees’ [buəmən] vs. *een kom* ‘a bowl’ [əŋkumə] - *kommen* ‘bowls’ [kumən]

All of this suggests that Buggenhout comes very close to the type of case which Steriade (2001) suggested was missing from our factorial typology. Having the repair of vowel epenthesis in our universal inventory might thus not be superfluous after all.

4 Comparison to alternatives

The TMR problem has been addressed in various ways in previous work (Steriade, 2001; Wilson, 2001; McCarthy, 2004; Blumenfeld, 2006; McCarthy, 2007); but since the problem shows up in many different contexts, not all of these solutions are applicable to the case at hand. For instance, McCarthy (2004)’s Headed Span theory is a representational proposal which aims to explain why requirements of (vowel or nasal) harmony do not lead to deletion. McCarthy (2004) points out that, if the relevant constraint would be a right Alignment constraint and the relevant feature would be underlyingly on the leftmost segment of the word, deleting all segments to the right could be a solution to the problem. It never is, however. Headed Span theory gives a different type of constraint for harmony, where deletion is not a solution by definition. However, Headed Span theory is not designed to have anything to say about final devoicing.

There is no reason to suspect that there should be one general solution to all instances of the TMR problem. Those instances all show that the present theory needs to be restricted, but it is quite possible that it needs to be restricted in more than one way.

Here, I will therefore discuss only three proposals which can each be seen as direct competitors to the present account, since they seem to be able to deal with the same facts in a different way: Steriade (2001), Lombardi (2001) and Blumenfeld (2006).

4.1 Steriade (2001)

We owe the observation of the TMR problem for final devoicing to Steriade (2001), but the solution proposed in that paper is quite different from the one defended here. Steriade (2001) observes that there is experimental evidence that the difference between, say, a [d] and a [t] is smaller than that between a [d] and an [n], a [d] and an [j], or a [d] and \emptyset (Fleischhacker, 1999). Her proposal is that these perceptual differences are reflected in the hierarchy of faithfulness constraints (by way of a so-called ‘P-Map’): a violation of IDENT-[voice] counts as less harmful than a violation of any other faithfulness constraint:

- (38) *Constraint hierarchy* (universal)
 IDENT-[nasal], IDENT-[consonantal], LINEARITY, MAX, ... \gg IDENT-[voice]

The universality of the constraint ranking is not necessarily innate, according to Steriade (2001), but it is due to the child’s taking into account perceptual (and possibly other phonetic) factors in establishing the constraint hierarchy.

It is hard to compare Steriade (2001)’s approach to the one put forward here, since they seem to be based on entirely different principles. Steriade (2001) presents a theory which departs radically from classical generative phonology by assuming that phonetic factors can radically influence the phonology, whereas a Containment based proposal stays close to the conservative ‘feed forward’ model of phonology-phonetics interaction.

Empirically, the two approaches seem to make roughly the same prediction for final devoicing, except possibly for vowel epenthesis, where it is not so clear what the ‘right’ prediction is. I believe, however, that we can find other cases where there is an empirical difference between the two approaches. One of the successes of OT is the fact that it can deal with so-called conspiracies: several processes leading to the same result. A classical case is the constraint *N C (‘No nasal followed by a voiceless obstruent’ Pater, 1999). Languages famously use many strategies in order to solve the conflict which this constraint raises:

- (39) a. *Post-nasal voicing* (Puyo Pungo dialect of Quechua; Rice, 1993; Orr, 1962):
- | | | | |
|-----------------|-----------------|-----------------|---------------|
| <i>sinik-pa</i> | ‘porcupine’s’ | <i>kam-ba</i> | ‘yours’ |
| <i>sača-pi</i> | ‘in the jungle’ | <i>hatum-bi</i> | ‘the big one’ |
| <i>wasi-ta</i> | ‘the house’ | <i>wakin-da</i> | ‘the others’ |
- b. *Denasalisation* (Mandar; Mills, 1975)
- | | | |
|-------------|------------|------------|
| /man+dundu/ | [mandundu] | ‘to drink’ |
| /man+tunu/ | [mattunu] | ‘to burn’ |
- c. *Nasal deletion* (Venda; Ziervogel et al., 1972; Myers, 2002)

/n-guhvo/	[n-guhvo]	'blanket (Class 9)'
/n-dou/	[n-dou]	'elephant (Class 9)'
/n-kholomo/	[kholomo]	'fowl (Class 9)'

Particularly interesting is the comparison between (39a) and (39c), since this involves a change in place (a violation of IDENT-[voice]) and deletion of a segment (a violation of MAX) respectively. Since both options are available, this means that Universal Grammar should allow both for IDENT-[voice]≫MAX and MAX≫IDENT-[voice] respectively. But this is in contradiction to (38), which itself is the most basic assumption of Steriade (2001)'s analysis of Final Devoicing.

Of course, this only counts as an argument if we can show that the Containment based analysis does not suffer from the same problem. We will go into this in more detail in section 5; for now, notice that in this particular case the harmonic bounding argument does not go through; deletion of the nasal and voicing of the following consonant are entirely separate processes, if only because they involve different segments. Notice also that the situation is typologically a bit more complicated, though, since a possible repair is also deletion of the voiceless plosive, as in Madurese in which the nasal final prefix may induce deletion of a stem-initial voiceless obstruent (Stevens, 1968; Myers, 2002):

(40)	/paŋ-arap/	[paŋ-arap]	'hope'
	/paŋ-puti/	[pam-uti]	'bleach'
	/paŋ-cukur/	[paŋ-ukur]	'razor'

4.2 Lombardi (2001)

Before we will go into the relevance of the data, we first turn to the other alternative analysis which is worth discussing, the one by Lombardi (2001). Her focus is on the difference between Place and Laryngeal features; the main observation is that those repairs which are impossible for final devoicing, appear to be possible for 'bad' place features. We know that many languages have severe restrictions against marked place features in the coda, known as CODA CONDITION (41a). Formulated in this way, these sound very closely related to FINDEV. However, at least consonant deletion and vowel epenthesis are known repairs for

- (41) a. CODA COND: A coda consonant may not be labial / velar / coronal / laryngeal
- b. CODA COND triggers consonant deletion: (Diola, Sapir (1965))
- | | | |
|--------------|-----------|-----------------|
| /let+ku+jaw/ | [lekujaw] | 'they won't go' |
| /ujuk+ja/ | [ujuja] | 'if you see' |
| /kob+kob+en/ | [kokoben] | 'yearn' |

- c. CODA COND triggers vowel epenthesis: (Ponapean, Rehg and Sohl (1981))

/kitik+men/	[kitikimen]	'rat'
/ak+dei/	[akedei]	(no gloss)
/ak+tantat/	[akatanat]	(no gloss)

Given that it is not so clear that Final Devoicing does not trigger vowel epenthesis, we believe that the really interesting comparison is in the realm of consonant deletion. We believe that Lombardi (2001)'s proposal is relevant and can be adopted within our framework.

The proposal consists of two parts. First, it is suggested that features are monovalent, and in particular that this holds true for [voice]: voiceless segments lack this feature altogether. This is an assumption we have also adopted in this paper. Secondly, it is suggested that placeless segments do not exist: they cannot be underlying and they cannot be generated by the phonology. Pharyngeal segments such as [h] and [ʔ] are marked for a feature [Pharyngeal], which happens to be the least marked place feature in a hierarchy [Velar], [Labial] < [Coronal] < [Pharyngeal].⁶

Let us adopt this second proposal. This leads immediately to a difference between the consequences of FINDEV and those of CODA COND. As a response to the first, it will be legitimate to delete only the feature [voice], since no illegal structure will arise. However, it is not legitimate to only delete a place feature as a response to e.g. CODA COND(Velar): an alternative place feature will have to be inserted instead, for instance Pharyngeal. This means that obeying CODA COND(Velar) implies violating *two* faithfulness constraints: PARSE- ϕ (Velar), and PARSE- μ (Pharyngeal). The latter is a constraint against epenthesis, hence it is freely rankable with respect to the constraint against deleting the whole segment PARSE- ϕ (segment). Hence there is no harmonic bounding and the possibility of deleting the whole segment arises in this case:

(42)	kitik+men	CODA COND(Velar)	PARSE- μ (Place)	PARSE- ϕ (segment)	PARSE- ϕ (Velar)
i.	kitikmen	*!			
ii.	☞ kitimen			*	*
iii.	kitiʔmen		*!		*

There thus is a universal representational difference which is responsible for the fact that there are more solutions available in the case of illicit Place features in the coda than in the case of illicit Voice.

⁶One way of implementing this idea would be to say that place features are heads of segments, and all segments need a head.

4.3 Blumenfeld (2006)

Blumenfeld (2006) attempts to deal with a specific class of TMR problems, viz. those which concern prosodic and segmental structure. The constraint favouring Final Devoicing is of such a type, since it states that a segment in a coda (prosody) cannot be voiced (segmental structure). Blumenfeld (2006) does not aim to provide a solution to any of the possible repairs in (3). He refers to Steriade (2001) for this, and he adds yet another logical possibility to the list: resyllabification in the case of vowel initial clusters. In particular, Blumenfeld (2006) argues that we would expect the following contrast to arise in some languages:

- (43) a. /apra/ → [ap.ra]
 b. /abra/ → [a.bra]

Thus, voiceless consonants would close the following syllable, whereas voiced consonants would not. Blumenfeld (2006) claims that this situation does not arise in natural language. We do have languages where the reverse seems to happen: “in Icelandic and Ancient Greek, the voiced but not the voiceless segments make the preceding syllable heavy. The standard analysis of such voicing asymmetries in syllabification appeals to syllable contact: ab.ra is preferred to ap.ra because it has a smaller sonority fall across the syllable boundary (cf. Gouskova, 2003).” But Blumenfeld (2006) claims that Final Devoicing never has this effect.

We cannot go into all the technical details of Blumenfeld (2006)’s proposal, but the key of it is that there is a new type of constraint, the *implicational constraint*. Constraints of this type state *if x then y*; however, different from logical implication, which are satisfied per definition if *x* is false, implicational constraints require *x* to be true if this is at all possible.

An example may illustrate this, and we will take Final Devoicing as our example (implicational constraints are marked by \blacklozenge in Blumenfeld (2006)’s notation, as are those candidates which violate a constraint because *x* is not kept constant):

- (44) \blacklozenge FINDEV: If a segment *s* is in the coda, then *s* should not be [+voice]

(45)

/apra/	\blacklozenge FINDEV	STRESS-TO-WEIGHT	FAITH-[voice]
a.pra		*!	
\rightarrow ap.ra			

(46)

/abra/	◆ FINDEV	STRESS-TO-WEIGHT	FAITH-[voice]
a.bra	◆!	*	
ab.ra	*!		
a.pra	◆!	*	*
☞ap.ra			*

For the sake of the argument, we assume that STRESS-TO-WEIGHT is the reason why we incorporate the [p] into the rhyme of the first syllable in (45), but there could of course be other reasons.

In (46), [ab.ra] is ruled out by ◆FINDEV for obvious reasons. However, [a.bra] and [a.pra] are also ruled out because here the relevant segment is not in a coda. How do we know that it should be in the coda? We take out the ◆ constraint and see which form is the winner then: [ab.ra]. This form, the ‘designated form’, now determines the prosodic shape of the whole form; candidates which do not have this prosodic shape will violate the constraint (marked with ◆).

The mechanism thus works somewhat like McCarthy (1999, 2003b)’s Sympathy Theory in that it allows a quasi-derivational approach by first considering only a subpart of the tableau before taking the whole constraint set into account. In the case of implicational constraints, we first fix the prosodic structure, before we consider its implications for segmental phonology.

The main problem for Blumenfeld (2006)’s is its technical complexity. Observe that there is no formal reason why ◆ constraints should always have the prosodic structure in the *if* clause, and segmental phonology in the consequent. The only reason why things are set up this way, is because it happens to work empirically. If the real world would have been organized differently, we could have formulated ◆FINDEV only slightly differently, and get the reverse results:

(47) ◆ FINDEV: If a segment *s* is [+voice], then *s* should not be in the coda

(48)

/abra/	◆ FINDEV	STRESS-TO-WEIGHT	FAITH-[voice]
☞a.bra		*	
ab.ra	*!		
a.pra	◆!	*	*
ap.ra	◆!		*

In this hypothetical analysis, we would fix the value for [αvoice], and then decide to violate STRESS-TO-WEIGHT: exactly the state of affairs which is not attested, according to Blumenfeld (2006). Although the observation that prosody often causes segmental phonology rather than being based on it is an interesting one, it is not really theoretically captured in Blumenfeld (2006)’s framework.

It also is not clear whether the generalisation holds in this particular case. Onset clusters /dl/ and /tl/ are not allowed in German, like in many other languages. Let us assume that the reason for this is the OCP. Intervocally, this constraint has the effect of splitting up a cluster: *Atlas* ‘atlas’ [at.las]. However, this in turn does not apply if the obstruent is underlyingly voiced: *Adler* ‘eagle’ [a.dlɛr] (Vennemann, 1992). We thus find exactly the type of structure which Blumenfeld (2006)’s is designed to rule out.

A somewhat more controversial example comes from Brussels French. Although this dialect does not have devoicing at the surface, it can be argued to have developed some reflexes of the constraint FINDEV; it may not be a coincidence that both Romance dialects are in close contact with continental West Germanic (Flemish).

Féry (2003) shows that word-final voiced fricatives are always preceded by long vowels in this dialect: *chose* ‘thing’ [ʃo:z] (*[ʃoz]), *nage* ‘swim’ [na:ʒ] (*[naʒ]), and she accounts for this by assuming that these voiced segments need to be in an onset, in this case of a so-called semi-syllable (without a vowel).⁷ The reason why these segments are in an onset, according to this line of reasoning then, is that in this way they can satisfy FINDEV while at the same time keeping faithful to underlying [voice] specifications. Languages with real final devoicing would then not allow for the possibility of semisyllables (or have a stricter requirement against voicing in such syllables).

5 The nature of conspiracies

We have noted in section 4.1 that the real challenge for any approach to the TMR problem is to account also for those cases where the same target indeed can be repaired in more than one way. We noted a particularly interesting case above: in response to a putative constraint against NC̣ clusters in (39a), both deletion and voicing are possible, unlike in the case of final devoicing.

Why are more solutions allowed in the case of NC̣ violations than in the case of FINDEV? Compare these two constraints (FINDEV was already defined in (2), but repeated here for convenience; *NC̣ is from Pater (1999)).

- (49) a. FINDEV: No voiced segments at the end of the syllable.
 b. *NC̣: No nasal/voiceless obstruent sequences.

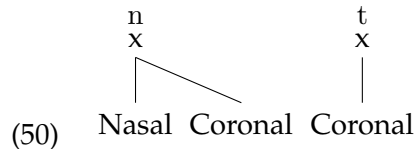
One difference is that FINDEV talks about one segment in one position, whereas *NC̣ talks about two segments in two positions. Further, the solution in the case of *NC̣ comes from voicing rather than devoicing.

We argued in the case of FINDEV that deletion of the whole segment is harmonically bounded by deletion of just the feature [voice]: if a segment is not parsed into the phonological tree, nor will its constituting features be.

⁷A similar argument has been put forward for Dutch dialects by ?.

The situation is different in the case of $*NC_{\circ}$. Here, we have a *sequence* of segments that is in an offending configuration: if we delete one, this does not affect any of the features of the other.

Suppose we have a language with high-ranking $*NC_{\circ}$, and the following structure:



This structure is illicit because of high-ranking $*NC_{\circ}$. We can repair it in various ways. One way obviously is to add voicing to the plosive, violating $PARSE-\mu(\text{Voice})$ and creating a [d].

Another option is to delete the nasal feature, so that we get denasalisation. This is actually attested in Mandarin, as (39b) testifies. This gives us a violation of $PARSE-\phi(\text{Nasal})$. Since voicing and denasalisation thus give very different violation profiles, both options should be available typologically, and both seem to be so. There is not TMR problem, since the relevant repairs are all attested.

If we can delete only a feature [nasal], this should harmonically bound deleting a whole nasal segment, given the line of reasoning followed in this paper. Notice, however, that feature deletion would result in a cluster of obstruents (or possibly a geminate):

(51) /n-kholomo/ → *[t-kholomo]

Deletion of only the [nasal] feature would thus result in an illicit obstruent cluster; that is the reason why the whole segment gets deleted, and there is no harmonic bounding.

We thus predict that languages where the nasal segment is deleted as a whole will have severe restrictions on obstruent clusters; a prediction which seems to largely been confirmed by the facts. Pater (1999) briefly discusses one potential counterexample: the case of Chamorro, in which clusters and obstruents are allowed, and we even find obstruent-final prefixes such as *hat-* and *tak-* (Topping, 1973).

Chamorro has segmental deletion rather than denasalisation. Crucially, however, the segment which is preserved, keeps the nasality. That means we have no harmonic bounding: if we have very high-ranking faithfulness to nasality, and less highly ranked faithfulness to the obstruent features (which may be a subset of those needed to describe the nasal) the result follows:

(52)

/man+saga/	PARSE- ϕ (Nasal)	*NC _̣	PARSE- ϕ (C) PARSE- ϕ (Place)
matsaga	*!		
mansaga		*!	
masaga	*!		*
↪majaga			*

This tableau seems to show that the form [masaga] is harmonically bounded by [majaga]. However, other factors may come into play, such as the relative markedness of nasals and obstruents in onsets. We will not go into the full details of different types of nasal substitution here; cf. Pater (1999, 2001) for discussion.

All in all, it appears that we have more possibilities in the case of nasal-obstruent clusters than are attested for final devoicing, and there is a clear reason behind it: *NC_̣ effects are complicated effects involving nasality, obstruency and voicing in two different segments. Final devoicing only involves syllable position and voicing in one position.

Interestingly, Myers (2002) observes that even in the case of *NC_̣, we still have a TMR problem under Correspondence Theory, since several logically possible options are not attested:

1. In the first place, again, metathesis is not an option: there is no language which transforms *ampa* systematically into *apma* while leaving *amba* untouched.
2. Secondly, lenition is not an option either. Turning *ampa* into *amwa* might solve the problem; but it never does.
3. Thirdly, we could epenthesize a vowel, turning *ampa* into e.g. *aməpa* (again leaving *amba* systematically unchanged). Also this pattern is unattested.

Myers (2002) provides an account of these ‘gaps in the factorial typology’, as he calls this TMR problem, by referring to diachrony and phonetics. Even though Universal Grammar in principle is able to generate all of these forms, they will never arise in reality because the phonetic events leading up to them are extremely unlikely. If a language has *ampa*, learners might get confused by the consonant cluster and hear *apa*, *ama* or *amba* instead, but it is very unlikely that they will perceive *apma*, *amwa* or *aməpa*. In that sense, then, phonetics makes certain rankings more plausible in phonological grammars, and others less so.

The problem with this account is that it makes phonological theory basically untestable: we can allow it very large generative capacities and account for all the gaps which nevertheless exist by reference to the phonetics.

Notice however that the first two possibilities mentioned by Myers (2002) are subject to harmonic bounding under our approach. The representation of

a metathesized form would again have to be quite complicated, if indeed it would be possible: it would involve deletion and insertion at the same time of either the nasal or the voiceless obstruent, and in that sense be harmonically bound by a form with only deletion.

Lenition similarly would be harmonically bounded, at least if we assume that *NC̥ prohibits the occurrence of a nasal followed by *any* consonant without a feature [+voice]: lenition would then involve a change in consonantality next to addition of Voice, and be harmonically bounded by a form which only adds the laryngeal feature.

The remaining problem, then, is epenthesis. Notice, however, that , vowel epenthesis seems to be very rare more generally in (homorganic) nasal+obstruent clusters in languages of the world, so there might be independent reasons why it does not occur here.

6 Conclusion

Phonological theories have a tendency to become more and more powerful, faced as they are with myriads of complicated facts. The TMR problem confronts us with the consequences of such power: we predict too many phonological systems, as compared to those which are found in the real world.

We can respond to this challenge in various ways. One option is to extend the power of the theory even further by proposing new types of constraints along the old ones. I believe that such a strategy eventually does not really solve the problem. Yet another possibility is to keep phonological theory in its present powerful state and relegate all restrictions to phonetics. That makes the business of phonology a less interesting one. This paper has followed a slightly different line of attack, trying to restrict the theory rather than enriching it.

In order to do this, we have retreated to a more conservative theory of faithfulness than the one which is currently most popular: instead of Correspondence Theory, we have adopted Containment. Note that literally nothing new has been added to the theoretical machinery in order to achieve this goal in the course of our analysis, although certain things might have been made slightly more explicit: the whole conception of Containment is based on Consistency of Exponence, a principle that seems to be assumed also in most work on Correspondence.

It is of course always possible that Containment based faithfulness theory turns out to be too restrictive, but it should be pointed out that restrictiveness has been considered a theoretical merit at least since the days of Occam. At present, Containment seems to be able to account for most of the relevant facts in an explanatory way.

This article may also be read as an argument in favour of a type of linguistics which takes microvariation as seriously as macrovariation. It is very

hard to be as precise about the precise implementation of final devoicing if we base ourselves only on a handful of (standard) languages. At various places in this article, I hope to have shown how the study of (Dutch and French) dialects give interesting evidence, e.g. for ‘grandfather’ or ‘Emergence of the Unmarked’ effects with respect to Final Devoicing.

Finally, this article has argued for a phonological methodology which plays close attention to its representations, and consequently to the precise formulation of its constraints. The argument, for instance, that nasalisation of a final obstruent is harmonically bounded by voicing of that obstruent, is quite straightforward, once we look at the feature representations of this segments, and once we have established that the most general formulation of Final Devoicing is one which requires *every* segment in the coda to not bear a phonological feature specification [+voice], regardless of its place in the sonority hierarchy, and its phonetic voicing.

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