

A Reduction and Spreading Theory of Voicing and Other Sound Effects**

Joan Mascaró

Universitat Autònoma de Barcelona, Departament de Filologia Catalana
08193 Bellaterra (Barcelona), Catalonia (Spain)
llf78@cc.uab.es

Abstract

A set of different surface effects commonly found in the phonology of natural languages, voicing assimilation and final devoicing, are derived from two parameters, Reduction, the loss of phonological structure, and Spreading, the association of two unsociated nodes. Reduction is an operation on a node (e.g. voice), and it can take three values: no operation, Deassociation of the node, or Deletion of the node. Spreading has just the two minimal values, + and -. Spreading can combine with Reduction, or with Deassociation, resulting in two different assimilatory effects. When Spreading takes the negative value, or when contextually no spreading is possible, the surface effect that results is devoicing. The different parametric settings of Reduction and Spreading coupled with syllable control, and stages of application, predict the appropriate surface clusters of voicing effects. These results are extended to other effects like place centralization, unmarked assimilation, and to a set of residual or *sporadic* effects like progressive assimilation in regressive systems.

Key words: phonological theory, voicing, assimilation, devoicing.

Resum. *Una teoria de reducció i d'escampament de la sonoritat i d'altres efectes sonors*

Tota una sèrie d'efectes superficials que es troben sovint en la fonologia de les llengües naturals, l'assimilació i l'ensorquiment final, es deriven de dos paràmetres: la Reducció,

* NOTE OF THE EDITORS. Although CatWPL normally publishes the results of ongoing research, the editors have considered that this 1987 manuscript was worth publishing.

To avoid problems of citation, this paper should better be referred to as Mascaró (1987). A reduction and spreading theory of voicing and other sound effects. UAB. Unpublished manuscript. [Published 1995 in *Catalan Working Papers in Linguistics*, 4.2, 267-328.]

* The basic ideas of this paper were presented at the 1985 *International GLOW Colloquium* in Brussels, and were later developed in two successive versions of a manuscript, of which the second circulated more widely. The version reproduced here, with minor typographical and style changes, is the second. I have included most of the material that was eliminated in the second version as an Appendix. I would like to thank Wayles Browne for his invaluable help in the analysis of Slavic, and the comments made by two anonymous reviewers of the first version. I am also indebted to René Kager, Gemma Rigau, Jerzy Rubach, and Teresa Vallverdú.

la pèrdua d'estructura fonològica, i l'Escampament, l'associació de dos nodes no associats. La Reducció és una operació sobre un node (p.e. sonor), i pot prendre tres valors: cap operació. Desassociació d'un node, o elisió d'un node. L'escampament té els dos valors mínims, + i -. L'Escampament es pot combinar amb la Reducció, o amb Desassociació, amb dos resultats assimilatoris diferents. Quan l'Escampament pren el valor negatiu, o quan no hi ha possibilitat d'escampament a causa del context, l'efecte superficial resultant és l'ensordiment. Els diferents valors paramètrics de la Reducció i de l'Escampament, associats amb el control sil·làbic i amb els estats d'aplicació preduen els grups superfcials d'efectes de sonoritat apropiats. Aquests resultats són estesos a efectes diferents del de sonoritat, com la centralització de punt, assimilació a no marcat i a un conjunt d'efectes residuals o esporàdics, com ara l'assimilació progressiva en sistemes regressius.

Paraules clau: teoria fonològica, sonoritat, assimilació, ensordiment.

Table of Contents

1. Voicing assimilation and final devoicing	6. Side effects
2. Clusters of Voicing Effects	7. Summary and Conclusions
3. Specification Stages	Appendix A. Additional Voicing Effects in Polish
4. Voicing in Polish, Russian, and English	Appendix B. Assimilation to Marked
5. Extensions	Appendix C. Extensions to Vowels
	References

The central concern of this study is to show how the enrichment of phonological representations brought about by autosegmental theory can be adequately compensated by radical restrictions on the class of permissible phonological operations.

Although there are clear examples of genuine autosegmental operations, association and deassociation (or delinking) being perhaps the most conspicuous examples, the kind of rules allowed by an SPE formalism (call them *segmental*) are in many analyses still allowed to mix freely with the more autosegmental-flavored processes. In many instances, of course, the use of segmental rules is intended implicitly to be a pure practical descriptive device, used to introduce generalizations that are relevant to the discussion, but whose formal structure is not the main concern of the analysis. In any case, it is evident that the enrichment of phonological representations, no matter how well supported, if coupled with a system of segmental rules that is not extremely restricted, might be a good descriptive improvement, but is a clear loss in explanatory power. The interesting innovation of autosegmental theory and other similar developments lies not only, and not mainly, in the fact that they are shown to be necessary enrichments of the phonological component. It rather lies in the fact that they allow a radical reduction of the class of language-particular operations on structures without loss in descriptive adequacy, via the increase in complexity of the system of universal principles—a desirable one,

since it accounts for the projection of a complex system from a very limited experience.

One of the strategies used to attain this reduction consists of deriving a set of apparently unrelated surface properties from a single parameter. This means that descriptive generalizations (*effects*) do not correspond to explanatory generalizations. The present study shows that different surface manifestations involving what appears to be a genuine autosegmental operation, assimilation, and what is usually analyzed as a segmental feature changing operation, i.e. devoicing, or centralization of place (e.g. $z \rightarrow s$, and $\eta \rightarrow n$, $m \rightarrow n$, $\lambda \rightarrow l$, respectively) can be derived from elementary operations on structure, i.e. by reduction and by spreading.

If the results of this procedure appear to be correct, then it is the case that at least some segmental rules can be reduced to a constrained autosegmental operation. The correct research strategy that derives from these results consists of trying to reduce similar cases of apparent segmental operations to the constrained autosegmental formalism. In this way the segmental *residue* (to use Poser's (1982) term) of autosegmental theory can be eliminated, or at least isolated and dealt with in an appropriate, adequately constrained way.

The theory proposed, Reduction/Spreading (RS) theory is therefore not a theory of assimilation; assimilation should be viewed as one of the *widespread* effects of RS, namely the result of the combination of the two parameters, Reduction and Spreading.

In the first three sections I will develop the theory by examining general properties of voicing. First I will show how different surface effects can be related to the same parameters, by deriving allegedly different operations, voicing assimilation and final devoicing, from the same parametric settings. Then I will examine how RS theory accounts also for the fact that voicing effects cluster in specific sets, while some combinations are not found. The different parametric settings of RS coupled with a limited set of other parameters, syllable control, and Stages of application (related to Underspecification theory) should predict the appropriate clusters. In section 4 I will examine some voicing systems in more detail, and add some further refinements. In the last sections I will try to reduce further the *segmental residue* by examining processes having to do with properties other than voicing, and by showing that they are governed by the same mechanisms responsible for voicing effects. In section 5 I will introduce place of articulation effects; in section 6 I analyze some consequences of the theory proposed. I will show that when unusual representations arise, RS mechanisms apply yielding a set of residual or *sporadic* side effects that should be otherwise accounted for by ad hoc rules.

I will adopt here standard autosegmental theory, with the enrichment of feature structure with feature nodes (e.g. voice, place) described in section 1. Two basic language particular operations on representations are considered: Reduction, the loss of phonological structure, and Spreading, the association of a skeletal slot with an already associated autosegment. The loss of structure can be of two kinds. One is the loss of a node (e.g. the loss of the node *voice*, or the loss of a skeletal unit in degemination), the other is the loss of the association relation between two or more nodes (hence the opposite of spreading). If the Reduction parameter is positive, it can take two different values: Deassociation, or Deletion. We have therefore three possibilities: no operation, Deassociation, and Deletion. Spreading has

just the two minimal values, + and -. The effect of Reduction is in most cases a representation that is not fully interpretable phonetically: it will contain elements which are unspecified for some property, e.g. some feature will not be assigned to any timing unit, or a timing unit will be unspecified for some phonetic property. Three different mechanisms, universal and language-particular, have the effect of producing a fully interpretable structure: Spreading and the general convention Float Deletion reassociate or delete unassociated elements; an independent theory, Underspecification, assigns unmarked values to underspecified units. Full Interpretation (Chomsky (1986: 98-101)) seems indeed to be a property of Phonetic Form. Uninterpretable elements contained in intermediate phonological representations appear to be made interpretable even before phonetic language-particular rules apply to give PF. Thus floating elements left by neutralizing processes (final devoicing, assimilation) are *short-lived*: they might be partly recovered through processes applying at the same level, but are not recoverable later; I return to the matter in the next section.¹

1. Voicing assimilation and final devoicing

Standard analyses of assimilation of voice and word final devoicing consist of rules of the following type:

- (1) a. [-sont] → [α voice] / _____ { -sont
α voice }
b. [-sont] → [-voice] / _____ ##

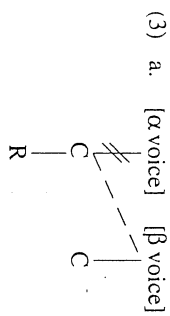
These rules account for a widespread type of alternations, illustrated here with Dutch and Catalan:

- (2) a. huis[zen] 'houses'
huis[s] 'house'
huis[k]ammer 'living room'
huis[b]jas 'landlord'
b. me[ʒ]os 'months'
me[s] 'month'
me[s] k[ʏ]urt 'short month'
me[ʒ] β[in]ent 'next month'

In the recent literature, autosegmental theory has been extended to treat assimilatory processes as *delinking cum spreading* operations (see Hayes (1986) and references cited there), like (3a). Such operations are kept unrelated to devoicing, which still tends to be analyzed as a *segmental* rule (3b) (Booij and Rubach (1985), Berendsen (1986), Dinnsen and Charles-Luce (1984), Kiparsky (1985: 108)). For

1. There is literature on recoverability of final devoicing that merits close attention (see Charles-Luce and Dinnsen (1987), and references cited there). It appears to be the case, however, that the findings are either not well-supported (Mascará (1987)), or they are cases of *phonetic* devoicing that apply at the phrase level in a gradient fashion, hence not cases of recovery of previous devoicing, but just cases of partial devoicing. I will consider later the possibility of inexistence of syllable control in some languages.

languages like Dutch and Catalan the assimilation is controlled by syllable structure; this is incorporated in (3a) by linking the first C to the rhyme node R:

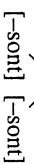


- b. [-sont] → [-voice] / _____ ##

It is clear that the relationship between the two processes is not one of mutual implication; if so, the phenomenon would not have passed unnoticed. There are languages with both processes, like Dutch and Catalan, but there are also languages with only assimilation, like Serbo-Croatian and some varieties of Spanish, and languages with only final devoicing, like German. The relationship is, as should be expected, of a more involved kind, and does not derive from superficial implicational universals, but from more abstract properties of the phonological system. I will show that they are indeed related, and that the specific way in which they are related follows from the formal properties of phonology, in particular from RS mechanisms. I will propose that assimilation should not be viewed as a single step process, like in standard α rules or *delinking cum spreading* autosegmental operations, but as the result of two different phonological operations, which will be termed Reduction, the loss of some phonological property, and Spreading, the association of some phonological property to adjacent skeletal units.² For the sake of illustration, we can rephrase, somewhat informally, rules (1a,b) within the framework proposed, which will be developed further in subsequent sections. The two distinct processes will then have the form of (4a) and (4b), respectively; the initial representation (4c) will turn into (4d) by Reduction (4a) (here in the form of autosegment deletion, one of the possible Reduction values), and into (4e) by Spreading.

- (4) a. REDUCTION (DELETION)
[α voice] → ∅ / _____ { [-sont]
}

- b. SPREADING
[α voice]



2. Poser (1982) had already shown that assimilation was a two step process, and presented an argument based on the application of another process between the two assimilation operations.

(4) c. ASSIMILATION

INITIAL STRUCTURES

[β voice] [α voice]

[α voice]

...[-sonr] [-sonr]...

...[-sonr] ##

d. REDUCTION (DELETION)

[α voice]

...[-sonr] [-sonr]...

...[-sonr] ##

e. SPREADING

[α voice]

...[-sonr] [-sonr]...

...[-sonr] ##

The word final obstruent in (4e) will not be associated to any voicing autosegment; assuming some variant of Underspecification theory, this unspecified obstruent should receive a value for voicing, namely the unmarked value, [-voice]. Devoicing in final position is hence the result of Deletion, of the fact that there is no available spreader, and of Underspecification theory.³

The simplification of the rules in (4) appears at first sight to be inadequate in two respects. First there is a problem of duplication: the rule of Spreading (4b) repeats part of the structural description of Deletion (4a): the [voice] autosegment spreads precisely on the rhyme obstruent which is left unspecified for [voice] by the preceding rule. A second problem is that the fact that deletion takes place both before another obstruent and in word final position is not accidental: in both cases the assimilation undergoer and the devoicing segment are in the same specific position, namely the syllable rhyme (at least in the cases of Dutch and Catalan illustrated above). Before dealing with these problems, I will make the structure of phonological representations and feature specification more explicit. I assume that phonological representations follow the model proposed in Mascaró (1983), Mohanan (1983), further developed in Clements (1985), Sagey (1986). A phonological representation is viewed as a sets of nodes (limited in the domain analyzed here to *feature (segmental) nodes*), related by precedence and association. The phonetic interpretation of precedence is precedence in real time, and that of association is (partial or total) cococcurrence in real time. These assumptions will become more relevant when we will consider extensions of the theory proposed to phonological properties other than voicing. For voicing it suffices to assume that voicing nodes are either unspecified or specified as + ([+voice]), or - ([-voice]). When unspecified, they will be represented by no voicing node or by the empty node

[e]Vc. I use this notation in order to be able to refer to the +, -, and e (=unspecified) value of a node. I will follow standard models of underspecification in considering underlying representations unspecified with respect to properties that are predictable. In addition I will follow Seriade (1986) in distinguishing two types of what I will term *Specification rules*: Complement rules and Default rules. Given a class of segments C consisting of two subclasses C1, C2 contrasting with respect to the property F, Complement rules fill in the value [-α F] for C1, which is underlyingly unspecified for F, the contrasting (complement) class C2 being specified underlyingly [α F]. Default rules fill in the value [α G] for a class of segments that does not contrast with any other class with respect to F, and is consequently underlyingly unspecified for that feature. In the present case, obstruents contrasting in voicing can be divided in two classes. Once one class is specified, the voicing value of the complement class becomes predictable. Thus one class will be specified as [+voice], the complement class being unspecified for voicing. The corresponding Complement rule will have the form in (5a), and will specify unmarked, unspecified obstruents as [-voice]. The class of sonorants is always voiced, hence the voice value is predictable for the whole class, and filled in by a Default rule. All sonorants will be unspecified underlyingly for voice and the Default rule (5b) will specify them as [+voice].

- (5) a. (Obstruent) Complement
[-sonr] → [-voice]

- b. (Sonorant) Default
[+sonr] → [+voice]

Seriade argues convincingly that Complement and Default rules are universally related in the following way:

- (6) "If an intermediate representation contains default values of F, it contains complement values of F as well."

The form of Complement and Default rules, and the way in which they are related by (6) will be made more precise later.

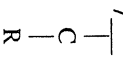
Returning to the two problems mentioned before, we can avoid the duplication problem in (4a) and (4b) by specifying the adequate context only for Deletion, and removing it from Spreading. This will allow us to restrict the number of parametric options of Spreading, which will have a very general form of the type *Spread X, X* a phonological node. This will lead however to a problem of overapplication; if the simplification of Spreading has to represent a real advantage, its application should be restricted to the cases of assimilation by general principles. I will deal with the overapplication problem directly.

The second inadequacy is corrected by reformulating Deletion to apply in the syllable rhyme; (4a) will then have the form in (7). In the case of final devoicing, resyllabification can make an onset of the devoiced sonorant, but at the specific point where devoicing takes place, word final implies syllable final. Throughout the paper I will use the term *syllable final*, not in the sense of *last segment in the*

3. The relation between neutralization and marking can be found already in Trubetzkoy (1958: 73 (section III 2 C)); contrary to the present analysis, however, he restricts unmarked elements to the *privative* oppositions (voicing, nasalization, rounding, etc., but not vowel height, place, etc.).

syllable, but rather as equivalent to *postnuclear*, or *coda*, i.e. as equivalent to last C(s) in the syllable.

- (7) a. **DELETION**
[+]vc → ∅
- b. **SPREADING**
Spread Voice



A consequence of formulating the rule in terms of syllable structure is that the regressive character of the kind of assimilation discussed so far needs not be stipulated, but is a consequence of the fact that syllable rhymes are more prone to phonological processes. This property can be stipulated, or can be incorporated in the formalism by different means; e.g. it can be proposed that syllables have the form $[\sigma \text{XlR YlR}]_{\sigma}$, which makes reference to onsets at least more complex than reference to whole syllables or rhymes. I will leave this question open.⁴ An important prediction is that syllable controlled voicing is incompatible with progressive assimilation. The fact that a superficial inspection reveals that this is not true, as witnessed by many cases, some of which will be discussed later, does not invalidate the theory. What is specifically predicted is that if a language with general regressive voicing effects shows at the same time progressive effects, there must be an independent mechanism that creates a spreading site, i.e. an unspecified segment, to the right of a possible trigger. Usually this mechanism shows independent effects in the language. Notice further that to formulate the rules in terms of syllable structure is not a question of possibility, but one of empirical necessity. Thus in Dutch /z/ devices not only in word final position, but also in internal syllable final position, like in *huif[s]raad* ('household goods'), and morpheme internally only [s] is possible syllable finally: *pri[s]ina*, *Ol[s]lo* (examples from van der Hulst (1985)). In Catalan obstruents assimilate also to sonorants, but just in case the former are syllable final. The contrast between [b] and [p] in $[\sigma \text{sém}][\sigma \text{blə}]$ ('it seems'), $[\sigma \text{tém}][\sigma \text{plə}]$ ('temple') affects an obstruent in the onset, in contrast to the same obstruent in the rhyme, with voicing contrast: $[\sigma \text{réb}][\sigma \text{blə}]$, $*[\sigma \text{rép}][\sigma \text{blə}]$ ('receives the'). I will deal with the overapplication problem later.

The effect of (7) can be illustrated with the forms in (8). These forms have underlying /b/ as shown by the related derivatives *Dut. krat[bl]er* ('to scratch'), and *Cat. dece[β]ador* ('deceptive') (in this last word [β] is derived from /b/ by lenition). Throughout I use boldface in representations to mark values supplied by Complement and Default rules.

4. We could dispense with the specification of the C slot in (7), and just have *Delete voice in rhyme*, if there were — as there should be — a principled way to explain the nonadjacent character of vowel assimilation (harmony), vs. the adjacent character of consonant assimilation. This would prevent reduction of the vowel. For the adjacency requirement in consonant assimilation (as opposed to vowel harmony), see some suggestions in Clements (1985: 241-244).

- (8) a. **DELETION**
- | | | | |
|---------------|-----------------------------|---------------|-----------------------------|
| [+] vc | [+] vc [-] vc | [+] vc | [+] vc [-] vc |
| kra/b/ | kra/b | perce/b/ | perce/b |
| 'scratch' | 'scrappings' | 'perceives' | 'perception' |
- b. **SPREADING, COMPLEMENT**
- | | | | |
|---------------|---------------|---------------|---------------|
| [+] vc | [+] vc | [+] vc | [+] vc |
| kra/b/ | kra/b | perce/b/ | perce/b |
| 'scratch' | 'scrappings' | 'perceives' | 'perception' |

Given the general formulation of Spreading just proposed, a problem of overapplication arises, as noted above. Assimilatory and reduction effects should be restricted therefore to the existing cases by general principles. The cases of illicit spreading that should be blocked are of two kinds: they involve illicit spreaders or illicit targets. Vowels and sonorant consonants are usually, though not always, illicit spreaders and illicit targets. In addition, consonants of any kind assimilate under strict adjacency: they are illicit *long distance* spreaders, i.e. they do not spread to other consonants across vowels.

Lexically, this follows from structure preservation, which limits spreading and deletion to obstruents, because vowels and sonorant consonants do not contrast lexically for voice. Notice however that structure preservation affects the structural change, but not the possible contexts of a process, which means that sonorants may be spreaders.

An interesting imitation of overapplication of voicing processes on vowels and sonorants at lexical and postlexical levels follows from the proper definition of Specification (Complement and Default) rules. I propose specifically the following definitions:

- (9) **SPECIFICATION RULES**
- a. **COMPLEMENT** rules are of the form $[e]N \rightarrow [-\alpha]N/P$, where N is some phonological node (such as Voice, Place, etc.), e an empty element, P some phonological context, and α is the marked, lexically specified value of N.
- b. **DEFAULT** rules are of the form $[X]N \rightarrow [\alpha]N/P$, where X is fixed and stands for any specification (+, -, e), and α is the predictable value of N in P.

By *fixed* in (9b) I mean that any individual Default rule must have the form $[X]N \rightarrow$, and cannot be $[+N \rightarrow, [-N \rightarrow, [e]N \rightarrow$ (the latter written as $[\] \rightarrow$ by some authors); therefore they apply regardless of the specification of N: they can be feature-filling, if the representation to which they apply has $[e]N$, or feature-chan-

ging, if it has [+N] or [-N]. Complement rules, on the contrary, are of the form [e]N → ..., i.e. they are only feature-filling: they only apply to representations having [e]N. For voicing, the Complement and Default rules will have the form of (10a) and (10b), respectively. They can reduce to a single Specification rule (10c), since their complement and default character is derivable. They will apply as Complement rules to segments presenting underlying voicing contrast and as Default rules to segments presenting no underlying voicing contrast. Or conversely, if we distinguish the two rules as (10 a,b), a general condition on underlying structures is automatically derived, that prohibits voice marking on sonorants, and allows the contrast for obstruents.

(10) SPECIFICATION

- a. [e]N → [-voice] / [-sonl]
- b. [X]N → [+voice] / [+sonl]
- c. [α son] → [α voice]

In the case of voicing of obstruents, (9) means that, voicing being marked only for voiced members in the class of obstruents, the value [-]vc will be filled in if and only if voicing is unspecified.

This definition of Complement affects its interaction with phonological rules in the following way. Underlying unspecified obstruents will turn to [-]vc except in the case that a phonological rule changes their value to [+]vc. Complement rules, filling in only unspecified values, will not be able to change an already specified segment (i.e. change [+]vc into [-]vc)—which would make no sense since it would imply an absolute neutralization of the contrast. Underlyingly specified [+]vc obstruents will remain so, unless phonological rules change their value to [e]vc (by Deletion), in which case Complement will be applicable and will derive [-]vc. A consequence of this interaction is that Steriade's principle (6) has to be interpreted in the sense that the first application of Complement precedes the first application of Default, but phonological processes can later give rise to representations with both (rule derived) unspecified complement value and specified default values.

Default rules work differently. They are just like standard phonological rules that specify a given value for a given feature, regardless of the input specification of that feature. Thus in the case of voicing and sonorants, they will change [e]vc to [+]vc, their *regular* use, but they will also change [-]vc into [+]vc. Of course at lower, more *phonetic* levels of representation it might be the case that Default (as well as Complement) do not apply anymore, and we might get effects like total or partial devoicing of sonorants. This seems to be the case for Russian (Hayes (1984), Kiparsky (1985)), which has occasional assimilation and final devoicing of sonorants in rapid speech.

Overapplication can now be dealt with satisfactorily. The bound character of assimilation, and the availability of targets follow from the form of Specification rules. Normally, in syllable controlled assimilation, regressive spreading seems to stop once the leftmost obstruent is reached. In fact, the whole rhyme is affected. Being controlled by syllabic structure, Reduction affects X in [σ W[RX]]σ TY[rZ]]

and the first onset to the left, W, cannot be reached. Default will then supersede the effect of Spreading, on sonorants. This should indeed be the case if we follow Pulleyblank (1986: 136-143) in assuming that default rules, once they begin applying, reapply at all stages afterwards. Default specifies hence sonorants in X as voiced, thus giving the correct surface effect. The onset elements to the right of the trigger T cannot be affected because they are not in rhyme position. Only under special conditions, when they are underlyingly unspecified and the Strict Cycle Condition (SCC) is circumvented, can we get *sporadic* assimilatory effects, to be dealt with in sections 4 and 6. I will return to some consequences of (9) later.⁵

Before turning to the examination of the clusters of effects predicted by this proposal, let us examine some of its advantages. From a formal point of view, it is clear that standard analyses positing rules like (1) allow for a vast range of phonological operations. To mention just a few, prefinal devoicing, voicing before coronals and devoicing before noncoronals, final voicing of obstruents, voicing assimilation of vowels to obstruents, would be perfectly natural phonological processes; it is impossible, however, to derive them by the deletion, deassociation and spreading operations of the RS framework. Also the interaction between rules allows for too many combinations. A striking property of many analyses of voicing is that Final Devoicing is always ordered before Voicing Assimilation. Since ordering is stipulated language particularly, the reverse ordering should be also possible. In other words, there could exist a language just like Dutch, but with assimilation feeding devoicing. The standard ordering predicts as one of the possibilities the actual Dutch forms *wooydles* → *woolydles* ('female' guardian), *wooyd/* → *woolxt* ('male' guardian), where the the finally devoiced /d/ causes assimilation of the preceding voiced /y/. But a standard analysis also predicts as possible the reverse ordering, which would yield *woofydes*, *woofyd/* → **woofyl*. Similarly, in Catalan we get *rel[β]en* ('they receive'), *rel[ps]* ('you receive') from underlying /bz/. The sibilant is underlyingly voiced because it appears voiced before clitics, a contrast position: [fɛ+z#u] ('do it!'). Here the reverse ordering would give *rel[β]en*, **rel[ps]*. And it would be expected that some Dutch or Catalan dialect, or some other language, of which there is no notice, would present such a distribution.

2. Clusters of Voicing Effects

So far I have claimed that surface voicing effects like *final devoicing*, and *voicing assimilation* are the result of two possible operations on the node Vc (Voice): Reduction and Spreading. The first parameter has three possible settings: Deletion of the Vc specification in the syllable rhyme, Deassociation of the CV specification in the syllable rhyme, and - (no operation). The possibility of nonsyllable-controlled Reduction will be considered later (section 4). The second parameter has just two possible settings, in addition to the node affected, here Voice: + (spreading) vs. - (no spreading). This limited set of possible operations in interaction with

5. I do not examine progressive, or majority progressive systems, hence the possibility of progressive effects through onset Reduction is left open. See Itó (1986) for a recent analysis of such a case.

phonological principles determines the distribution of voicing effects in natural languages. But the class of possible operations should not only be limited, it should also give the correct empirical predictions, in correspondence to what can be observed in particular languages. I will test the empirical adequacy of the theory proposed in two different directions. I will first determine the gross empirical effects predicted by the different combinations of parameters, and match them with general properties of voicing in different languages. Then I will investigate the interaction of voicing with other processes by examining in more detail the phonology of voicing in some languages. The same procedure will be followed when RS theory is extended to domains other than voicing.⁶

I have proposed for the voicing pattern of Dutch and Catalan the parametric combination Deletion + Spreading of Voice. (11) summarizes the possible combinations for the node Vc. We assume for the moment that Reduction applies to units in the syllable rhyme.

(11)	REDUCTION	SPREADING	Voicing effects
a.	Deletion	+	Final Devoicing, Regressive assimilation
b.	Deletion	-	Syllable rhyme devoicing
c.	Deassociation	+	Regressive assimilation
d.	Deassociation	-	No effect
e.	-	+	No effect/Limited assimilation
f.	-	-	No effect

In some cases combinations result in no effect; the last case is self-explanatory. In general, when Deassociation takes place and there is no Spreading, the deassociated, floating autosegment will reassociate by one of the general association conventions which I phrase here as in (12); so unless some other language-specific process interacts, reassociation will undo always the effects of Deassociation. This is the reason for having no effect in (11d).

- (12) REASSOCIATION
A floating node [X]_N reassociates to the first available N-bearing skeletal unit.

In (12), which is an extension of part of the tonal association conventions (e.g. van der Hulst & Smith (1985: 17), Pulleyblank (1986: 94-96, 114-116)), N-bearing should be understood in the sense of the association of [X]_N results in a permissible configuration. I will use the term *Reassociation* to refer to application of (12) to nodes delinked by Deassociation.

6. It might be worthwhile to mention, to avoid confusion, that the distinction between a *parametric* and a *rule* approach, if the aim of the latter is to reduce drastically the complexity of rules, might be purely terminological. It is also clear that the fact that we have not yet attained a stage where the phonology of any natural language has been reduced to a set of simple parameters does not entail that the approach is not a *parametric* one.

Let us first see the different effect of Deletion depending on whether there is Spreading or not. We already saw the case of Deletion followed by Spreading in the preceding section. Deletion removes [+]_{Vc} and the voicingless obstruents either get their voicing value from the following obstruent, or, if no obstruent follows, they get their [-]_{Vc} value by Complement. If no Spreading takes place after Deletion, i.e. if the value for Spreading is -, like in (11b), the voicingless obstruent will be unable to get a voicing value except by Complement. This means that there will not only word final devoicing, but also internal preconsonantal devoicing, i.e. general syllable final devoicing. This situation corresponds exactly to the German *Auslautverhärtung*:

- (13) a. run[d]e 'round-pl.' lö[z]en 'to loose' We[ɣ]e 'way-dat.'
 b. run[t] sing. lo[s] 'loose' We[k] nomin.
 c. Run[t]glang 'round' lö[s]bjar 'soluble' we[k]zjam 'translatable'
 d. Run[t]s'äule 'cylinder' lö[s]t 'looses' We[k]ʃpur 'trace'
 e. Run[t]lauf 'roundrun' Lö[s]lichkeit 'solubility' We[k]ʃa[r]beiter 'roadman'

In (13a) the obstruents *d, z, g, are* in the onset and are not affected for that reason by Deletion. In (13b-e) the obstruent is in the rhyme and it is affected by Deletion. A following voiced consonant (13c,e) has no effect on the syllable final obstruent. The effect of syllable structure is crucial, as witnessed by the position of the syllabic boundary (·) in pairs sharing the same root like *Run*. [dʊŋg ('sphericity') - *run*ft. ʔu]m ('around'). The derivation of the third example goes as follows. I omit the effects on the rhyme vowel; partial syllabic structure is indicated in (14a):

- (14) a. [+]_{Vc} [+]_{Vc} [+]_{Vc} [+]_{Vc} [+]_{Vc} [-]_{Vc} [-]_{Vc}
 | | | | | | |
 Wege Wege weg zann weg weg ʃ pur
 V V V V V V V
 R R R R R R R

b. DELETION

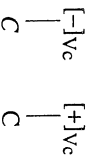
- | | | | | | |
 Weg weg zann weg weg ʃ pur
 V V V V V V V
 R R R R R R R

c. COMPLEMENT

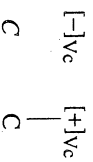
- | | | | | | |
 Weg weg zann weg weg ʃ pur
 V V V V V V V
 R R R R R R R

Let us examine now the case of Deassociation + Spreading. The need to distinguish between two different Reduction processes, Deletion and Deassociation, is justified by the existence of voicing effects that differ from the ones just discussed, in that they include assimilation but lack final devoicing. Deassociation allows Spreading to act, because it creates an empty skeletal element. In final position there is no possible trigger, and Reassociation returns the affected segment to the initial situation. Consider typical cases with obstruent cluster (15a) and final obstruent (15b), where C stands for a [-son] C, and syllable final Cs appear in italics:

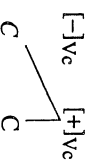
(15) a.



DEASSOCIATION



SPREADING



REASSOCIATION



b.



(16) Float Deletion

Floating autosegments that are unable to reassociate by the Association Conventions are deleted.

Full Interpretation is an empirical claim; we might equally well argue for *uninterpretation*, i.e. that, contrary to (16), floating elements are left in phonetic representation and uninterpreted, i.e. disregarded. Of course uninterpretation is not distinguishable from saying that the last operation before PF is the deletion of uninterpretable elements, which is however different from (16). Poser's (1982: 156) requirement that every segment be fully specified, because otherwise the state of some articulators would be left indeterminate, is correct, but this can be attained either by mechanisms like Float Deletion, which are consistent with Full Interpretation, or by *uninterpretation*.

In (15b) after Deassociation in final position, the floating [+ve] has an available slot, to which it reassociates. This voicing effects arise in languages like Serbo-Croatian (*k-* ('wh-'), *kaji* ('which'), *gde* ('where'); *boga* ('god' gen. sg.), *bog* ('god' nom. sg.), and also Spanish (see section 3).

The case of Spreading with no Reduction should result in no voicing effect, since spreading is dependent on previous reduction. In the case of unspecified segments, which would be possible targets of Spreading, the Strict Cycle Condition (SCC) will limit application to derived environments. There can be phonologically derived ones in the case of Reduction, and morphologically derived ones in the case of affixation. For Spreading to apply with no previous Reduction, two conditions must be satisfied. First, there must be an available target. The only possibility, if this target is phonologically underived, is that it is underlyingly unspecified for voice. Second, the SCC has to be eschewed, since the structure is not derived by Reduction, it must be morphologically derived. This will happen for instance if an affix with an unspecified obstruent is added to a root, the obstruent forming a cluster with a peripheral root consonant. I will illustrate briefly these effects with English progressive assimilation, which I will analyze in more detail below; similar effects arise in Dutch (see section 4).

Obstruent clusters not agreeing in voicing are possible in English (transcriptions are from Kenyon and Knott (1953)): *o[bsk]lure*, *a[bs]lurd*, *j[il]slaw m[il]stl*, *A[ɪ]zlec*; *d[ɪʃ]lestrɔs*, *Na[ɪ]ʃvɪlle*, *Ma[ɪ]k'vɪleəgh*, *Həlp[s]lurg*, *Ru[ɪ]t[ɛ]ers*, *A[ɪ]g[ɪ]nɪstɪn*, *s[ɪ]vɛljɪ*. In word final position however, the following well-known contrasts arise:

(17) a.	graze	[z]	grace	[s]	greys (verb)	[z]	grates	[s]
	glans	[z]	glance	[s]	fans	[z]	laps	[s]
	blaze	[z]	place	[s]	Jay's	[z]	Dick's	[s]
	grease	[z]	Greece	[s]	he's	[z]	hat's	[s]
	tide	[d]	tight	[t]	tied	[d]	typed	[t]
	fond	[d]	font	[t]	phoned	[d]	talked	[t]

Deassociation applies to the rhyme consonants in (15) leaving floating nodes; Spreading is applicable only in (15a). Notice that Spreading takes precedence over the association convention (12). This follows from the *Relinking condition* proposed by Pulleyblank (1986: 115), which states that segments delinked by rule at a given cycle are not subject to reassociation on that cycle.⁷ In (15a) the floating [-ve] has no available skeletal host and cannot associate. Following the principle of Full Interpretation mentioned in the introduction, I will assume that unassociated, floating elements are deleted according to (16):

7. This condition should be extended also to noncyclic rules. In general, Deassociation makes no sense if it is to be followed by automatic reassociation.

The third person, plural, genitive, contracted *is* and past/participle morphemes acquire the voicing specification of the preceding segment (17c, d), whereas [z] and [s] contrast, at least after sonorants (17a, b), when homomorphemic with the preceding segment. Assume that *s* and *d* are unspecified for voicing; when they are attached to the preceding word, Spreading will associate the voicing value of the preceding segment. The level at which these morphemes attach has to correspond to a stage at which all segments are specified for voicing. Since stages of application of RS will be introduced in next section, I will return to the discussion of English voicing effects below. Notice that while in syllable controlled Reduction the fact that the rhyme is affected determines its regressive character, here the progressive direction is dictated by the suffixal character of affixation.

3. Specification Stages

Up to now we have worked with representations that were specified with respect to voicing. Given that underlying forms will contain specified and unspecified consonants, the application of the different options in (11) might give different results depending on the point in the derivation at which they apply. Following Steriade's principle (6), representations with default values will also contain complement values. In addition, according to the form of Specification rules presented above (9), there will be three different phonological stages. At Stage 1, all segments will have the lexical specification, namely, sonorants and voiceless obstruents will be voice-unspecified, and voiced obstruents will be specified. At Stage 2 Complement will have applied, hence only sonorants will remain unspecified; obstruents will be either [+]vc or [-]vc. At the third stage Default and Complement will have applied, hence all segments will be specified, sonorants as [+]vc, obstruents either as [+]vc or as [-]vc. The fourth possible combination, all obstruents specified and sonorants unspecified, is excluded in principle by (6). We might consider also a Stage 4, at which rules of phonetic implementation apply, and where no Specification rules apply anymore (or, maybe, apply in a different fashion).

Complement and Default can reapply if the appropriate structures arise. We can have reapplication of Complement at stage 1, and of both Default and Complement at stage 2 and 3, usually via Reduction, but also as the result of other phonological or morphological processes.

There is independent evidence (see Pulleyblank (1986: 24, 103, 140-142) for tone) that languages vary as to the levels (lexical, postlexical, phonetic) at which the application of Specification rules takes place. I have not investigated the relationship between what here I call *stages* and the different lexical and postlexical levels. A clearer understanding of such relationship might further restrict the class of voicing effects. Notice however that in principle Stage 3 cannot overlap with a lexical level, since segments that do not contrast for a given feature (here sonorants and voicing) cannot be specified lexically for that feature. Notice also that at the phonetic Stage 4 Specification rules do not apply anymore, hence all segments can assimilate and deviate, although the form of such processes might be different at this stage.

The distinction of three different phonological stages explains another gross generalization that can be noticed in voicing phenomena, the trigger/target asym-

metry. Obstruents are always possible targets and triggers of assimilation and devoicing, like in Standard Dutch (Barendsen (1986), Zonneveld (1983)). In some systems sonorants can be triggers also, but only obstruents are targets, as is the case for Catalan (Mascarcó (1976)). Consider now the configurations, at different stages, of marked obstruents (O_m), unmarked obstruents (O_u), and sonorants (S), and the corresponding effect on their status as triggers and targets. (18) shows for each stage the predicted triggers and targets of RS, and the effect of reapplication of Default:

(18)	Stage 1	Stage 2	Stage 3
	[+]vc	[+]vc [-]vc	[+]vc [-]vc [+]vc
	↓	↓	↓
	$O_m O_u$ S	$O_m O_u$ S	$O_m O_u$ S
TRIGGERS	Voiced obstruents	Obstruents	All consonants
REDUCTION TARGETS		All segments	
SPREADING TARGETS		All segments	
EFFECT OF DEFAULT	(controlled by structure preservation and the SCC)		Revoicing of Sonorants
(RE)APPLICATION			

Only nodes which are present might spread, therefore triggers are the specified segments, for each stage. At the first stage only voiced obstruents, the only specified segments, will trigger assimilation. At Stage 2, Complement will have applied, so that all obstruents are specified, and all might spread. Now consider stage 3. Since all Specification rules have applied, all segments are specified with respect to voicing. Hence all of them can trigger Spreading. Targets of Reduction are all consonants, since, while only specified nodes can spread, Reduction might apply to specified and (vacuously) to unspecified nodes as well. Spreading does not specify the spreader; since only elements affected by Reduction can be targets, all consonants are possible spreading targets. But the effect of Spreading is affected differently at each stage by Default (re)application. The first application of Default will respecify any sonorant as [+]vc, thus undoing previous devoicing by assimilation. Even if at this stage all consonants can assimilate to all consonants, while any segment can be a trigger, only obstruents can be targets, because the effect on sonorant targets will be undone by (re)application of Default (recall that Default (9b), as opposed to Complement, can be feature-changing). This accounts for the trigger-target asymmetry.

As an illustration, consider the case of Dutch and Catalan. (19) shows that in Dutch RS takes place at a stage at which Complement has already applied, but Default not yet, as opposed to Catalan. Hence they differ in that in Catalan, but not in Dutch, sonorants are voice-specified, therefore triggers. Thus in (19a) the *n* in *huisnummer* is unspecified, which results in no assimilation, but devoicing by Default; in (19b) the *m* in *dos mil* is specified and triggers assimilation:

(19) a. $[+]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$

huiz huiz kammer huiz huiz huiz huiz
'house' 'living room' 'house number' 'house number'

a. $[-]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$

huiz huiz kammer huiz huiz huiz huiz
'house' 'living room' 'house number' 'house number'

b. $[+]\text{vc}$ $[-]\text{vc}$ $[+]\text{vc}$ $[-]\text{vc}$ $[+]\text{vc}$ $[+]\text{vc}$ $[+]\text{vc}$ $[+]\text{vc}$

doz doz temps doz doz deu doz doz mil
'two' 'two-stroke (engine)' 'two twenty' 'two thousand'

b. $[-]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$ $[-]\text{vc}$

doz doz temps doz doz deu doz doz mil
'two' 'two-stroke (engine)' 'two twenty' 'two thousand'

Let us now review the different effects of the parametric combinations of (11), depending on the stage(s) at which they are applied. These effects are summarized in (20):

(20)

	Stage 1	Stage 2	Stage 3
a. Deletion+ Spreading	OBSTR. TO OBSTR. ASSIM., FINAL DEV.	OBSTR. TO OBSTR. ASSIM., FINAL DEV.	OBSTR. TO CONS. ASSIM., FINAL DEV.
b. Deletion	σ FINAL DEV.	σ FINAL DEV.	σ FINAL DEV.
c. Deassociation + Spreading	$[+]\text{vc}$ OBSTR. ASSIM.	OBSTR. TO OBSTR. ASSIM.	OBSTR. TO CONS. ASSIM.
d. Spreading	LIMITED ASSIM.	(NO EFFECT)	(NO EFFECT)

Let us analyze first the cases of Deletion + Spreading (20a). At Stage 1 only voiced obstruents are specified. Deletion will delete the voicing autosegment in the rhyme, and Spreading will apply only when there is a trigger, i.e. a specified voiced obstruent in the onset. Clusters with a $[+]\text{vc}$ in the second member will undergo assimilation, resulting in a voiced cluster. If the second member is $[e]\text{vc}$, we will have either $[+]\text{vc}$ or $[e]\text{vc}$, which will turn to $[e]\text{vc}$ by Deletion, or $[e]\text{vc}$ by either case we get an homogeneous voiceless cluster. A regressive assimilation effect results. In word final position there will be deletion, therefore final devoicing will obtain. An example of such a system is (standard) Dutch. If the same situation arises at Stage 2, no difference will ensue; $[+]\text{vc}$ or $[-]\text{vc}$ in the rhyme will become $[e]\text{vc}$ and then Spreading will apply regressively from the following onset. At Stage 3, however, sonorants will be specified with respect to voice, being now potential triggers; as targets they will assimilate, but Default will undo assimilation, as said before. Therefore Spreading will take place from sonorants and obstruents onto obstruents. Word finally obstruents will devoice; sonorants are voice-deleted word finally, but Default will restore the original value, $[-]\text{vc}$. This corresponds to the voicing effects of most Catalan dialects. Notice that vowels will not be triggers usually, because the preceding possible target will, under normal conditions, be an

onset, hence not a Reduction target. But in word final position final obstruents are possible targets. Under special conditions of ordering of resyllabification and RS operations, we might get a situation in which a vowel is voice-specified and a word final obstruent is affected by Deletion. Some languages present this particular type of assimilation. Obstruents assimilate in voicing to vowels, but this assimilation is restricted to word final obstruents. All the examples I know of are languages presenting also final devoicing, and the obstruent to consonant type of assimilation, which, in the analysis developed in section 3, was attributed to Stage 3 application of RS. At this stage not only obstruents, but also sonorants are voice-specified, which allows spreading from sonorants on obstruents. Languages with this cluster of voicing effects are all Catalan dialects,⁸ Cracow-Poland Polish (Bethin (1984)), some Dutch dialects, like Limburg Dutch (Wezels (1981)), and Ecuadorian Spanish (Kimball (1979)).

In the case of Deletion with no Spreading, (20b), Stage 1 obstruents will be either unmarked ($[e]\text{vc}$) or marked ($[+]\text{vc}$). In both cases Deletion will yield an unmarked obstruent and, no Spreading taking place, it will result in a devoiced obstruent; sonorants will not show any voicing effect due to subsequent application of Default. The same happens in stages 2 and 3. This is the situation found in German, illustrated above in (13) and (14).

Deassociation + Spreading, (20c), determines a different effect in final position: whereas Deletion of voicing ends up, after Complement (12) results in reassociation in the case of Deassociation the application convention (12) results in reassociation of the floating Vc autosegment to the skeleton, hence no final devoicing. In the case of clusters, Spreading might apply: at Stage 1, where only $[+]\text{vc}$ values are present, we have the four possibilities shown in (21) with their corresponding derivations.

(21)

a.	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	
	X	X	X	X	X	X	X	
b.	DEASSOCIATION							
	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	
	X	X	X	X	X	X	X	
c.	SPREADING							
	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	
	X	X	X	X	X	X	X	
d.	REASSOCIATION, FLOAT DELETION							
	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	$[+]\text{vc}$	
	X	X	X	X	X	X	X	

8. In most dialects only fricatives present C to V assimilation, probably due to differences in syllabification between fricatives and stops.

Deassociation gives (21b) and Spreading (21c). Since only present (or, equivalently, nonempty) autosegments spread, only [+ve] will be able to spread. After reassociation by convention of the floating autosegment, and deletion of floating autosegments that are unable to reassociate, we get the structure (21d).

If we now compare (21d) to the initial structure (21a) we can see that we get only assimilation to the marked voicing value, i.e. [+voice] assimilation, but no devoicing assimilation. Notice that we cannot have just Spreading, since this would mean regressive voicing in some cases, and progressive voicing in others (e.g. *pd* → *bd*, but *bt* → **bd*). This in turn means that we need the empty voicing autosegment to be derived, by vacuous application of Reduction, to ensure circumventing the SCC and getting the correct regressive effect. This particular kind of voicing effect with only [+voice] assimilation is found in Ukrainian. The following examples show that obstruents are voiced before voiced obstruents, but voiced obstruents remain voiced before voiceless obstruents, and no final devoicing shows up:

- (22) a. kiz'bá 'mowing' (from the root *kis-*, and *-ba* 'action noun surf.')
- molod'bá 'reshing' (root *molot-*, and *-ba* 'action noun surf.')
- xóž by (xóč 'although' and by 'conditional mood') (ž = dž)
- b. berézka 'birch-diminutive' (*beréza* 'birch', *-ka* 'dim.')
- obkrásy 'to rob' (*ob-* 'verbal prefix', *krad-* 'rob')
- jízte 'eat-imp. pl.' (*jíz* 'eat-imp. sg.')
- c. čub 'tuft'
- xólod 'cold'
- v'iz 'cart'
- boson'iz 'barefoot'

Returning to (20c), at stages 2 and 3, on the other hand, obstruents will be all specified, which results evidently in regressive voicing and no devoicing. As in other cases, assimilated sonorants will turn to the voiced value by Default. Since at Stage 2 all obstruents are specified, and at Stage 3 all consonants are, the assimilation will be of obstruents to obstruents in the first case, and of obstruents to both obstruents and sonorants in the second case. Normally, but not always, vowels are unable to act as triggers, because syllabification will syllabify the potential target as an onset. An illustrative case is Spanish, which shows some dialectal variation of voicing effects; typically, within a dialect the results vary also. Navarro Tomás (1971: 86-145) describes Castilian as presenting (translation supplied) [*β*] which "in contact with a following voiceless articulation is not always pronounced completely voiced"; "before voiceless fricatives [*θ*] gets, in general, partially devoiced"; [*θ*] "in contact with a following voiced consonant becomes also voiced (...). Slow, strong or emphatic pronunciation prevents totally or partially this voicing"; similar descriptions for [*k*], [*x*], [*s*]. In word final position noncontrasting obstruents ([*f*], [*θ*], [*s*], [*β*], [*x*]) show up voiceless, whereas obstruents contrasting in voicing ([*β*]-[*t*], [*θ*]-[*t*], [*f*]-[*k*]), appear as a

partially devoiced continuant. This suggests a low level, stage 4, application of Reduction and Spreading. Notice that a stage 4 application will be a postlexical application. Since postlexically word boundaries are ignored we expect an absolute final or prepausal devoicing, which is in fact what we find: *liberal*[θ] *absoluta* – *absoluta* *liberal*[θ] ('absolute freedom').

In Porteoño Spanish, however, as reported by Lozano (1979: 43-45), there is no assimilation in a very formal, slow style (*Largo*), but in more normal styles (*Andante* and *Allegretto*) there is assimilation. In no case does devoicing appear word finally.

- (23) *Largo* *Andante, Allegretto*
- | | |
|---------------------|-----------|
| o[βx]eto 'object' | o[βx]eto |
| a[θx]unto 'adjunct' | a[θx]unto |
| a[ɣf]a 'Agra' | a[ɣf]a |

Largo, Andante, Allegretto

su[βm]arino 'submarine'
amliyó[ɰ]alas 'tonsils'
di[alɣn]ó[st]ico 'diagnosis'
clu[β]i 'club'
se[θ] 'thirst'
zi[ga]z[ɰ] 'zigzag'

This is clearly a case of Deassociation (no final devoicing effect) applying at Stage 3 or 4 (assimilation to all consonants, hence sonorants must be voice-specified).

Let us consider now the last case in (20d). Spreading with no Reduction will have no effect at stages 2 and 3, because obstruents will be all specified, hence not a possible target, and sonorants will be devoiced by Default. At Stage 1 however, there might be specified and unspecified obstruents. This implies that assimilation will be always from the unmarked value to the marked value, and that, in order to circumvent the SCC, the structure must be derived by some process other than Reduction, i.e. by affixation as is the case for English progressive voicing assimilation, to be discussed in more detail in the next section.

Notice also that the term *stage* might need some clarification. It might be the case that at some point in the derivation we have stage 2 or 3 radicals to which morphological processes affix morphemes directly from the lexicon. Being lexical, these morphemes will be *Stage 1 morphemes* and might undergo Spreading.

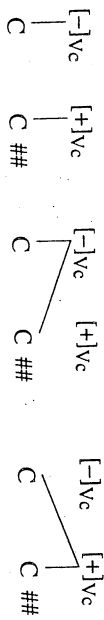
A final problem should be mentioned. Consider clusters in bisyllabic and in monosyllabic domains, i.e. ...C]_σl_σC... and ...C]_σg##, respectively. In Reduction + Spreading languages we get assimilation in the first case, and in the second case, i.e. word-finally, we have devoicing if the Reduction parameter takes the Deletion value. When two or more consonants are found word finally, the Deletion value predicts, correctly, devoicing of the whole cluster, which is not different from the standard *last C devices, preceding Cs assimilate to it* analysis. But consider the same situation in the case of Deassociation:

- (24) a. [-]vc [+]vc
 | |
 C C ##

b. DEASSOCIATION
 [-]vc [+]vc

- C C ##

c. SPREADING / REASSOCIATION BY CONVENTION



After Deassociation, which affects both consonants in the rhyme, we get two floating autosegments in (24b). Depending on the form and the ordering between Spreading and Reassociation we will obtain one of the three different results in (24c). So far I have no evidence bearing on the choice, but in section 5, where I will discuss extensions of the theory to place of articulation, I will show that the correct choice is the third one in (24c).

I now turn to a more detailed examination of some particular cases.

4. Voicing in Polish, Russian, and English

We can illustrate some of the voicing effects typical of Slavic with Polish, following the analyses of Rubach (1984), Bethin (1984), and Booij and Rubach (1987). In Warsaw Polish there is regular regressive voicing of obstruents to obstruents, both word internally (25a), and across words (25b), and final devoicing of obstruents before sonorants internally (25c) but across words (25d) there is regular devoicing re sonorants internally (25d) but across words (25e) there is regular devoicing. Examples are from Rubach (1984: 206-208) and Booij and Rubach (1987: 13, 18-20).

- (25) a. *szufla*[d] + a 'drawer'
Arab[b] + a 'Arab-gen.'
lic[ʧ] + ę 'count'
proś[ʃ] + ić 'ask'
- b. *chle*[p] + bly 'bread loaves'
zakaz[z] + bly 'prohibitions'
sa[d] + bly 'orchards'
- c. *gta*[z] + bly 'stones'
sa[d] + bly 'orchards'
bu[ʒ] + a 'storm'
- z*ufla[t+k+a] 'drawer dim.'
ara[p+sk'+i] 'Arabic'
li[ʃ] + ba 'number'
pro[ʒ] + ba 'request'
- chle*[p] + j + szenny 'wheat bread'
zaka[s] + p + stoju 'no parking'
sa[d] + vj + sznowy 'cherry tree orchard'
- gta*[s] 'stone'
sa[t] 'orchard'
bu[ʃ] + a 'storm gen. pl.'

- (25) d. *wta*[d+n] + y 'entitled'
mo[z+] + j + w + y 'possible'
tra[f+n] + y 'well-aimed'
- e. *sa* 'orchard'
sa[t] 'neighbor'
- wil*[g] + t + n + y 'moisture-adj.'
napa[st+] + j + w + y 'aggression-adj.'
spra[v+n] + y 'efficient'
- sa*[t] 'fruit tree orchard'
sa[t] + radzi 'neighbor advises'

To account for these data, standard analyses like the ones cited above posit two voicing rules, a regressive voicing assimilation rule, and the standard rule of Final Devoicing. Within the RS framework, we will have Deletion, since there is final devoicing (25c). Deletion and Spreading will apply at a stage where default values for sonorants are not yet present, hence Stage 1 or Stage 2, to prevent sonorants from triggering assimilation (25d). The derivation of some of the examples *szufla*/d/+a, *szufla*/d/+k+a, *pro*/s/ić, *pro*/š/b/a, *sa*/d/y, and *sa*/d/, is shown in (26):

- (26) a. INITIAL STRUCTURE
- $$\begin{array}{ccccccc}
 [+]vc & & [+]vc & [-]vc & [-]vc & [+]vc & [+]vc & [+]vc \\
 | & & | & | & | & | & | & | \\
 szufla/d/+a & szufla/d & + & k/+a & pro/š/ić & pro/š & b/a & sa/d/y & sa/d/
 \end{array}$$
- b. DELETION
- $$\begin{array}{ccccccc}
 [+]vc & & [-]vc & [-]vc & [+]vc & [+]vc & [+]vc \\
 | & & | & | & | & | & | \\
 szuflad/+a & szuflat & + & k/+a & prošić & prož & ba & sady & sad
 \end{array}$$
- c. SPREADING, COMPLEMENT
- $$\begin{array}{ccccccc}
 [+]vc & & [-]vc & & [-]vc & & [+]vc & & [+]vc & & [+]vc \\
 | & & | & & | & & | & & | & & | \\
 szufla[d] + a & szufla[t & + & k] + a & pro[š]ić & pro[ž] & b]a & sa[d]y & sa[t]
 \end{array}$$

If we consider Polish to be like Dutch, i.e. if we assume, as in Bethin (1984), that it is rhyme controlled, we would get (26b) by deletion of syllable final obstruents, which does not affect the onset consonants in *szuflada* and *sady*. Then Spreading applies deriving (26c) by spreading of the following autosegment, except in the last example where the voicing value is gotten by the universal Complement rule (5a) that specifies unmarked obstruents as [-voice].

But consider now the obstruent-sonorant clusters in (25d), with no assimilation, and compare them with parallel cases in Dutch. Dutch, as discussed in the previous sections, has a system similar to Polish in that it has obstruent to obstruent assimilation, but it differs from Polish because obstruents before sonorants undergo devoicing. The following Polish data (27a) are taken from (25d). The Dutch data contain stem final obstruents followed by the diminutive suffix *-je* and verb-clitic sequences; see Berendsen (1986: 45-74), from where the data are drawn, for extensive justification of the syllable final character of the position of the devoicing obstruents.

(27) Polish

a. w[ɛ]l(d+ɲ)+y 'entitled' w[il]gɔ(l+ɲ)+y 'moisture-adj.'
 mɔl(z+ɺ)w+ɣ 'possible' nap[ɔ]st+ɺ|w+ɣ 'aggression-adj.'
 tɔl f+ɲ)+y 'well-aimed' spr[ɔ]v+ɲ)+y 'efficient'

Dutch

b. proe[f]jɛ 'little experiment' proe[v]ɛn 'to taste'
 plɔt[f]jɛ 'little explosion' plɔt[f]ɛn 'to explode'
 wɛl[p]jɛ 'little cobweb' wɛl[p]ɛn 'to web'
 stɛp[j]ɛ 'little step' stɛp[j]ɛn 'to step'

c. wɛlkɛ proe[f]l-wɛ doɛn 'what experiment we do'
 ik proe[f]l-mɛn drɔnkjɛ 'I taste my drink'
 hɨj gɔt f-mɛ ɛɛn boɛk 'he gave me a book'
 wɛlk wɛl[p]-wɛ zjɛn 'which cobweb we see'
 (cf. wɛlk wɛl[p]-jɛ hɛɛft gɛzjɛn 'which cobweb he has seen', etc.)

In (27a) the voicing distinction is preserved before sonorants, whereas in (27b,c) it is neutralized. This difference between Dutch and Polish has not to be stipulated. Dutch, like Catalan (see section 1, and also (20), and corresponding discussion), is a rhyme controlled language for voicing, hence in syllable final position Deletion will trigger Complement whenever no available trigger might cause Spreading. Because RS applies in Dutch at an early stage, at which sonorants are not specified for voice, syllable final presonorant obstruents will devolve, as illustrated above (27b,c). Let us now follow our initial assumption, namely that Polish voicing effects are rhyme controlled. Being a final devoicing language, the Reduction value must be Deletion, hence we should get syllable final devoicing before sonorants, since sonorants are not triggers. This would be in contradiction with the data in (27a). But if Polish voicing is not rhyme controlled, assimilation takes place across a sequence of obstruents, which assimilate to the last obstruent in the sequence. This last obstruent does not get its voice deleted, and thus preserves the underlying voice value.

It appears to be the case that in Slavic in general voicing assimilation is not rhyme controlled, but takes place across a sequence of consonants of which the last member is the trigger⁹. Cases of assimilation in word initial position, hence onset position necessarily, are perhaps the best proof of inexistence of rhyme control. This is the case of Russian *k+akóĵi* ('which') *g+de* ('where'), Polish *v domu* ('in the house') *f skole* ('in the school'). Also in Polish we get (f. Rubach, personal communication) *tward+ɣ* ('hard') [d], *tward+sz+ɣ* ('harder') [ʃ] (sz = ʃ), syllabified as *twardzy*.

The conclusion seems to be that languages can vary as to whether Reduction is or is not rhyme controlled. In rhyme controlled Reduction, as in Dutch, we get syllable final assimilation before obstruents (/krabsel/ — [krapsɛl]) and syllable

final devoicing word finally (/krab/ — [krɔp]). When there is no rhyme control we should get Deletion operating only on obstruents before other obstruents. Hence the *d* in *wɛl(d+ɲ)+ɣ* and the *r* in *w[il]gɔ(l+ɲ)+ɣ* (27a) are not affected because they are not followed, as the *d* in *szufladka* (25a), by another obstruent.

We thus derive from different combinations of + rhyme control, and stage 2 (or 1) vs. stage 3 application, the three different effects that obtain in obstruent-sonorant sequences: Neutralization by devoicing in Dutch (*wɛl[p]jɛ* → *wɛl[j]jɛ*, *stɛ[p]jɛ* → *stɛ[j]jɛ*), neutralization by assimilation in Catalan (*tɨl/s m]ɛ* → *tɨl/z m]ɛ* ('cough on me'), *kɨl/z m]ɛ* → *kɨl/z m]ɛ* ('sew for me')), no change in Polish (*wɛl(d+ɲ)+ɣ*, *w[il]gɔ(l+ɲ)+ɣ* -unchanged).

We should now determine more precisely the mechanisms that account for assimilatory effects which are not rhyme controlled. Focusing on assimilatory effects, we saw that, in a sequence of obstruents, all assimilate to the last obstruents in the sequence. Since, contrary to the case of rhyme controlled systems, onsets also assimilate, we might describe the process as a Reduction of the whole rhyme and a reduction of all but the last onset obstruent. (28) gives the form of rhyme controlled Reduction and non-rhyme controlled Reduction; (28a, b) shows their respective effects on consonantal clusters in a case of Deletion; the triggers appears in boldface¹⁰.

(28) a. Rhyme controlled Reduction

Reduce (delete / deassociate) rhyme consonants.

b. Non-rhyme controlled Reduction

Reduce (delete / deassociate) rhyme consonants and all but last onset consonants.



For assimilation this means that we have two possible triggers (C_T): first onset consonant, in the case of rhyme controlled Reduction (28a), or last onset consonant, in the case of non-rhyme controlled Reduction (28b). In the latter case this takes care of any initial or medial sequence; for initial sequences the onset undergoes assimilation to its last member, in medial sequences all the rhyme and all but the last member of the onset assimilate to this onset final element.

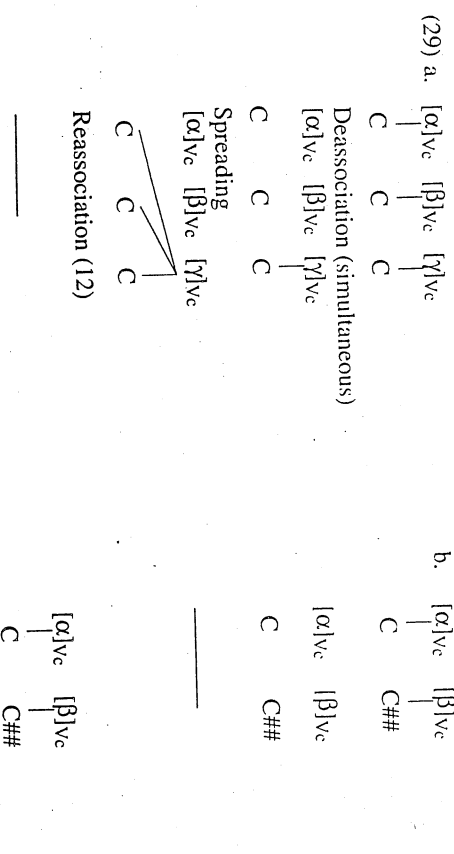
Consider now the case of final sequences. In word final position all the elements are in the rhyme, hence all are affected by Reduction. If Reduction parameter takes the Deletion value, we get final devoicing. Thus both options (28a,b) have the same effect in final position.

9. This last member of the sequence is normally an obstruent, as in Warsaw Polish or Russian, but it can be, for Stage 3 RS varieties like Cracow-Poznań Polish (Behn (1984)), a sonorant consonant.

10. A possible line of investigation would be to try to derive the Slavic cases by imposing no syllabic conditioning whatsoever on Reduction. Iterative application would then proceed from left to right till the last C in the sequence, where it would be stopped by the SCC, since it would end up in absolute neutralization. I have been unable to make such an analysis work out properly.

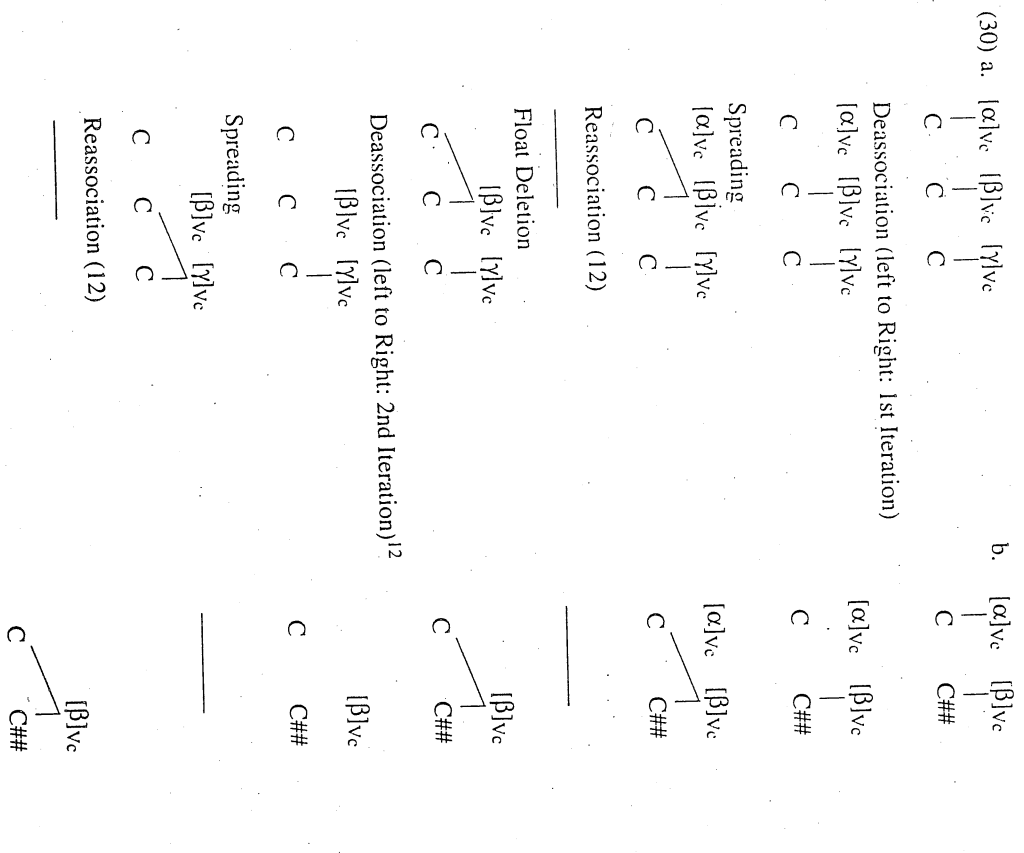
Another question that should be addressed now is how Reduction and Spreading rules are applied. In the case of the universal Association Conventions, there is little doubt that they apply iteratively, from left to right. For Deletion and Spreading there is little evidence as to whether they apply simultaneously to any element that meets the appropriate conditions, or they apply in another fashion. I have no evidence in this respect in the case of Spreading, but I will propose, for empirical reasons that will be presented later, that the mode of application of Reduction is universally determined: they apply, just like the Association Conventions, iteratively from left to right. The situation where simultaneous vs. left to right applications makes a difference is the one that obtains when we have Deassociation and Spreading in final position.

Before proceeding, let us review the operations so far discussed, and their ordering relations. The operations are universal principles, like the Association Conventions, and Float Deletion. The language particular operations are Reduction and Spreading. As far as I can see, there is no need of ordering extrinsically Reduction and Spreading, although there will be an intrinsic order, because Reduction creates targets for Spreading. As we saw in Section 2, a deassociation rule blocks immediate application of the Association Conventions, since otherwise the deassociated autosegment would reassociate, and the application would never have any effect. In any case it must precede Spreading. For similar reasons Float Deletion must also precede the Association Conventions: otherwise in word final position we would get incorrect devoicing, since Deassociation + Float Deletion is equivalent to Deletion. ¹¹ Now consider a case like the one examined above in (15), i.e. a Deassociation + Spreading combination, but with longer sequences of obstruents: (29a) shows a sequence of medial obstruents, and (29b) a sequence of word final obstruents:



11. An interesting possibility would be to have no Reduction at all, but just a +/- Deassociation parameter, and get deletion effects from the combination of Deassociation and immediate Float Deletion. Although at present this solution seems not to work technically, I think it is worth considering.

Deassociation applies to all rhyme obstruents and to all but the last onset obstruent. In (29a) this onset obstruent can spread its voicing on the preceding obstruents. In (29b) both obstruents get their voicing value deassociated, and the Association Conventions reassociate them from left to right. If instead of simultaneous Deassociation we have left to right Deassociation, and Spreading can apply whenever a target is available, we get the following derivation:



12. Notice that what Reduction (28a,b) does is to affect the autosegment, by deleting it, or deassociating it (from any association); hence here in the second iteration two association lines are erased.

Further iterations are not possible, since in the first example the last C must be a trigger, and in the second example we have already exhausted the sequence. The result is the same in (29) and in (30) for internal assimilatory effects. In the case of word final effects we predict no assimilation within the sequence in (29), but assimilation to the last member of the sequence, if Reductions is applied from left to right (30). I will present a case in section 5 that supports empirically the second solution.

So far I have restricted the Reduction to a binary option: first onset C = trigger, and last onset C = trigger. More assimilatory systems should be studied to determine how much more variation is possible. This system excludes, correctly I would say, voicing effects like *assimilate all Cs to the third C in the sequence*, but it is also probably true that there is more than just the binary option suggested. Other systems should be studied carefully, because surface violations of the present proposal do not constitute direct counterexamples. There are many exceptions that follow from different principles. An example is English progressive assimilation. Consider the position of the trigger, which appears in boldface in the following examples: *nations* [nɪz], *triumphed* [mɪfɪ], *boiled* [bɔɪd], *belts* [bɛlts]; *thanked's* [θæŋkɪz], *hanged's* [hæŋdɪz], *midst's* [mɪdɪstɪz]. Here Spreading is restricted by the SCC and the morphological structure of English to apply to obstruent suffixes, which means that the selection of the trigger is not dictated by the phonological properties of the sequence itself, but by morphological structure. The trigger is the morpheme final element of a root to which suffixes are attached at a particular morphological level: [nɪz], [mɪfɪ], [bɔɪd], [bɛlts]; [θæŋkɪz], [hæŋdɪz], [mɪdɪstɪz]. I will return to the English case below.

After having incorporated into the theory the difference between rhyme Reduction languages and non-rhyme Reduction languages, I turn to the examination of cases of transparency and of progressive assimilation.

The phonology of Russian voicing has been examined most recently within an autosegmental/metrical framework by Halle and Vergnaud (1981), Hayes (1984) and Kiparsky (1985). Although I will adopt basically Kiparsky's analysis, with only minimal changes, the differences that are dictated by the RS theory are worth of comment. Let us review the facts reported by Kiparsky (1985), which cover all those in the other references with some additions. There is word final devoicing of obstruents (31a), and regressive assimilation of obstruents: assimilation takes place in a sequence of consonants assimilating its obstruents to the rightmost obstruent. Sonorant consonants (in italics in the illustrative examples in (31)) do not trigger nor undergo assimilation but are transparent to the propagation of voicing to obstruents. Final Devoicing feeds assimilation.

- (31) a. sal'dja 'garden'-gen.sg. sal[t] nom.sg.
 klup'ba 'club'-gen.sg. klup[b] nom.sg.
- b. mɛnɛn[sk] 'Mcensk'
 o/ɪ 'from'
 bɛ/z/ 'without'
- mɛnɛn[ʒg b]y 'if Mcensk'
 o[t]oʒɛra 'from a lake'
 bɛf[z]oʒɛra 'without a lake'
 o[ld mɪz]dɪ 'from the recompense'
 bɛl's mɛnɛn'skɪ 'without Mcensk' (c = f)

The labial fricative *v* acts like an obstruent as an undergoer, since it assimilates and word finally it devoices (32a). But, following the pattern of sonorants, it does not trigger assimilation, as shown in (32b). As would be expected, when it is in medial position in a cluster, it both undergoes assimilation and allows it to propagate backwards (32c).

- (32) a. koro[f k]a 'little cow' (from koro/v/ka)
 zɔro[f] 'healthy' (from zoro/v/)
- b. ja[ʒf] 'wound'
 o[t v]as 'from you'
- c. o[ld v]dɔvɔy 'from a widow'
 bɛl'sf]oʒɛrɔj 'without the second'

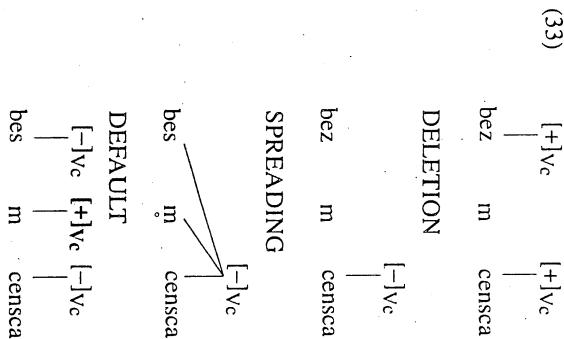
Notice in particular that in the first example in (32b), it acts at the same time as an obstruent devoicing, and like a sonorant not triggering the assimilation of the preceding *z*.

To these more regular cases, a set of optional changes should be added. Sonorants may appear voiceless in some environments; the sequence obstruent-w can sometimes surface with a voiceless obstruent when a voiced one would be expected (*ʃal'sf]*, instead of *ʃal'z]*, cf. (32b)). Obstruent to obstruent assimilation can be only partial, and in cases of sonorant transparency an obstruent might assimilate to a following sonorant, instead of skipping it and assimilating to the following obstruent (*f]z mɛnɛn'skɪ* instead of *f]s mɛnɛn'skɪ*).

Hayes' (1984) important contribution to the analysis of Russian voicing assimilation, which is incorporated in Kiparsky's analysis, is to explain the transparency of sonorants with respect to voicing propagation by assuming that obstruents do undergo voicing assimilation. The reason why they do not show assimilation is that the phonetic interpretation of the feature voice in terms of vocal cord vibration is different in obstruents and sonorants: it corresponds to an articulatory state which produces voicing in obstruents even if they are [-voice]; this would explain that they show up with vocal cord vibration. Kiparsky (1985) simplifies considerably Hayes' system by introducing the principles of lexical phonology, which allow for the elimination of some of the language-particular stipulations.

The analysis of Russian that is dictated by the RS framework gives a phonological, rather than a phonetic explanation to the transparency of sonorants in Russian. If we assume that assimilation in this language applies to all but the last C in a sequence of Cs, we may let Deletion apply at Stage 2: since at this stage sonorants are voice-unspecified, they cannot act as triggers, but nothing, except for a language-particular extra limitation of Spreading to obstruents, will prevent them to be undergoers. The voicing specification of the last obstruent in the sequence will thus spread on preceding obstruents and sonorants. Hence sonorants cannot block the propagation of spreading. Now recall that the general form given to the rule of Spreading (*Spread X, X a phonological node, rule (7b) for voicing*) lead to a problem of overapplication. Overapplication was solved at the end of section 2 by Default rules which undo illicit marking of sonorants as [-voice], by respecting

them as [+voice]. The interaction of general spreading on both obstruents and sonorants with sonorant revoicing by Default rules determines automatically the voicing discontinuity effect. For *bel[sm]c[ɛ]nska* in (31b) above we will have the following derivation:



Notice that Default, a general principle, can undo a sequence linked to a single autosegment, thus violating an OCP effect (Hayes' (1986: 471-473) *Intalatability*). It should be noted also that the transparency effect necessitates application of Spreading before Stage 3: otherwise specified sonorants will block it. In languages in which voicing is rhyme controlled, the transparency effect is more difficult to obtain, due to the fact that the sequence of targets is restricted to the rhyme, and syllable rhymes do not contain sequences of obstruent + sonorant, the sonorant consonant being normally syllabified in such sequences as an onset. In the case of Russian the sonorant transparency is due to the availability of complex consonantal clusters, to the fact that the subsequence affected by Reduction can be longer (rhyme + all but last onset obstruent), and to early application of Spreading.

Although it might well be true that, following Hayes' proposal, [-voice] is interpreted phonetically as an articulatory state that for sonorants yields vocal cord vibration, this would mean that [+son, -voice] and [-son, -voice] are both voiced but phonetically distinct. Hence [m] and [m̥] in *old mzdly* and *bel's m̥c[ɛ]nska* should be phonetically distinct. Notice also that languages with clear sonorant or vowel devoicing pose a problem for rules interpreting [-voice] sonorant and vowels as voiced, although it might be argued that in such cases the feature involved is not [-voice], but [+spread glottis]. But the phonological *revoicing* that

derives from the RS framework is necessary for independent reasons. Notice that under the phonetic analysis the fact that sonorants do not show (normally) surface devoicing is adequately covered by the phonetic interpretation of [voice], but the fact that sonorants are not triggers has to be dealt with in an ad hoc fashion. There is no major problem with final devoicing, which can be formulated as affecting all consonants, devoiced sonorants being interpreted as having glottal vibration. But in the case of assimilation, while undergoers can be all consonants, the fact that triggers have to be limited to the class of obstruents must be stipulated. Although this could possibly be the correct analysis for Russian, an analysis allowing this stipulation does not rule out a language with the reverse stipulation: a language in which triggers were only sonorants, hence with assimilatory effects like [zm], *[sm], [zb], [sb], etc. As was noted at beginning of section 3, it appears that languages present the obstruent-sonorant asymmetry only in one direction: there is assimilation of obstruent to obstruent (Russian, (Warsaw) Polish, Dutch) and assimilation of obstruent to obstruent and to sonorant (Catalan, Spanish, (Cracow-Poznań) Polish), but not just obstruent to sonorant alone, or obstruent to vowel alone. In the present framework, if sonorants are triggers, voicing processes must take place at Stage 3, at which obstruents will always be specified for voice (see (18)); hence obstruents must also be triggers. Default respecifies sonorants as [+ve, therefore they are never surface phonological undergoers. Later *phonetic* rules can modify sonorants causing changes in the extension and quality of voicing (interpreted along the lines suggested by Hayes), and other changes. A different argument in favor of the interpretation of Default rules as superseding specified values will be presented in the next section ((45), (46), and corresponding discussion).

Another reason for having phonological revoicing of sonorants by Default has to do with the optional assimilatory effects mentioned before. Kiparsky sets up a rule of phonetic implementation with language-particular conditions, formulated as (34a), which revoices sonorants that have been devoiced by assimilation: *l[zm]c[ɛ]nska* instead of *l[sm]c[ɛ]nska* and *jal[sf]* instead of *jal[zf]*, cf. (32b). Instead, the RS framework requires that the universal Default rule revoice all sonorants at Stages 1 and 2 at least, which means that phonetic implementation rules must be formulated, not as revoicing, but as devoicing rules applying in the complementary environment (34b).

(34) a. *Sonorant Revoicing*
 [+son] → [+voice] Optional in fast speech for liquids under certain conditions, such as next to a voiceless segment. Obligatory elsewhere.

b. *Sonorant Devoicing*
 [+son] → [-voice] Optional in fast speech for liquids under certain conditions, such as next to a voiceless segment.

(34b) needs not stipulate the obligatory condition of (34a). In addition, similar detail phonetic rules like partial obstruent to obstruent assimilation, could be treated as the same process as (34b), maybe a case of Stage 4 Reduction and Spreading. Notice that this correctly predicts that final obstruent devoicing will not show

partial devoicing effects.¹³ Stage 4 Spreading might voice or devoice partially, but word finally an obstruent, once devoiced at stages 1, 2, or 3, cannot recover its underlying voicing (see footnote 1).

I turn now to the English voicing assimilation discussed at the end of section 2. I repeat here the examples in (17) as (35):

(35) (= (17))

a.	graze	[z]	grace	[s]	greys (verb)	[z]	grates	[s]
	glans	[z]	glance	[s]	fans	[z]	laps	[s]
	blaze	[z]	place	[s]	Jay's	[z]	Dick's	[s]
	grease	[z]	Greece	[s]	he's	[z]	that's	[s]
	tide	[d]	tight	[t]	tied	[d]	typed	[t]
	fond	[d]	font	[t]	phoned	[d]	talked	[t]

In English we can just assume that affixing in the case of third person, plural, genitive, past participle, and contracted auxiliaries takes place at a lexical stratum at which affixes are added from the lexicon. The Reduction parameter takes the negative value, as shown by nonhomogeneous clusters like *obskljur*, and other examples cited at the end of section 2: only Spreading takes place. Spreading, as has been argued before, needs two conditions to apply. First, there must be a site, i.e. a C with empty voice node. Since the suffixal consonant is voice-unspecified, the first condition is met. Second, Spreading must not fall under the SCC; that is, the structure must be derived. Since it cannot be rule-derived, because there is no Reduction, it should be morphologically derived, which is the case, because affixing creates a derived structure. Notice that the combination of a voice-specified sonorant and a voice-unspecified obstruent is unusual, since Complement applies before Default (see (6)). The only possibility is that the root be at Stage 3, but the affix at stage 1, which is true under our assumption that these affixes are taken from the lexicon. For cases like *places*, *heated*, etc. we assume that vowel insertion precedes Spreading. We get thus the desired dependence of the voicing of the suffixal obstruent on the voicing of the preceding segment.

In earlier levels spreading is responsible for the limited regressive assimilatory effects that obtain in some varieties of English. This assimilation shows up in [wajd] – [witθ], [brɔd] – [brɛθ], [li:v] – [li:ft], [kli:v] – [kleft], [faiv] – [fiftθ], [twelv] – [twelfθ], [lu:z] – [lɔst]. Halle and Mohanan (1985: 105) propose a voicing assimilation rule that devoices an obstruent adjacent to another obstruent when both are in the same syllable. This rule should account for these cases, and also for the regular progressive cases in (35). The homogenous voicing of onset and rhyme clusters is general in English, although exceptions can be found ([sv]d, [mɪdʒt], etc.), as already noted in section 2. If the plural, past, etc. regular cases are accounted for by Spreading at stratum 4, as I propose, how are the regressive

cases to be dealt with? Notice that not all speakers have regressive assimilation in all cases (Kenyon and Knott (1953, s.v.), Jones and Gimson (1986, s.v.), Hayes (1986: 476), while progressive voicing is general. For those that do not have regressive voicing the unassimilated obstruent corresponds normally to an orthographically voiced element: [widθ], [brɛθ]. In some cases (*love-lost*, *five-fifty*) the assimilated voiceless obstruent shows up also in nonassimilatory environments: *loss*, *five* (syllabified as *fi:vi*), suggesting an allomorphic analysis. In varieties in which the regressive effect is justified, we can have Deassociation at stratum 1, which will interact with Spreading to assimilate all the Cs in a sequence to the last C in the sequence. Spreading alone will be active at stratum 4, and will induce the regular voicing effects.

Consider now irregular inflection. There is no need to set up different allomorphs for the past, except in extremely irregular cases. Irregular inflection takes place at stratum 1, and the past morpheme is unspecified for voicing. Since sonorants are not specified for voicing at this level, Spreading will not apply, and we will get the voiceless value by Complement. This is consistent with the results of the analysis of English segmental phonology in Halle and Mohanan (1985). For totally independent reasons they conclude that irregular inflection takes place at stratum 1, whereas regular inflection is added at stratum 4. This accounts for the past or participle verb forms *fell*, *spell*, *built*, *smell*, *knelt*, *burnt*, *dealt*, *meant*, *sawt*, *spent*, *burnt*, *dreamt*, *girt*, *besought*, *bought*, *caught*, and some others. The differences like *learned/learnt* are not due therefore to the phonological form of the suffix itself, but to the stratum at which inflection takes place. After voiceless (hence unspecified) obstruents we get the final voiceless consonant by Complement: *wept*, *slept*, etc.

The plurals like *lif*[f] – *lif*[vz], *clɔ*[θ] ('piece of cloth') – *clɔ*[θz], *hɔul*[s] – *hɔul*[zɪz] could be treated as a case of regressive voicing at stratum 1 if, contrary to the present analysis, the plural suffix is underlyingly voiced. Notice however that what seems irregular in these cases is the singular, rather than the plural. Related derivatives show the voiced obstruent: *lif*[v] (adj.), *lif*[v]y; *clɔ*[θ]ing, *hɔul*[z] (verb). This explains the fact that there is while there is no difference between *lads* and *lads*'s, or between *laps* and *laps*'s, there is a difference in the case of *lives* [vz] and *life*'s [fs], *clothes* [θz] and *cloth*'s [θs].

In the case of the contracted auxiliaries 's, and 'd, the forms are related to the full forms [ɪz] and [wɜ:ɪd], [hæd], which contain themselves the voice-unmarked suffixes attached to the allomorphic forms of the verbal root of *be*, *will*, and *have*, /i/, /wɜ:ɪ/, and /hæ/, respectively. Compare now the past suffix with the contracted negative *n't*. When attached to the verb, the SCC allows Spreading in the case of *t+s*, *rob+s*, because it affects two segments brought together by virtue of suffixation. Consider now *isn't*, [ɪzn̩t]. The voiced [z] can have no effect on the also voiced [n], but why isn't there progressive voicing from the [n] to the [t], like in *listened* [lɪsɪnd], or of the [z] on the whole sequence [ɪzn̩t]? In the first case we have the independent morpheme *n't*. The SCC prevents voice from spreading within any lexical, undervived element: voicing cannot spread from the [n] on the [t] for the same reason that it cannot spread in, say, *ant*, or *entry*. On the other hand, *n't* is added at a later stratum than the suffixes that undergo progressive voicing: this is consistent with the fact that *n't* always appears after them:

13. See however Slowiaczek and Dinnsen (1985), for Polish.

$ha+s+n$, $doe+s+n$; $ha+d+n$, $wol+d+n$. From this follows that at least Complement has applied to n , which makes Spreading on the voice-specified r of n impossible.

The fact that the spreading mechanism that is in part responsible for assimilatory effects is reduced to the general form *Spread node X* has important consequences. One of these consequences is that a language with regressive assimilation for the property X must have the Spreading parameter positive for X . This means that if in this language the structural conditions that we find in English are also met, then a progressive voicing effect is automatically predicted. I will present two such cases. One will be discussed in section 6, and has to do with place assimilation. The second is based on work in progress on Dutch voicing effects. We have seen earlier, (section 1), the regressive voicing assimilation of standard Dutch. But Dutch has also cases of more restricted progressive assimilation. One of such cases is parallel to the past morpheme in English. The past tense suffix takes the form [tə] after verbal roots ending in a voiceless segment, and the form [də] if the verbal root ends in a voiced segment. The infinitive in (36a) has the root final consonant in onset position where it is not affected by assimilation, and shows its underlying voicing value; (36) shows the alternations of the past morpheme:

(36) a.	Inf.		b.	Past
	kruif[s]en 'to cross'			kruif[tə]
	schralf]en 'to hate'			schralf]tə]
	verziel[k]en 'to spoil'			verziel[k tə]
	la[x]en 'to laugh'			la[x tə]
	Inf.			Past
	huit[z]en 'to live'			huit[z də]
	el[b]en 'to ebb'			el[b də]
	le[y]en 'to empty'			le[y də]
	zoel[n]en 'to kiss'			zoel[n də]
	speel[j]en 'to play'			speel[j də]

As Berendsen (1986: 45-66) points out, there are two basic approaches in the literature. One positing an abstract /ð/ which never surfaces as such, but feeds an independent rule of progressive assimilation to [θ], and a more ad hoc rule that turns these fricatives to stops, [d] and [t] respectively. The other analysis is based on an underlying form /dɑ/ from which [tə] is derived by a rule of allomorphy when a voiceless segment precedes (see Berendsen (1986) and references cited there).

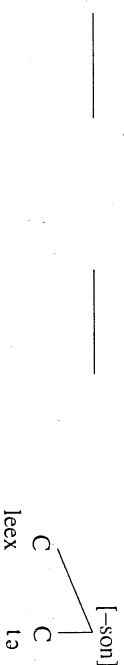
Both solutions seem inappropriate in the measure that they attribute idiosyncratic properties to the past suffix (underlying /ð/, or allomorphy). Imagine that, like in the case of English suffixes that undergo progressive voicing, the past tense suffix in Dutch begins in a voice-unspecified /T/, and that the suffix is taken from the lexicon and is attached to a root having undergone Complement and Default for voice. Compare *kruiste* ('crossed') and *leegde* ('emptied'), with past suffix /Tə/ (37a,b), with *leegte* ('emptiness'), with the derivative suffix /tə/:

(37) a.	[-son]	b.	[+son]	c.	[+son]	[-son]
	C C		C C		C C	C C
	kruis Ta		lee y Ta		lee y	le

SPREADING



DELETION, SPREADING



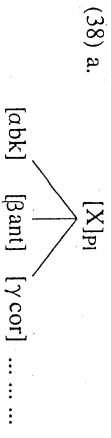
Spreading applies to (37a,b), because the environment is derived and the target unspecified for voice. (37c) shows a morphologically different case. In *leegte* ('emptiness') (compare to *leel[y]e* ('empty')) the derivative suffix /tə/ is phonologically identical to the past tense suffix, but it is morphologically different. It undergoes the rules of Specification, Complement in this case, at the same time as the root itself, and behaves in this sense, for assimilatory effects, in the same way as the compounds like *huilt[s]ammer* in (2a): we get regressive assimilation.

5. Extensions

The theory developed so far constrains to a considerable degree the available mechanisms of universal grammar, but it is restricted to a small domain, the phonology of voicing. When seeking a similar goal in the investigation of other areas of phonology, it might be the case that different principles are at stake, or that the same theory can be extended to them. Although some areas appear to obey partially different mechanisms (e.g. stress), I will show that the RS theory can be extended to areas other than voicing.

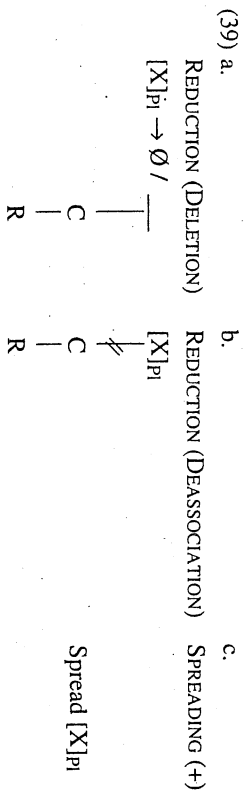
As indicated before, I assume that (segmental) phonological representations consist of a sequence of skeletal units (CV tier) each linked to a tree structure in which dominance but not precedence is defined (Clements (1985), Sagey (1985), (1986)). This tree structure specifies the segmental properties of the timing unit. Terminal nodes are phonological features; meaningful sets of features constitute nodes dominating them, and the root is linked to the skeletal tier. Although the justification of individual features is somewhat unstable, I will take a conservative approach, and suppose that SPE place features are well justified. In this case, it seems clear enough that a natural grouping is precisely the set of place of articulation features. The Place node will dominate an (unordered) set of place fea-

tures (I will not be concerned with the internal hierarchical structure of the place node):



For ease of presentation I will denote any given set of place specifications by its traditional term. Thus [Alv]pi (Alv for *alveolar*) stands for a place node [ɰ] dominating the features [+ant], [-back], [-lab], [+cor], etc.

If we extend without further qualification the theory of voicing developed so far to the node Place, there should be the following parametric options for place, assuming that we also have syllable control:



As for Voice, this operations may take place at stages 1, 2, 3, or later, and the general surface effects run parallel to the voicing effects, summarized in (11) and (20). The sonorant/obstruent asymmetry of voicing discussed at the beginning of section 3 carries over to place, but it opposes different classes of sounds. Recall that the asymmetry resides basically in the fact that for voicing only obstruents are targets, whereas sonorants can be triggers, and if sonorants are triggers, then obstruents must also be. The asymmetry derives from the structure of Specification rules.

Let me illustrate first the case of assimilatory-only effects, corresponding to Deassociation + Spreading. In Catalan there is assimilation of consonants to consonants in place. The standard analysis consists of a set of place assimilation rules, nasal assimilation, lateral assimilation, stop assimilation, etc. (e.g. Wheeler (1974), Mascareó (1976)). Consider the case of Majorcan Catalan, which presents the most extended assimilation, illustrated in (40) with nasal assimilation (Moll (1934), Biblioni (1985)).

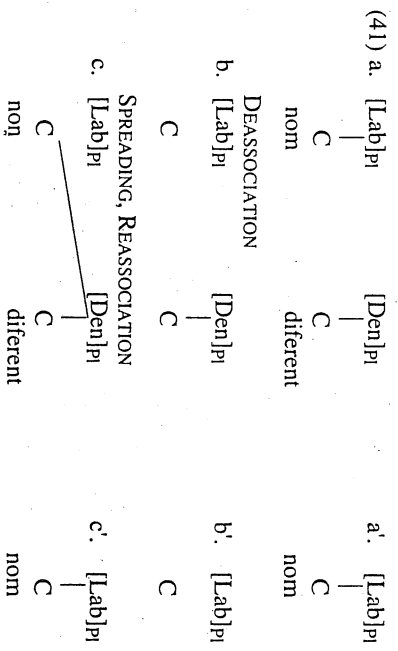
(40) a.

ni[m]	'child'	no[ɲm]	'name'
ni[m] pjeit	'small c.'	no[ɲm] pjeit	
ni[ŋ] djiferent	'different c.'	no[ŋ] djiferent	
ni[ʝn] Aljure	'free c.'	no[ʝn] Aljure	
ni[ŋ] g[ʝ]ran	'big c.'	no[ŋ] g[ʝ]ran	

b.

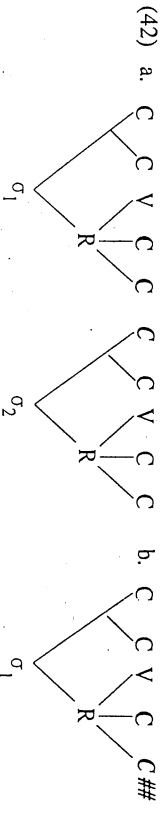
no[ɲm]	
no[ɲm] pjeit	
no[ŋ] djiferent	
no[ʝn] Aljure	
no[ŋ] g[ʝ]ran	

As the first line of (40) shows, word finally nasals contrast in place (the case of the third contrasting nasal /ɲ/ is more complex, and will be discussed in section 6). Before a consonant they assimilate its place properties. Since before a vowel they will always syllabify as an onset, it is sufficient to state that the target of assimilation is in the rhyme. In fact the trigger need not be an onset: the plural morpheme is the suffix [s]: when added to no[ɲm], the assimilation shows up as well: no[ɲns]. Deassociation, Spreading, and Reassociation will have the effect shown in (40); I disregard the fact that dental assimilation is due to a postlexical application, as shown by Kiparsky (1985).



The situation is parallel to (11c) for voicing. There is assimilation but no final effect.

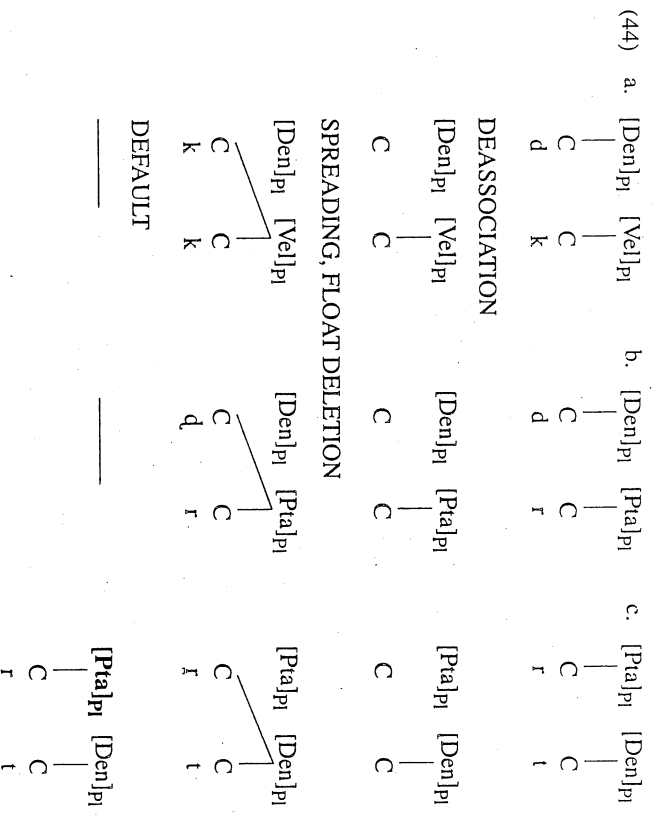
Before illustrating other parametric combinations, we can investigate the general consequences (bounds, regressivity, trigger-target asymmetry) of RS in the case of place. Like in the case of voicing, under rhyme control the *domain* of assimilation is the largest sequence of consonants belonging to the syllables σ₁σ₂ (or σ₁ in monosyllabic, i.e. word final domains), beginning with the leftmost C in the σ₁ rhyme and ending in the leftmost C in σ₂'s onset (or rightmost C of σ₁ in monosyllabic domains). The domain is constituted by the *target*, which is the rhyme, and the *trigger*, which is the first onset consonant (or last rhyme consonant in monosyllabic domains). This is illustrated in (42) for CCVC syllables. The domain of assimilation appears in boldface, the trigger in italics.



The cluster syllable control-regressivity follows, as for voicing, from the fact that Reduction applies to syllable rhymes that have only potential triggers to their right, in the following syllabic onset. Cases of sporadic progressive effects predicted by the theory will be examined below, in section 6.

Let us consider now the trigger-target asymmetry, which derives from the Complement / Default distinction. As I said, vowel and consonant nodes are different, although they might dominate some common place features. It follows that only consonants are triggers and potential targets of place assimilation. Within consonants, the class of potential triggers and potential targets do not coincide, parallelly to what obtained for voice. Place trigger-target asymmetries are more complex than in the case of voicing, due to the fact that the place node has more than two values. Let us take the case of Catalan as an illustration. Obstruents, as well as nasals, contrast in place: *p/ʋ/k*, *b/d/g*, *m/n/ɲ*. But *r* and *l* do not contrast in place, they are both postalveolar. The unmarked stop or nasal will be specified by Complement as dental ([l]) or alveolar ([n]). *r* and *l* will be unspecified for place. Since they do not contrast in place, the content of the place node (postalveolar) will be filled in by Default, parallelly to what happens for voice in the class of sonorants. We expect therefore that stops and nasals will show full place assimilation, and will be able to trigger it too. *r*-sounds, on the other hand, might trigger assimilation, if this takes place at Stage 3, because they will be specified for place at that level. As targets, however, they show the same pattern as sonorants for voicing. Default will specify *rs* as postalveolar, hence their postalveolar specification will override any effect of previous spreading. The following examples show the predicted distribution.

- | | | | | | |
|---------|--------------|-------------------|--|--|--|
| (43) a. | tol[t] | 'all' | | | |
| | tolp p[leit] | 'all small' | | | |
| | tol t[lemp] | 'all weather' | | | |
| | tol d[riç] | 'all rich person' | | | |
| | tol k[ɫjamp] | 'all lightning' | | | |
| | tol k[klop] | 'all hit' | | | |
| c. | pol[k] | 'few, not much' | | | |
| | polp p[leit] | | | | |
| | pol t[lemp] | | | | |
| | pol d[riç] | | | | |
| | pol k[ɫjamp] | | | | |
| | pol k[klop] | | | | |
| b. | cal[p] | 'no' | | | |
| | calp p[leit] | | | | |
| | cal t[lemp] | | | | |
| | cal d[riç] | | | | |
| | cal k[ɫjamp] | | | | |
| | cal k[kɫjar] | | | | |
| d. | pel[r] | 'by' | | | |
| | pelr p[leit] | | | | |
| | pel t[lemp] | | | | |
| | pel r[riç] | | | | |
| | pel r[ɫjamp] | | | | |
| | pel r[kɫjar] | | | | |



After Spreading, the final structures in (44) will be affected by Default, which applies only to place-noncontrasting *rs* to specify them as postalveolars.

Let us now change the parametric combinations to Deletion + Spreading of place. An important effect observed in voicing, the final devoicing effect, can be observed also, as should be expected, in the case of place. Recall that the two different values of the Reduction parameter, Deletion and Deassociation, were responsible for the appearance of final devoicing as opposed to no final devoicing, respectively. In the case of place, Deletion of the place node will trigger the application of Complement yielding the unmarked place, namely [Alv]_{pl}, unless language particular rules specify otherwise. Although less widespread than final devoicing, this word final *centralization*, is also attested. This cluster of effects is found in Occitan (Alibert (1976)). In most dialects sonorant consonants contrast in place (*/m-/n-/ɲ/*, */l-/ʎ/*) in syllabic onsets; before a consonant they assimilate, and word finally they centralize to [n] and [l] (*lh* and *nh* are digraphs representing palatals).

... to all pieces, in (c) the effect ... shows the ...

This is a clear case of Deletion, which affects sonorant consonants, and accounts for the appearance of the unmarked value in final position. Spreading combines with Deletion when an assimilatory trigger appears, giving an assimilatory effect. Only when the sonorant is not syllable final, i.e. when it syllabifies as an onset, is the place of the noncentral sonorant preserved.

A similar situation arises in Alguerese Catalan, where, according to recent studies and my personal observations, there is in general word final centralization of nasals and laterals. I will not deal with this system here, but will analyze instead a prior stage of Alguerese Catalan, described in Kuen's (1932) accurate report. At this point nasals and laterals assimilated in place to a following consonant, but they kept the place properties in final position. This Alguerese situation is interesting because it shows the structure of a transition from a Deassociation to a Deletion system. The examples in (46a, b) show that nasals assimilate in place, but do not change their place properties in absolute final position, or before a vowel. Laterals and sibilants, on the other hand, show a special pattern. They assimilate to alveolars and to palatals, as shown by some of the examples in (46d).^{14,15} Both remain unchanged in absolute final position or before a vowel (46c). The striking feature of this stage of Alguerese is that although unchanged in final position, *final* *ʃ* before *re consonant* becomes *s* and *final* *ʎ* before *nonpalatal consonant* loses its *palatal character* (Kuen (1932: 166-167); translation supplied). In other words, in assimilatory contexts, i.e. before coronals, they assimilate (nonunderlined examples in (46d)); nonassimilatory contexts determine two possible outcomes. In prevocalic, hence non-syllable final position, and in absolute final position, there is no change (46c). But in nonassimilatory preconsonantal contexts, i.e. before noncoronals, they undergo centralization to [l], and [ʃ], respectively ([akél paráw], [akés paráw], and the other underlined examples in (46d) (I have adapted Kuen's phonetic notation to the IPA):

- (46) a. rém 'oar'
 éŋ 'year'
 astém 'we are'
 l últim 'the last'
 grán 'big'
 éŋ 'year'
 kom tina 'like one'
- b. réns pl.
 áns pl.
 astén tótas 'we are all-fem.'
 l últim kwált 'the last quarter'
 grám paráw 'big palace'
 am pasát 'last year'
 kon ta díuz de sáŋk 'how are you called of blood?(=what's your family) name?'
- c. dʒita l uríva 'throw the olive'
- d. truba l paráw 'find the palace'
 trubáva ʎ fit 'found the bed'
 béŋ dʒóva 'beautiful youngster'
 béŋ fit 'beautiful bed'
 akél ditsjunári 'that dictionary'
 akél paráw 'that palace'

14. Probably also other coronal places. Kuen (1932) does not give detailed place assimilation.
 15. Sibilants delete before sibilants and palatals (Kuen (1932: 45-47)), hence the existence of assimilatory effect can only be supported indirectly.

- (46) c. kaváŋ 'horse'
 kavadíŋu 'little horse'
 kaváŋ i 'horse and...'
 fíŋ 'son'
 fíŋ i 'son and...'
 fíŋʒl 'godson'
 réŋ 'bundle'
 matéŋ 'same'
 akéŋ 'this-masc.'
 akéŋa 'this-fem.'
 akéŋ inyéŋ 'this winter'
- d. kavál bó 'good horse'
 fíŋs 'sons'
 fíŋ de réŋ 'king's son'
 féz de jéŋna 'bundle of wood'
 matéŋ típu 'same type'
 akés sa díw 'this names'
 akéŋ gabó 'this coal'
 akés paráw 'this palace'

The peculiarity of this stage of Alguerese is that it does not present centralization in all nonassimilatory environments (like in Occitan), but just in preconsonantal nonassimilatory environments.

Since in absolute final position there is no centralization, we should chose Deassociation as the parametric option of Reduction. How can we get then the centralization effect before noncoronals without ad hoc stipulation? Let us assume that there is Deassociation and Spreading. This will account for the nasals in (46a, b), since we will get Spreading from the following consonant, and when no consonant follows we will get reassociation. Consider now the case of laterals. Let us examine the first part of the predicted derivation (47a-d) of two regular cases, [akéŋ] (unchanged) and [akél ditsjunári] (assimilation), and a problematic case, [akél paráw] (nonassimilatory preconsonantal centralization):

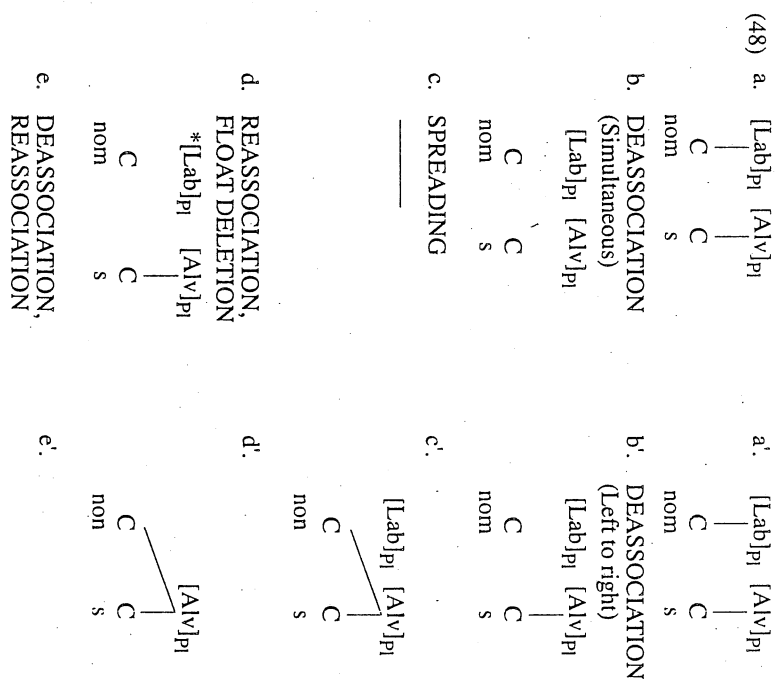
- (47) a. [Pal]p | [Pal]p | [Alv]p | [Lab]p
 akéŋ | akéŋ | ditsjunári | akéŋ | paráw
- b. DEASSOCIATION, SPREADING
 [Pal]p | [Pal]p | [Alv]p | [Lab]p
 akéŋ | akéŋ | ditsjunári | akéŋ | paráw
- c. REASSOCIATION, FLOAT DELETION
 [Pal]p | [Alv]p | [Lab]p
 akéŋ | akéŋ ditsjunári | akéŋ | paráw
- d. DEFAULT
 [+cor]p | [Lab]p
 akél | paráw

The first two cases in (47c) offer no problem. They just illustrate the case of no effect in final position, and of assimilation when a trigger follows. Notice again that [akéŋ] dictates a deassociation solution, since Deletion would yield *[aké]. The third case in (47c), however, is problematic. It shows a lateral which is associated to the place [Lab]p. Normally such structures do not arise because of the prohibition on operations that give rise to illicit structures, a labial lateral in this case.¹⁶ Notice that these cases of centralization in preconsonantal nonassimilatory environments affect segments that have a limited place contrast: both sibilants and laterals must be coronal (/s/-/ʃ-/l/-/ʎ/). It follows that they are specified for the alveolar-palatal distinction by Complement, but their coronal character must be introduced by Default, since they show no coronal-noncoronal contrast. Hence for the same reason that determines the cancellation of voicing effects on Default-specified sonorants, or the cancellation of assimilatory effects on Default-specified rs, in the case of sibilants and laterals there should be partial cancellation. Assume then, that Default in this case introduces [+coronal] (or a *coronal* or *tongue blade* node, if further structure is assigned to the place node). In assimilatory cases like [aké] or [akéŋ], or [béŋ dʒóva], the [+cor] specification that results from Spreading will be compatible with the dentoalveolar place of [l], and the palatal place of [ʎ]; therefore Default applies vacuously. In the case of [aké] paráw] or [akéz galbó] assimilation will have replaced the underlying palatal place by a labial or velar place. Now application of Default will respectify it as [+cor], with the effect of cancelling out incompatible specifications and, in this case, the labial and velar places. Having no place specified, Complement will further specify the node with the unmarked place, alveolar. We get thus the right result: unmarked coronals before noncoronals, to be specified by Complement as alveolars, and palatal, alveolar, etc. coronals before coronals, as the result of assimilation.

We can now return to the problem that arose in our examination of voicing, in the case of two or more Cs in final position ((29), (30), and corresponding discussion). I proposed there that RS apply from left to right like the Association Conventions, and not simultaneously. (48a-d) shows the result of simultaneous application, (48a'-e') the result of left to right application. For the combination Deassociation + Spreading, two final Cs in ...CC]g## deassociate, being in the rhyme, but they are unable to find an associated spreader to their right (or left). If the final structure is the result of applying Reassociation (12) to the two simultaneously deassociated Cs, we would get *no]ms*] (48c) from underlying *no]ms/* (48a). The word final effect would be the same in the case of several Cs as in the case of a single C illustrated above with *no]m]*, ('name' in Majorcan), (second example in (41)), namely no effect. Whereas this result in non (41c') is correct, it is wrong in the case of the same word *no]ms* in Alguerese (48c). The effect that should obtain is no effect in the case of a single final C (*no]m]*), but in the case of several Cs we should get assimilation of the nonfinal Cs to the final C (*no]ms*] ('names')). Other examples with the plural, or 2nd sg. morpheme -s are *sa[k]*

16. Labialized coronal laterals are of course possible. But I assume that these result from lower level rules, which take place at least in other varieties of Catalan. There is labial coarticulation of [l] in contact with rounded vowels, total labialization between rounded vowels; the dark Catalan [l] is also more velarized before velars (Wheeler (1979: 301-302)), etc.

('bag-se') - *sa*]s], *po*]k] ('few') - *po*]s] ('few-pl. '), *re*]p] ('s/he receives') - *re*]s] ('you receive'), *corro*]mp] ('s/he corrupts') - *corro*]ms] ('you corrupt') (*p* deletion is regular, see (51) and discussion).



These examples show that Reduction should apply from left to right, Spreading applying whenever the appropriate configurations arise. The place node will be deassociated from its first C(s), and its right neighbor will spread on the nodeless C(s); then this node will be deassociated from its Cs and the next node to the right will spread. At each step unassociated nodes will be deleted by Float Deletion, being unable to associate by convention (under normal conditions). Finally Reduction will reach the end of the target domain. This will be before the first onset C under rhyme control, or the last onset C under non-rhyme control, and at the edge of the word in both cases. At this point the whole target domain will be associated to

a single node, which will deassociate from the cluster. If an onset C follows, it will spread its associated node to the whole cluster. If no onset C follows, the deassociated node will be linked by Reassociation, giving a sequence of Cs with the node value of the last C, as desired.

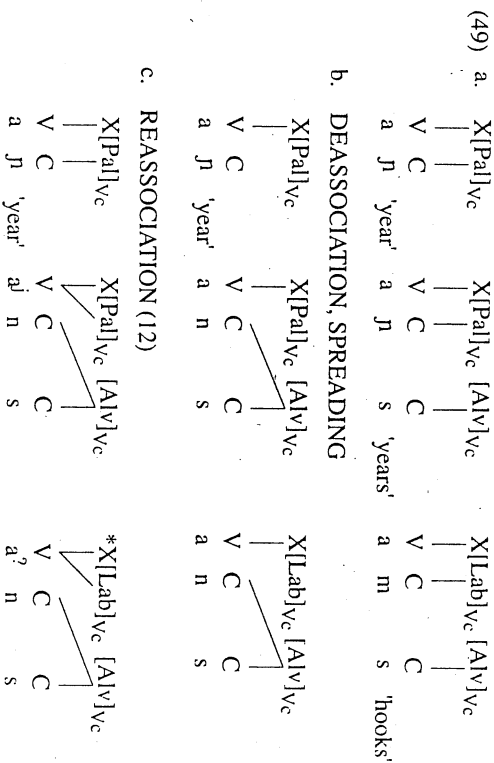
6. Side effects

Another positive outcome of the RS approach is the coverage of assimilations of a more limited sort, that would have to be treated otherwise by allomorphy or special ad hoc rules. Many such cases correspond to assimilation that is controlled morphologically, as in the English and Dutch cases that have been already discussed in section 4. In this section I will first discuss a case of diphthongization and a case of progressive assimilation in rhyme controlled regressive systems. Clearly enough, under a one-step assimilation analysis such cases would have to be treated by unrelated rules. For rhyme controlled systems the RS theory predicts regressive effects, but contrary to the one-step assimilation analysis, it allows for *sporadic* progressive effects if particular properties of the phonology or the morphology of the language give rise, under special conditions, to the appropriate targets. I will begin with the discussion of a *diphthongization* case, which is a good case of independent support for the Deassociation option of Reduction. Recall that the main motivation for Deassociation was the existence of assimilatory effects combined with the lack of final devoicing or centralization effects. In the case of assimilation, the deassociated, floating element is *short lived*: its available site is occupied by the assimilating autosegment and it will be deleted, shortly after being delinked, by Float Deletion (16) (see (47c,d), for an example). Since it is deleted shortly after left floating, direct evidence for its existence is difficult to come by.

I will summarize briefly, with some additions, Mascaró (1985), which analyzes a vowel to consonant assimilation effect of Majorcan Catalan, termed *compenjatory diphthongization*. As justified at the beginning of section 5, Majorcan has a Deassociation and Spreading system for place. The floating autosegment left by Deassociation and Spreading (as in (41c)) is unable to associate and is deleted. Sporadically, however, a special structural configuration might arise that makes it possible for this floating element to reassociate, so that its effects surface in a more direct form. In most cases, the situation will be like in (41c) above: the floating [Lab]_{pl} of [nɔŋ difərənt] (← *mòm difərənt*) will not be able to associate either to the right, because the consonant will be now place-specified as a result of spreading, or to the left because the available slot is a vowel. In some cases, specifically in the case of a [Pal]_{pl}, the autosegment will be able to associate to the preceding vowel. This is made possible because a V associated to two place autosegments can be interpreted, in some cases, as a short diphthong.

The singulars *any* [áŋ] ('year') and *ham* [ám] ('hook') do not show any assimilatory or centralization effect, although the nasal is in the rhyme, because, as expected, no spreading being possible. Deassociation will be followed by Reassociation. Their derivation is the same as [nóm] in (41). But when a consonant follows, as in the plurals *any's*, *ham's*, the place-deassociated nasal will have a possible trigger for Spreading, and it will assimilate to the following consonant's place. Now the floating autosegment will in consequence be unable to reassociate to the

nasal. The derivations that give this result for the singular *any* and the plurals *any's*, *ham's* are shown in (49a,b); X stands for the segmental specifications of [a].



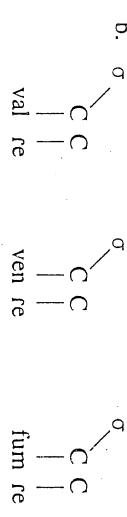
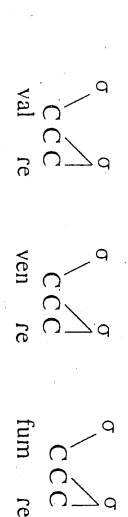
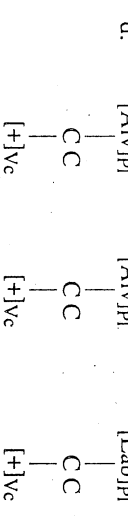
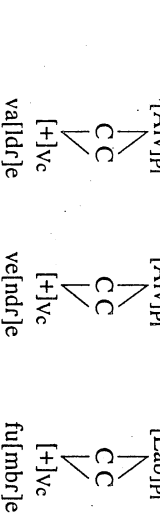
To (49b) Reassociation applies. The first example, *any*, would be the same for the singular *ham*, i.e. the case already discussed in (41) for the word *nom*: the floating autosegment is reassociated to the free C. But when the plural morpheme /s/ follows, we get for the plurals structures with no free C slot (49b). The results shown in (49c) for these cases seem to show that there is reassociation to the V for *any's* but no reassociation at all for *ham's*. The generalization that underlies this distribution is straightforward: the association to an already associated CV slot creates a place contour. Place contours are not accepted in the language, hence no reassociation to the C is possible. In the case of the V, reassociation is possible, because the [Pal]_{pl} autosegment is [-lab, -ant, +high, -back], and can be interpreted as the glide [j]. As a result the floating deassociated element can have a direct representation in phonetic form. But the second structure in (49c) is ill-formed because there are no diphthongs ending in a glide specified as [+lab, +ant, -high, -back] ([w] is [+back], [+high]), hence no reassociation takes place and the surface form is the one appearing in (49b). Notice that in *any's* the vowel features are not deassociated, which results in no *strict* vowel assimilation (a → j), but what can be viewed as a *postpalatalized* a. It is interesting to add a fact not observed by Mascaró (1985), which confirms the structure with a single V slot associated to two consecutive place specifications. This [aj] diphthong is different from the normal [aj] diphthong. The [j] in [aj] is not treated as a C or a V, as the analysis correctly predicts, since it does not arise by insertion of a glide, but by association of a floating, *skeletonless* autosegment. The argument for the character of short diphthong of [aj] is provided by the general rule deleting the medial C in CC₁C₂C sequences (Moll (1934); Biblioni (1985: 183-189)). Compare the examples in (50a) with

medial C deletion in particular the deletion in [jɪs], where [j] is a lexical, full glide, with the non deletion in [ájns] (50b):

- (50) a. ...VCC]s
 áit 'high'
 vint 'twenty'
 akésr 'this'
 dins 'inside'
 vút 'eight'
- ...VCC]sC
 áits → ái s (pl.)
 vints → vins (pl.)
 akés cá 'this dog'
 din da 'inside of'
 vút séns → vút séns 'eight hundred'
- b. VC]sC
 ájns → *ájns (as in (57))
 ájn sént → *áj sént 'year one hundred'

Notice finally that under a single step deassociation-cum-spreading analysis the floating autosegment left would be able to reassociate in any system. The RS analysis allows it only in the case of Deassociation as the Reduction value; it predicts, correctly that Deletion systems (like Spanish or Occitan), which leave no floating autosegment, cannot show the diphthongization effect.

Another case of sporadic RS effects involves progressive assimilation. The first case is an instance of *intrusive* stop (see Weizels (1985) for discussion of other examples of the same phenomenon). In Catalan the liquid *r* following a nasal or a lateral in VNrV or VirV sequences cannot be syllabified as an onset. An extra C is introduced between the two Cs. Within morphemes it is associated to the following *r*, yielding, similarly to word initial *r*, a tense [r] (see Mascarcó (1976: 47-50) for justification of *rr* → *r*): *Elmrjic* ('Henry'), *Ce[r]r[ɔ]* (place name). Across morphemes (as as in the case of verbal roots ending in *m*, *n*, or *l* and followed by inflective morphemes beginning with /r/) it surfaces in the form shown in (51a). Let us now see what is predicted under the minimal assumption that the inserted element is just a C slot. Since it is the unmarked consonant, we would expect *r*. But this language has voice and place assimilation. Under an RS analysis this implies that there is voice and place Reduction and voice and place Spreading. Since Spreading has the general form *Spread voice* and *Spread place*, voice and place should spread whenever a licit site is available. Now the inserted C is voice and place unspecified, and at the same time the rule of insertion creates a (rule) derived environment, so that the SCC does not block Spreading. Assuming that Spreading associates free CV slots to autosegments to their left in the unmarked case, like in the case of the Association Conventions (van der Hulst and Smith (1985: 17)), we get voice and place specifications of the intrusive stop from the preceding consonant. Other specifications ([-cont, -sonit, -nas, etc.]) are supplied by Complement and Default. Therefore we get lr → ldr, nr → ndr, and mr → mbr. The form with /mr/, arises only in some varieties of Catalan, but when it does, the result is [mbr]. (51a) shows the alternations; C Insertion applies to the partially unsyllabified structures (51b) to give (51c). In (51d) I give the segmental representation corresponding to the cluster of sonorant + intrusive C in (51c), to which *Spread place* and *Spread voice* apply to give (51e).

- (51) a. call] 'it is necessary' ve[n] fu[m] 's/he sells'
 call[dr]e 'to be n.' ve[ndr]e fu[mbr]e 's/he does'
 call[dr]ia 'would be n.' ve[ndr]ia fu[mbr]ia 'would do'
 call[dr]ja 'will be n.' ve[ndr]ja fu[mbr]ja 'will do'
- b. 
- c. C-INSERTION, SYLLABIFICATION

- d. 
- e. SPREADING


In usual assimilation, Spreading is triggered by syllable controlled Reduction, which entails regressive character. In the case of the infinitive, future and conditional morphemes, there is suffixation and C insertion, which give rise to a configuration with the unspecified element to the right of a possible trigger. Once this configuration arises, the independent mechanism of Spreading automatically determines a progressive assimilatory effect.

A more complex case of trigger/target asymmetry can also be derived from the theory proposed. The set of place effects found in some varieties of Spanish provides a compelling argument for the double parameter analysis of assimilation. I will summarize here the argument from work in progress on Spanish voicing effects. It can be shown that the rules of *depalatalization* (see Harris (1983) for interesting consequences of this processes), which are particular cases of *centralization*, as illustrated in (52) below, are impossible to be projected from the set of initial data that show central (i.e. alveolar) – noncentral place alternations. On the other

hand the pronunciation of new lexical items that were not part of the initial data suggests that a phonological rule is operating. I will give a brief illustration of this situation with some examples. Some dialects of Spanish present alternations of syllable initial [ɲ] or [ʎ], with central [n] and [j], respectively, in syllable final position:

(52) a.	desde[ɲ]ar	'disdain'	desde[n]	'disdain'
	re[ɲ]ir	'to quarrel'	re[n]cilla	'quarrel'
	do[n]	(as in <i>don Juan</i>)	do[ɲ]a	(fem.)
	be[ʎ]o	'beautiful'	be[ɲ]dad	'beauty'
	e[ʎ]a	'she'	e[n]	'he'
	done[ʎ]a	'lass'	donec[ɲ]	'lad'

This process extends to all nasals and laterals; the labial [m] should also be included. It affects only certain dialects, the present tendency being towards gradually allowing final noncentral nasals and laterals.

The depalatalization rule proposed formally in Harris (1983) has a particular status, since the set of examples to which it applies is rather scarce. A pretty exhaustive examination of possible alternations gives a set of examples from which one might extract at most seven, probably less, common examples to which the child can reasonably be exposed to in the process of language acquisition (one example with [m], two with [ɲ], four with [ʎ]).¹⁷ The logic conclusion seems to be that what is projected is not a *rule*, but an allomorphic alternation restricted to the small set of lexical items. This conclusion is supported by the comparison with similar alternations that affect sets of lexical items similar in size, which are clear cases of allomorphic alternation.

Contrary to this conclusion, the examination of borrowings shows that they are adapted in a way which is typical of borrowings that are subject to universal phonological processes. Let me illustrate this with a couple of examples. Compare clear cases of allomorphic alternations and of phonologically governed alternations with instances of centralization.

(53) a.	<i>Final [t] (Allomorphy)</i>	a.	
	café[é] – cafetlera		Montserrat[á] – montser[á]jino
	*caffé[é]		Montserrat[-á] – *montser[á]jino
	'coffee' 'coffe-pot'		Montserrat[áɔ] – *montser[áɔ]jino
			'Montserrat' <i>adj. derivative</i>
	b.	<i>Lenition (Phonological Rule)</i>	b.
	il[nd]ucir – r[ie]ducir		ki[nd]ergarten – S.I.D.A. [fɔ]
	'induce' 'reduce'		'AIDS'

17. The examples are albu[n] 'album', -pl. albu[m]es, desde[n] 'disdain', desde[ɲ]ar 'to disdain', do[n] 'Mr.', do[ɲ]a 'Mrs.', é[n] 'he', e[ʎ]a 'she', aque[n] 'that-masc.', aque[ʎ]a 'that-fem.', pie[n] 'skin', pe[ʎ]ejo 'skin, hide, peel', mil[ʎ] 'thousand', mil[ʎ]ón 'million'.

(53) c.	<i>Centralization</i>	c.	
	desde[ɲ]ar – desde[n]		champa[n]
	*desde[ɲ]		*champa[n]
	e[ʎ]a – é[n]		'Champagne' French [ʃãpɛ̃n]
	*é[ʎ]		
			detal[ɲ] (ortographic <i>detail</i>)
			*detal[ɲ]
			'retail'

The alternations in the first column (53a,b,c) are some of the common words from which the phonological system is projected. The second column (53a',b',c') contains new lexical items (borrowings, acronyms, etc.). In the case of clear allomorphic alternations (53a), the introduction of new lexical items with the structure of one of the allomorphs does not end up always in a new allomorphic pair, specially in cases like (53a) where only a limited set of pairs are related by the same allomorphic alternation. Instead the anomalous word final [t] is adapted as the reflex of a similar underlying segment (/d/), or as a close phonetic adaptation (53a'). In the case of a clear phonological alternation, like Lenition in (53b), the introduction of a new lexical item containing one of the members of the alternation results without exception in the adoption of the underlying form to which the rule applies as to the rest of the lexical items, as (53b'), and any other parallel examples show. This seems to be the case for any similar instance of allomorphy and automatic phonological rule, respectively. When the cases of centralization are examined, the result is that in all cases in which a final [ɲ], [m], [ʎ] from a direct borrowing, or via an orthographic form is introduced, the final consonant is invariably centralized, and no other adaptation does appear. In no case do we find other solutions, like deletion of the final consonant or adaptation to a close segment like [ʎ]—[j].¹⁸ In the second column, the cases of (53c') behave exactly like the cases of (53b'): they behave as governed by a rule, and not by allomorphy. Centralization cannot be obviously a property of universal grammar, therefore we must conclude that since there is a rule governing it, and it cannot be projected from the scarce initial data showing it up, the rule must be projected from other data.

RS theory not only allows for a solution of the paradox we are discussing, but it predicts automatically centralization as an effect in Spanish phonology. Spanish has a rule of nasal and lateral assimilation (Harris (1969)), Navarro Tomás (1971)), /n/ and /l/ assimilate in place to a following consonant. There is a limited set of controversial cases of assimilation of /m/, /ɲ/, and /ʎ/, but even if alternations are controversial, nasal-consonant and lateral-consonant clusters are always homorganic. Under the theory proposed the parameter value for Spreading must be positive, because there is assimilation; since all clusters are homorganic, and no noncentral nasal or lateral appears, the Reduction value must be Deletion. Therefore assimilatory effects in the initial data determine the projection of a grammar with

18. In this restructured system the residual alternations of (52) will clearly be treated as allomorphic. This is even more evident in the (larger) group of dialects that do not have /ʎ/, substituted mainly by /j/, in their phonological system.

Deletion and Spreading. Now Deletion of a nasal or a lateral before another consonant will trigger Spreading from this consonant, which will result in the assimilatory effect that determined its projection, namely nasal and lateral assimilation. Consider now final position. In this position centralization is the predicted effect, although it is inexistant in principle because of the lack of inputs. For a speaker never confronted with new lexical items with final [m], [n], [ɲ], [ʎ], the centralization effect never appears, or appears limited to the small set of alternations mentioned earlier (52). But when confronted with new cases, such as those in (53c), the centralization effect surfaces. Notice that this situation should be unstable, as it actually appears to be. This is so because a generation with the parametric situation just described might add, after acquisition, new lexical items, adapted as exceptions, which preserve the original noncentral final consonants ([m], [n], [ɲ], [ʎ]). Such elements will be now part of the initial data from which the grammar is projected. Once its number is sufficiently rich, the next generation will find assimilatory data compatible with both Deassociation and Deletion, but the new word final items with final noncentral sonorants will constitute positive counterevidence to Deletion, which will end up in the projection of the Deassociation value of Reduction.

7. Summary and Conclusions

In this study I have tried to show that a reasonably wide set of segmental phenomena can be accounted for by resorting to a limited set of operations on autosegmental representations. The basic operations are Reduction (Deletion or Deassociation), and Spreading of nodes. Each of these operations allows for a limited number of other possible options: the node affected (voice, place, etc.), the stage at which it applies, and, for Reduction, two possible types of syllabic control on the operation. Under rhyme control, the rhyme is chosen as the domain of reduction; under non-rhyme control the domain of reduction is the rhyme and all but the last onset consonants.

The first reason to prefer a system with two different operations is the *independence* of such processes; there are languages having, for a given node, only Deletion (German, for voice), or only Spreading (English, for voice). But the independence of these operations appears not only in individual languages; it also shows up in specific areas of a given language. If a language chooses Reduction and Spreading of a node, the effects of Spreading are not absolutely dependent on previous Reduction. In case a morphological or a phonological operation gives rise to various Reduction. In case a morphological or a phonological operation gives rise to the appropriate configuration, the general Spreading rule *Spread X, X a node*, takes place independently of Reduction. Inversely, under similar circumstances, if the configuration is such that Reduction can take place, but Spreading is impossible because of the lack of an available trigger, the effects of Reduction surface independently, in the form of final devoicing for voice and final centralization for place.

Another advantage of RS lies in the *transfer* of phonological conditions on operations from particular grammars to universal grammar. Thus, a segmental rule like final devoicing has to mention the value [-voice] in the structural change, and centralization of place has to mention the specification of dental/alveolar place. In an RS analysis, Deletion just specifies the loss of the voicing properties,

or the place properties, and Underspecification takes the burden of specifying which value will be chosen for that property. The same situation arises in the case of the target of assimilation. If we consider rules like voicing assimilation or place assimilation, the fact that the first one usually reads, *obstruents assimilate [voice]...*, and the second *nasals (or stops) assimilate place...* is arbitrary. Here again it is the fact that obstruents can contrast in voice and nasals in place that makes assimilation more natural for these classes of segments. This is captured by allowing overapplication of very general rules, which is later rectified by universal mechanisms. Default rules undo illicit assimilations at phonological stages by respecifying nasals as voiced, R-sounds as alveolar (or uvular), laterals as coronal, etc.

The combination of certain values of the different parameters determines only a restricted set of possible clusters of surface effects. Thus a language which shows assimilation of unmarked consonants only must have Deassociation as the Reduction value, since otherwise the marked value would delete and would cause also assimilation of the marked consonant. But this choice of Deassociation has other consequences. It is predicted, for instance, that this language cannot show any *final effect*, since final effects are tied to Deletion. On the other hand, if a language chooses Deletion, because it presents a final effect, then it will have also a *syllabic final effect* in case it is rhyme controlled. In other words, a language cannot have final devoicing, and voicing assimilation before obstruents affecting only the rhyme (like Dutch), and present at the same time a contrast of obstruents before onset initial sonorants (like Polish). A segmental analysis would allow any of these possibilities. This last case, for instance, would be accounted for by Final Devoicing, [-son] → [-voice] / ____ #, and an assimilation rule like [son] → [a cor, etc.] / ____rhyme [-son, a cor, etc.].

It is obvious that the set of phenomena examined here is very limited. The present proposals should be refined in two different ways. First, by examining voice and place effects in typologically different systems. On the other hand, we should determine to what extent the properties of the system carries over to other domains, and to what extent they are governed by different principles. We have seen that the Association Conventions apply for these segmental processes like they do for tone. We have also seen that principles proposed for tone apply also in the segmental domain. It is not clear however at the present stage of our understanding of these phenomena, how much they have in common.

APPENDIX

A. Additional Voicing Effects in Polish

Cases of voicing effects that present both regressive and progressive spreading direction seem to pose a challenge to a highly constrained theory. It appears that such cases need two different processes, as in standard analyses, and hence one would expect such cases to be rare. On the other hand we could also expect bidirectional assimilation, or similar distribution of regressive and progressive effects, whereas typically one seems to be more restricted than the other. Thus in Dutch progressive assimilation, even if fairly extended, is restricted to devoicing of a cluster containing a fricative as the second element and to morphologically restricted cases. In Catalan only word final palatal-s clusters and inserted Cs present a progressive assimilatory effect, to be analyzed below, in section B. Consider now another instance of such *sporadic* effects, accounted for by a progressive devoicing rule by Booij and Rubach (1985: 23-24). I repeat their examples, and the progressive assimilation rule proposed.

(1) a. $w \rightarrow f$

listw+ta	'board' gen.pl. [lɪ'st+fa]	listew+tek	dimin. [lɪ'siev+ek]
pochw+ta	'sheath' gen.pl. [poxf+ta]	pochew+tek	dimin. [poxev+ek]
bitw+ta	'battle' gen.pl. [bitf+ta]	biew+tn+ɣ	'war-like' [p'iev+tn+i]

b. $r \rightarrow ʒ \rightarrow ʒ$

Piotr	'Peter'	Piołrz+e	voc.sg. [p'jofe]
wicher	'wind'	wichrze+e	loc.sg. [v'ixfe]
kufier	'trunk'	kufiz+e	loc.sg. [kuf+e]

c.

$$\left[\begin{array}{l} +obstr \\ +cont \end{array} \right] \rightarrow [-voiced] / [-voiced]$$

For (1b) Booij and Rubach argue that an independently motivated rule *spells out* /r/ as [ʒ] when not followed by a consonant (Rubach (1984: 199-200)). The alternations in (1a) are a typical instance of Slavic *w*, which surfaces as [v], but acts like a sonorant at the same time. Now consider what happens if the rules turning sonorants into obstruents apply at Stage 2. Obstruents will be specified for voicing, but sonorants not yet (the status of the *sr* cluster as linked to two or to a unique [-]vc is irrelevant to the argument):

(2) a.	[-]vc	[-]vc	b.	[-]vc
	lɪs	t		p'jot
		wa		re

(2) SPREADING

[-]vc	[-]vc	[-]vc
lɪs	t	p'jot
	wa	re

$w \rightarrow v, r$ SPELL-OUT

[-]vc	[-]vc	[-]vc
lɪs	t	p'jot
	fa	ʒe

It is clear that both $w \rightarrow v$ and r Spell-out do not mention [voiced]: they just change features like [son], and the voiced character of [w] and [r] are, under normal circumstances, kept in [v] and [ʒ]. Recall now that we argued before that at the appropriate level sonorants do undergo Spreading, but the result of Spreading is normally undone by Default. This is the case in Polish for *trza[ʃ]ny* ('well-aimed'), *w[ʃ]al[ʒ]ny* ('important'), *or[ʒ]al[s]ny* ('clear') with a voiced nasal. Thus the initial structures in (2) are a licit input to Spreading, which result in the intermediate structures in (2). Later the effect of desonorantization of *w* and *r* ($w \rightarrow t$, r spell-out) will be to derive the correct obstruents [t] and [ʃ], with no need to add a rule of progressive assimilation or, for that matter, syllable initial fricative deletion followed by spreading. This confirms that the analysis proposed earlier, by which sonorants do assimilate and are later reassigned their default voicing value, is correct. In cases in which a rule applying before Default turns them into obstruents the prediction is that the devoicing effect should reappear. But consider now *[-son]/##w* sequences, where the cluster is separated by a word boundary. Deletion and Complement will have applied at the word level to the word final obstruent, and $v \rightarrow w$ will have applied to the word initial sonorant independently. At the phrase level we will have a *[-son]v + obstruent* sequence to which Reduction and Spreading apply, resulting in regressive assimilation. And this is in fact the case, as reported by Booij and Rubach (1985: 27): we get [lɪst+fa] from *listw+ta*, but but *Wojtk+ta* with the same underlying sequence /w/ surfaces with [dv].

If we follow Bethin (1984), and analyze Polish voicing as controlled by syllable structure, the rule of Morphological Voicing (Booij and Rubach (1985: 31)) has not to be stipulated. Morphological Voicing (3b) voices an obstruent before a sonorant in the case of prepositions (*w* stands for a bracket labelled *word*).

(3) a.	sa[ʃ] owocowy	'fruit tree'	po[ʃd] owocem	'under the fruit'
	po[ʃt]	'under'	prze[ʒ] ogród	'across the garden'
	prze[ʃs]	'across'		

b. $[+obstr] \rightarrow [+voiced] / \left[\frac{\text{PRE}}{\text{PRE}} \right]_{(w [+sonor])}$

Instead of introducing morphological information in the rule we can assume that prepositions are added to their complements directly from the lexicon, without having passed a phonological cycle—as opposed to other word classes, like nouns. The noun *sad* of (3a) will have undergone Deletion and Complement and will show up with a voiceless *t* before it is joined to *owocowy*. *Pod* is added with the underlying voiced obstruent to *owocem*; syllabification will then follow one of two options. If a sonorant follows, the final *d* will be syllabified with it as part of the onset; if an obstruent follows it will remain syllable final. Hence in the first case Deletion will not apply and the *d* will remain voiced. In the second case it will be in the syllable rhyme, hence it will undergo Deletion, and it will assimilate to the following obstruent.

We can now turn to some variations of voicing effects found in Cracow-Poznań Polish. In this variety, voicing assimilation is extended to obstruents across words. Assimilation takes place even if the following segment is a vowel:

- (4)
- | | |
|---------------------|---------------------------|
| sasia d r adzi | 'neighbor advises' |
| rosmo v o statny ch | 'last conversations' |
| ja g n igdy | 'as never' |
| zró b i nwentarz | 'do inventory!' |
| gfo z n arodu | 'the voice of the nation' |

If the voicing rules apply before resyllabification at the phrase level there is no need of a rule that mentions specifically word boundaries; the position taken by Bethin (1984). (5a, b) are the rules proposed for Warsaw and Cracow dialects, respectively:

- (5) a. Warsaw
 [-son] → [α voice] / ___ [α voice, -son]
- b. Cracow
 R[|hyme]
 |
 C
 [-son] → [α voice] / ___ [α voice]

If the analysis in terms of syllable structure is correct, the difference between the two dialects can be interpreted as a difference of levels of application of the same Deletion and Spreading operations. In the dialect with more restricted assimilation, Warsaw Polish, Deletion and Spreading take place at the stage at which only obstruents are specified for voicing, Stage 1 or 2. No sonorant consonants or vowels will be able to act as triggers, since they are unspecified with respect to voice, nor as targets, because Default will undo the effect of Spreading. In the other dialect the phonological operations on Voice will apply at Stage 3. At Stage 3 we get an extension of voicing effects because sonorants will now be specified. In word internal position these sonorants are syllabified together with the obstruent as an onset, hence obstruents assimilate only to obstruents. In word final position

the obstruent will be syllable final, and the sonorant syllable initial, as a result of word level syllabification. The fact that the obstruent is in the rhyme and that the sonorant is specified for voicing will determine the possibility of Reduction and Spreading, respectively. The effect will be therefore the presence of assimilation of obstruents to obstruents in general, and of obstruents to sonorants across words only:

- (6) →
- a.
- | | |
|---------------------|-----------------|
| wa[3n]y 'important' | ja[sn]y 'clear' |
| [+]vc [e]vc | [-]vc [e]vc |
| C C | C C |
| σ | σ |
- b.
- | | |
|---|-------|
| gfo[z n]arodu 'the voice of the nation' | |
| [-]vc [+]vc | [+]vc |
| C C | C C |
| σ | σ |

B. Assimilation to Marked

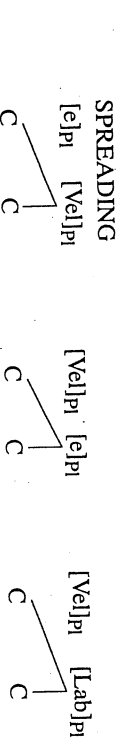
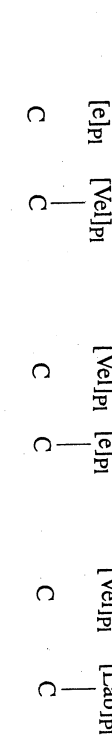
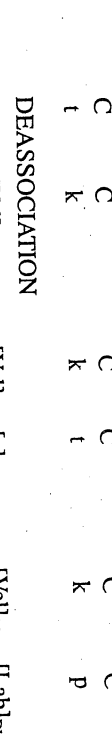
I want to include an example of *unmarked* assimilation of place, because in this case the RS theory runs into some interesting and unsolved difficulties.

Unmarked assimilation is the parallel to the voicing effects at Stage 1 (see (19c) in section 3 above), namely no final devoicing and no assimilation to voiceless segments, but assimilation to voiced ones. In the case of place there is no *centralization*: labials, palatals, velars, etc. will remain with the same place properties word finally. On the other hand, place-marked consonants, labials, palatals, velars, will not assimilate, but deno-alveolars, which are unmarked, will assimilate to other places. The interest of unmarked assimilation in the case of place derives from the fact that, as opposed to voicing, place allows more than one marked place. Of course voice, or rather *laryngeal* features might be more complex (following the proposals of Halle and Stevens (1971)), but they work binarily in the cases discussed above, and therefore have only one marked value. The parameter settings responsible for these effects are Stage 1 application, Deassociation, and Spreading. The extension of voicing effects to place could follow two directions. Recall that for voicing we get assimilation only in one of the four possible cases, e.g. /s/ → [sʃ], /zv/ → [zv], /z/ → [zʃ], but /sv/ → [zv]. These facts have two possible descriptive interpretations: they can be interpreted in terms of the observation that *only voiced obstruents are assimilation triggers* (a), or equivalently as *only voiceless obs-*

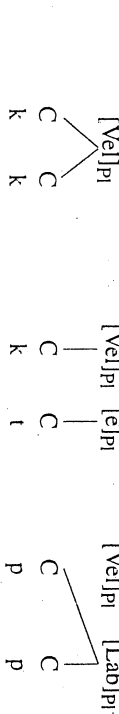
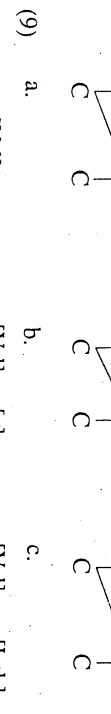
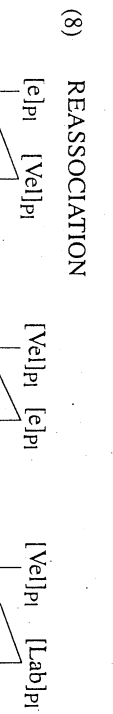
trients are assimilation targets (b). In the case of voice these two observations are equivalent, but translated into place, they are not. We get different results for (a) and (b), due to the fact that we can get a sequence of two nonidentical marked consonants, e.g. /pk/. For (a) and (b) we would get the results in (7a) and (7b), respectively, exemplified for regressive assimilation with unmarked /t/, and marked /p/ and /k/:

- (7) a. Marked=trigger b. Unmarked=target
- | | |
|--|---|
| /k/ → [k]
/p/ → [p]
/k/ → [k]
/p/ → [pp]
/pk/ → [pk] | /k/ → [k]
/p/ → [pt]
/k/ → [kk]
/p/ → [pp]
/pk/ → [pk]
/kp/ → [kp] |
|--|---|

We can now examine the predictions of the RS theory. In clusters of two obstruents, since there might be different marked values (e.g. [Vel]p and [Lab]p), there will be three possibilities, if we disregard identical place nodes, which are left unchanged (except for the fact that after Spreading they will be necessarily attached to a unique place node). The three possible clusters are unmarked-marked, marked-unmarked, and nonidentical marked-marked; they are shown in (8). After Deassociation and Spreading, Reassociation will be able to apply in (8a,b) which are nondistinct from (9a,b), respectively, like in the voicing cases shown above in section 3 (20d,e). Reassociation cannot apply in (8c), which contains the illicit structure *[C[Vel]p][Lab]p, i.e. a C dominating two *full* place nodes (I assume the structure to be ill-formed provided that the language that does not allow contour place articulations). Hence Spreading will not apply in this case and the result will be (9c).

- (8) a. 
- b. 
- c. 

(8) REASSOCIATION

- (9) a. 
- b. 
- c. 

Comparing now the initial structures in (8) to (9), the effect predicted is the one in (7a) (/pk/ → [kk], /kp/ → [pp]), namely *only marked trigger assimilation*, and not *only unmarked target assimilation*. This appears to be the wrong prediction.

Unmarked place assimilation can be illustrated with Central Catalan. Dental obstruents assimilate to all consonants (10a-c), provided that the obstruent is in the syllable rhyme. The same is true of nasals (10d-f).

- (10) a.

[set]	selb bjeus	seld djones	selʎ djadres	selk kjosins
'seven'	'voices'	'women'	'thieves'	'cousins'
- b.

[relp]	relb bjeus	relb djones	relb djadres	relp kjosins
's/he receives'				
- c.

[dik]	dilg bjeus	dilg djones	dilg djadres	dik kjosins
'I say'				
- d.

[sɔ̃n]	sɔ̃m bjeus	sɔ̃n djones	sɔ̃n djadres	sɔ̃n kjosins
'they are'				
- e.

[sɔ̃m]	sɔ̃m bjeus	sɔ̃m djones	sɔ̃m djadres	sɔ̃m kjosins
'we are'				
- f.

[ciŋ]	ciŋ bjeus	ciŋ djones	ciŋ djadres	ciŋ kjosins
'five'				

Except for voicing, there is no assimilation in the case of labial or velar nasals and stops. Only dentals and alveolars assimilate in place to a following consonant. The assimilation is controlled by syllable structure. It requires that the assimilated segment be in the syllable rhyme. Compare *s'atreuvia* ('s/he dared') [sa.tɾa.βi.a] to *se' rebia* ('you were received') [sa.d.ɾa.βi.a].

It is important to determine how strong the case for unmarked assimilation really is. It appears indeed that this kind of assimilation is not restricted to place. Catalan segments are divided in fricatives, stops, stop/approximants, nasals and liquids. Since the class of stop/approximants shows always the stop in the syllable rhyme, this class can be collapsed with the class of stops. These classes can be distinguished by the features [strident], [continuant], [nasal] and [lateral]. Consonants

belonging to a given class can assimilate most properties except those they are marked for, or those that are incompatible with them. So nasals are marked for nasality, and never lose this property, but they can assimilate in place, as shown above, and for other features as well, e.g. they may become lateralized. [-voice] is incompatible with [+nas] (in other words, [+voice] is introduced by Default for [+nas]); hence they do not enter in voicing assimilation as targets. Similarly laterals assimilate to those places compatible with their lateral specification. They can become palatal, dental, but not labial, and they can become nasal. The place-unmarked stops, /t/ and /d/, assimilate to all consonants, except for the feature continuant; there is full assimilation before nasals, laterals, etc.:

- (11) a. fo[ɲ] fo[ɲ]ja *fo[ɲ]ja
 'melt' 'melt it-fem.'
 b. ma[ɲ] ma[ɲ]dʒat ma[ɲ]ʎloc ma[ɲ]ɲnom ma[ɲ] pʎas *ma[ɲ] pʎas
 'bad' 'badness' 'bad place' 'bad name' 'bad step' 'bad step'

We can think of different (still unsatisfactory) solutions to handle this and similar cases. We might enrich the theory by introducing a new parameter, distinguishing *Delete P/Ddelete* [e]/p], the second value will trigger Spreading only on unmarked elements. An alternative would be to stipulate that at Stage 1 Reassociation takes precedence over Spreading, which as the reader might check, will have the effect of allowing Spreading to apply to [e]p][Vel]p], but not to [Vel]p][Lab]p], the first autosegment having reassociated.

This case is also interesting because it requires unspecified consonants at a quite late level, contrary to the usual assumption that processes sensible to the marked/unmarked distinction are lexical and not postlexical (Kiparsky (1985)). As (55) shows, assimilation takes place across word boundaries, hence at a postlexical level.

Another case which relates to the present problem, progressive assimilation in the syllable rhyme, will be discussed in the next section.

Notice finally that whatever the right formal solution might be for unmarked assimilation, RS correctly predicts that unmarked assimilation systems, for voice or place, cannot show reduction (devoicing and centralization) effects. Unmarked assimilation (Ukrainian voicing, Central Catalan place assimilation) requires Deassociation which results necessarily in no reduction. General assimilation on the other hand is compatible with no reduction via Deassociation + Spreading (Serbo-Croatian voicing; Majorcan Catalan place assimilation), and with reduction via Reduction + Spreading (Dutch voicing, Occitan place assimilation).

C. Extensions to Vowels

The effect of spreading of vowel properties, vowel harmony, has been widely discussed. Here I will restrict my attention to nonharmonic changes, which according to RS theory will be cases in which there is no Spreading. Consider as an illustration two simple cases. (12a) and (12b) show the *full*, stressed vowel systems

of two Catalan dialects: (12c) and (12d) show their underspecified and specified feature values, respectively.

- (12) a. Western dialects b. Majorcan
- | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| i | e | ə | o | u | | i | e | ə | o | u |
| ε | ɔ | | | | a | ε | ɔ | | | a |
-
- | | | | | | | | | | | | |
|-------|---|---|---|---|---|-------|---|---|---|---|---|
| high | + | - | - | - | + | high | + | - | - | - | + |
| back | - | - | - | - | - | back | - | - | - | - | + |
| round | - | - | - | - | + | round | - | - | - | - | + |
| low | - | - | - | - | + | low | - | - | - | - | + |
| ATR | - | - | - | - | - | -ATR | + | + | + | + | + |
- c. d.

If we now apply Deletion to the feature ATR, the underspecified Western system (=12c), except for /ə/ will lose the two minus values of ATR. The vowels that are unspecified for ATR will not be affected by Deletion, obviously. But /e/ and /ɔ/ will lose their negative value, which will make them identical to /e/ and /o/, respectively. The result will be (13a), which is the reduced Western system. In parentheses I give the source of the reduced vowel.

- (13) Reduced Systems
- | | | | | | | | | | | | |
|------------|--------|-----|---|---------|---|--|--------------|-----|---|---------|---|
| a. Western | i | e | ə | o | u | | i | e | ə | o | u |
| | (e, ε) | → e | o | -(o, ɔ) | | | (a, a, ε, e) | → ə | o | -(o, ɔ) | |
- b. Majorcan

In Majorcan vowel reduction is more complex. Both ATR, low, and back are deleted from nonhigh vowels. Since the only specifications of the vowels /e, ε, ə, a/ belong to this set of features, they will lose all specifications, becoming identical to /ə/. On the other hand, /ɔ/ will lose ATR, becoming /o/. (12c) will be converted into (14), with the resulting merger of /ə/, /e/, and /ε/ into [ə], and of /ɔ/, /o/ into [o]:

- (14)
- | | | | | | | | | | | | |
|-------|---|---|---|---|---|-------|---|---|---|---|---|
| high | + | - | - | - | + | high | + | - | - | - | + |
| back | - | - | - | - | - | back | - | - | - | - | + |
| round | - | - | - | - | + | round | - | - | - | - | + |
| low | - | - | - | - | + | low | - | - | - | - | + |
| ATR | - | - | - | - | - | ATR | + | + | + | + | + |

This gives the Majorcan reduced system in (13b) above. Reduction applies to unstressed vowels, as illustrated below: