

XX

***External sandhi as gestural overlap?
Counter-evidence from Sardinian***

D. ROBERT LADD and JAMES M. SCOBBIÉ

XX.1 Models of assimilatory external sandhi

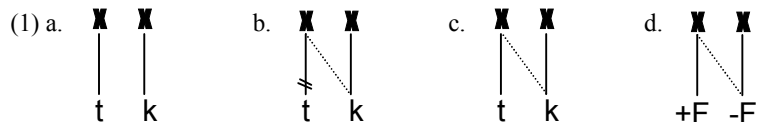
External sandhi stands right at the heart of a number of current issues in phonology and phonetics. The traditional assumption is that such “phonological adjustments” involve the categorical modification of the affected segment or segments, e.g. the coalescence in English of /t#j/ to /tʃ/ in *past_your prime*, or the change in *that_case* of /t#k/ to /k/. Hayes’s (1986) analysis of the assimilatory external sandhi of Toba Batak established that autosegmental feature spreading, the canonical mechanism for analysing assimilation (Goldsmith 1979; Clements 1976), was able to account for complex sandhi patterns just by linking and delinking autosegments. Such feature spreading, which relies crucially on the traditional assumption of categorical phonological modifications at word boundaries, has subsequently been the received analysis of external sandhi generally, including the English cases mentioned above.

More recently, however, a number of studies on English (Barry 1985; Wright and Kerswill 1989; Browman and Goldstein, 1989, 1990; Nolan, 1992; Holst and Nolan 1995; Holst, Nolan and Kühnert 1996; Zsiga, 1995) have cast doubt on the assumption that external sandhi assimilation involves categorical modifications of segments. Rather, the appropriate processes appear to involve language-specific rules of phonetic co-articulation,¹ usually expressed in terms of gestural overlap and gestural reduction. For example, neither the “total” assimilation of word-final /t/ to word-initial /k/ in *that_case* nor the “partial” assimilation of word-final /s/ to word-initial /j/ in *miss_you* are categorical — the putative outputs (/k/ and /ʃ/ respectively) are typically not the same as underlying /k/ and /ʃ/ in similar contexts but rather may incorporate residual aspects of the apparently deleted /t/ and /s/. Such behaviour has also been demonstrated in a number of languages other than English: Barry (1992) on Russian; Kühnert (1993) on German; Jun (1996) on Korean; and Zsiga (1997) on Igbo.

Sardinian External Sandhi

As a result of this instrumental research, accounts of sandhi based on phonetic co-articulation are gaining acceptance. The leading model involves gestural overlap (Browman and Goldstein, 1989, 1990), in which phonetic segments are epiphenomenal, and the categorical transformation of one segment sequence into another is not predicted. In the analysis of *that case*, for example, the gestures of velar closure overlap the weakened gestures of alveolar closure and thereby mask them perceptually. This analysis explains the percept of total /t/ to /k/ assimilation while providing an account of the residual presence of gestures related to /t/. Traditional accounts deal only with the percept of assimilation.

Hayes's original feature-spreading model of assimilation provides only two possible outcomes for *that case*: no assimilation (as shown in 1a below) or complete assimilation by means of a new association to the initial consonant /k/ and the delinking and deletion of the final consonant /t/ (as seen in 1b). Since this model is not adequate for the cases of English assimilatory external sandhi, Hayes (1992), following Nolan (1992), employs two further distinct classes of phonological representation: the complex segment (1c) and the contour segment (1d). (The complex segment has two places of articulation, while the contour segment contains a sequence of opposite values of a feature F.) Both arise when associations between word-final and word-initial segments are made but *underlying links are not broken*. This is a less radical departure from traditional analyses than the gestural overlap model. It also, arguably, less convincing: first, because it relies on a phonetic component which is not specified in any detail (Nolan 1992); and second, because the use of contour segments — seldom used in underlying representations — results in a less predictive conception of “possible phonological representation” (Scobbie 1995).



Despite the obvious differences between the revised autosegmental approach and the gestural overlap model, it is important to note that both are intended to reflect the non-categorical nature of the English external sandhi mentioned above. They are also both intended to handle non-categorical word-internal phenomena, such as English stop epenthesis (Clements 1987; Browman and Goldstein 1990). In general terms, therefore, these models fit rather well into the post-lexical component of Lexical Phonology (e.g. Kiparsky 1985). While post-lexical rules are most commonly categorical, Kiparsky (1985:110) makes it clear that some post-lexical rules must be able to apply “in gradient fashion, particularly when they contravene the lexical marking conventions”. In addition, Kiparsky notes that language specific phonetic implementation might be respon-

sible for such phenomena as the devoicing of sonorants. The implication to be drawn from the various laboratory studies of gradient post-lexical phenomena mentioned above is that, indeed, some sort of language specific phonetic account is required, although the exact details of are still hotly debated. For our purposes, the revised autosegmental approach and the gestural overlap approach are equivalent in the limited sense that neither predicts that the outputs of external sandhi will fall into categories already established for lexical contrasts.

It is an empirical question whether all cases of assimilatory external sandhi, under close phonetic scrutiny, turn out to be non-categorical. Our own initial assumption was that a phonetically-based framework would provide the more appropriate analysis of the data discussed here, but our instrumental results suggest otherwise. This finding is relevant to conceptions of the phonetics/phonology interface and further confirms the importance of laboratory-based reinvestigations of phonological data.

XX.2 Sardinian lenition and gemination

The specific empirical phenomenon with which we are concerned is the external sandhi system of Sardinian, specifically Logudorese, a dialect group spoken in the north-western quarter of the island. We begin with a brief sketch of three general aspects of Sardinian phonology: first, alternations in word-initial consonants; second, the system of oppositions in (word-medial) intervocalic position, especially the status of geminates; third, alternations among word-final consonants and the system of codas in general.²

XX.2.1 External sandhi part 1: initial lenition

There are many synchronic alternations across word boundaries in Sardinian involving the intervocalic lenition of obstruents. (“Intervocalic” includes the context /V_rV/ despite the intervening rhotic.) Voiceless word-initial fricatives (2ab) are voiced when intervocalic (2a’b’). Voiceless word-initial stops (2cd), when intervocalic (2c’d’), are voiced with a weak closure.³ Voiced word-initial stops (2e), when intervocalic (2e’), disappear, leaving only vowels in hiatus. There are no word-initial voiced fricatives except in loan-words.

(2)	a. [fraɖe]	“brother”	a’.	[su’vraɖe]	“the brother”
	b. [saldu]	“Sardinian”	b’.	[su’zaldu]	“the Sardinian”
	c. [tera]	“land”	c’.	[sa’ɖera]	“the land”
	d. [kane]	“dog”	d’.	[su’gane]	“the dog”
	e. [bak:a]	“cow”	e’.	[sa.’ak:a]	“the cow”

Intervocalic lenition does not merely occur within closely linked phrases, but may (and often does) apply across quite major phonological boundaries. This is illustrated in (3), taken from unscripted recordings of one of our speakers.⁴

Sardinian External Sandhi

- (3)
- | | | |
|----|----------------------------------|----------------------------------|
| a. | [azen'tezu, gustu'entu'vritu] | |
| | /as entesu kustu bentu frittu/ | “Did you hear that cold wind?” |
| b. | [markɔva'ɛd:a'b:enɛ'gɔmɔ] | |
| | /marko faeddat bene komo/ | “Marco speaks well now” |
| c. | [markɔgere,mandi'garezu'budu] | |
| | /marko keret mandigare su puddu/ | “Marco wants to eat the chicken” |

Indeed, native speakers appear largely unaware of the effects of lenition on voiceless obstruents (2a-d), suggesting that it is a matter of “low-level” phonetic implementation. There are a few lexical exceptions (4a), but these can be treated as exceptional underlying geminates. By contrast, the alternations between initial voiced stops and zero (2e) are readily remarked on by native speakers, and there are many lexemes which do not alternate (4b).

- (4)
- | | | | | | | |
|----|------------|----------|--|-----|--------------|--------------|
| a. | [tʰia] | “aunt” | | a'. | [sa'tʰia] | “the aunt” |
| b. | [du't:ɔɾɛ] | “doctor” | | b'. | [suɖu't:ɔɾɛ] | “the doctor” |

XX.2.2 Word-medial contrasts of length and strength

In word-medial position, Sardinian sonorants display a clearly audible contrast of phonetic duration (5), signalling an underlying opposition between “long” or “geminate” vs. “short” or “singleton”.

- (5)
- | | | | | | | |
|----|-----------|---------------------|-----|--------|----------|----------------|
| a. | [bɛ:la] | “beautiful (f.sg.)” | vs. | [mɛla] | “apple” | |
| b. | [fɛru] | “iron” | | vs. | [bɛru] | “true (m.sg.)” |
| c. | [maŋ:ɔzɔ] | “big (m.pl.)” | | vs. | [manɔzɔ] | “hands” |

The same opposition is said to apply to obstruents as well (6).

- (6)
- | | | | | | | |
|----|----------|----------------|--|----|---------|---------|
| a. | [is:u] | “he” | | c. | [gat:u] | “cat” |
| b. | [lu'iza] | “Luisa (name)” | | d. | [kaɖ:u] | “horse” |
| | | | | e. | [naɖu] | “born” |

The difficulty of establishing strictly durational correlates of gemination, however, especially for stops, is well known (cf. Contini 1987:56; Jones 1988: 321). More generally, there is a close link between gemination and the intervocalic lenition described in the preceding section, such that “geminate” is essentially equivalent to “not lenited”. For fricatives there is only a two-way lexical contrast, between a long voiceless geminate fricative and a short voiced lenited one, e.g. [s:] vs. [z] (6a,b). For stops, there is a three-way distinction: between voiced and voiceless “geminates” on the one hand, which are clearly articulated as stops and may be of long duration, and a short voiced weakly articulated obstruent (a lenited stop?) on the other, e.g. [t:] vs. [d:] vs. [ɖ] (6c-e). The weakly articulated obstruent in (6e) is apparently identical to the lenited intervocalic alternant of initial voiceless stops seen in (2c', d') above.

XX.2.3 External sandhi part 2: word-final consonants

The close link between gemination and lenition just illustrated becomes even clearer when we consider word-final consonants. Sardinian has four such consonants, /t s n r/, but they are subject to a rich set of alternations caused by severe restrictions on codas.

XX.2.3.1 Prevocalic position

When a word ending in a consonant is followed in a phrase by a vowel-initial word, intervocalic lenition of obstruents takes place (7), exactly as in (2) above. Since sonorants do not lenite, /n/ and /r/ simply appear as [n], [r].

- (7) a. [beniɖin'domɔ] /benit in domo/ "s/he comes in the house"
 b. [treza'migɔzɔ] /tres amigos/ "three friends"

Furthermore, in phrase-final position, the word-final consonant is normally followed by a so-called "paragogic" vowel, which in quality is a copy of the immediately preceding vowel. This vowel, though it may be whispered or otherwise weakly articulated, has the effect of making the final consonant intervocalic (8), thereby leniting it if it is an obstruent (/s/ or /t/). Since citation forms are phrase-final, no citation form ends in a consonant.

- (8) a. [beniɖi] /benit/ "s/he comes"
 b. [benini] /benin/ "they come"
 c. [kanɛzɛ] /kanez/ "dogs"

XX.2.3.2 Preconsonantal position

When a word ending underlyingly in a final consonant is followed by a word which is consonant-initial, the potential for a consonant sequence arises. Some such abutting clusters are potentially "fake geminates" (Hayes 1986), i.e. sequences of identical consonants (9). Obstruent fake geminates (9a) are voiceless: sonorant fake geminates (9b) are impressionistically of long duration.

- (9) a. [sɔs:antɔzɔ] /sos santos/ "the saints"
 b. [ɪn:nuɔɔ] /in nuoro/ "in Nuoro"

Phonetic consonant sequences appear phonetically when a word-final continuant (/s/ or /r/) is followed by a non-identical consonant. Note that the contrast between /s/ and /r/ is neutralised in this context; both are realised phonetically as [s] before /p t k/ and /s/, and as [l] elsewhere (10). We introduce here the term "variable continuant coda" to refer to neutralisable /s/ and /r/.

- (10) a. [treɪlmanɔzɔ] /tres manos/ "three hands"
 b. [bat:ɔl'fraɖɛzɛ] /battor frades / "four brothers"
 c. [sɔs'puɖ:ɔzɔ] /sos puddos / "the chickens"

Sardinian External Sandhi

Sequences of /n/ plus obstruent (11) are most often realised as homorganic sequences of nasal plus obstruent.

- (11) [sumbɛs:iɖɔzɔ] /sun bessidos/ “they have gone out”

However, in some external sandhi consonant sequences, there is apparently total assimilation of the final consonant to the initial consonant, giving rise to “geminate”. This occurs with the final /t/ of 3rd person singular verb endings and to the final /n/ of the negative particle /non/. If the following word-initial consonant is a sonorant, the resulting “geminate” is durationally long, like the lexical geminate sonorants. If it is an obstruent, the “geminate” is of indeterminate duration, but it is voiceless and, if it is a stop, it is fully articulated as such. That is, *it is protected from lenition even though it is intervocalic*. Such cases are shown in (12). In what follows, we refer to these non-lenited apparent geminates in external sandhi contexts as “post-lexical geminates” (PLGs).

- (12)
- | | | | |
|----|-------------------|-------------------|---------------------|
| a. | [am:andɪ'gaɖu] | /at mandigadu/ | “s/he ate” |
| b. | [ap:ɔmandɪ'gaɖu] | /appo mandigadu/ | “I ate” |
| c. | [a'fatu] | /at fattu/ | “s/he did” |
| d. | [ap:ɔvat:u] | /appo fattu/ | “I did” |
| e. | [af:æɛ'd:adu] | /at faeddadu/ | “s/he spoke” |
| f. | [nɔ'f:age'n:uɖ:a] | /non faget nudda/ | “it doesn't matter” |

The analysis of PLGs as true geminates is supported by the existence of a handful of proclitic function words apparently ending in a vowel which behave nevertheless as if they end in a consonant when they are followed by a word which itself begins with a consonant. Specifically, they protect the following word-initial consonant from lenition. This behaviour is generally analysed as the reflex of a final phantom consonant or empty skeletal slot (e.g. Bolognesi, 1998), which gives rise to the gemination of the following word-initial consonant. Contrast the preposition /a^C/, which contains the phantom (13a), with the truly vowel-final preposition /dae/ (13b).

- (13)
- | | | | |
|----|---------------|--------------------------|----------------|
| a. | [ap:a'leɾmɔ] | /a ^C palermo/ | “to Palermo” |
| b. | [daeɸa'leɾmɔ] | /dae palermo/ | “from Palermo” |

XX.2.4 The categorical status of post-lexical geminates

The facts just sketched are germane to the issues raised in the introduction. Specifically, they raise the question of whether the PLGs — the durationally long sonorants and unlenited obstruents that arise in sandhi contexts (examples 9, 12, 13) — can be identified with the word-medial lexical geminates (5, 6). A traditional analysis (e.g. Pittau 1991) would treat the total assimilation cases in (12, 13) as involving the creation of segments that are categorically identical to underlying word-medial geminates. Such an analysis is readily translated into the traditional autosegmental notation, using feature spreading and delinking (14):



The categorical-identity analysis is supported by impressionistic phonetic observations: there is a clearly perceptible difference in duration between the PLG [m:] in (12a) and the singleton [m] in (12b), just like the lexical contrast. Similarly, the PLG [f:] in (12c) — represented autosegmentally in (14) — is clearly voiceless even though it is phonetically intervocalic, while the fricative in (12d) is voiced and somewhat shorter, again like the lexical contrast.

One can equally well conceive, however, of a gestural (or revised autosegmental) account of PLGs, in which word-final and word-initial consonants overlap, producing a surface segment that is unlenited (because it is not truly intervocalic) and of relatively long duration. It would thereby resemble word-medial geminates phonetically without being the same phonologically. In some cases this analysis seems highly appropriate: we sometimes observe audible nasalisation on the vowel preceding the final /n/ of the prepositions /in/ ‘in’ and /kun/ ‘with’, although the /n/ itself has apparently assimilated to the following consonant (15). Such behaviour is typical of gestural overlap.⁵

- (15)
- | | | | |
|----|-------------------------------|----------------|--------------------|
| a. | [kus:u'vraðe] ~ [kūs:u'vraðe] | /kun su frade/ | “with the brother” |
| b. | [is:a'ida:a] ~ [ɿs:a'ida:a] | /in sa bidda/ | “in the village” |

However, the negative particle /non/ (12f) never gives rise to observable residual nasalisation: is not clear how a gestural account would deal with this kind of lexical sensitivity. Other challenges for a gestural approach are: first, the final alternation involving /s/ and /t/, which does not seem reducible to gestural weakening; second, the fact that final consonants other than /n/ do not reveal any residual quality or quantity; and third, the phantom consonant (13).

The discussion so far, like much of the literature, represents the phonetic data in terms of segmental transcriptions. Yet it has been on the basis of instrumentally measurable phonetic properties, not transcription, that investigations of English external sandhi have discovered that post-lexical segments arising from assimilation are *not* the same as lexical segments. The patterns of external sandhi in Sardinian are therefore an obvious candidate for instrumental study.

XX.3 The Experimental Study

XX.3.1 Introduction

Our instrumental measurements are based on recordings of three speakers, MS, LS, and MT, of whom LS is our main experimental speaker.^{6,7} Creating con-

trolled speech materials was made difficult by the fact that there is no standard orthography for Sardinian. For MS, we wrote sentences in English, which she translated silently and then spoke aloud. This procedure worked reasonably well, though it meant that we did not always get the Sardinian forms we were anticipating. However, LS and MT do not speak English, and we did not want to elicit Sardinian by presenting sentences written in Italian, due to the potential for cross-language interference. For LS, we were able to use an Italianised version of the phonemic transcriptions given in this paper, essentially the same as the orthography used by Pittau (1991). LS had no trouble producing fluent utterances from these materials. MT found Pittau's system too abstract: if word-final *t* and *n* were present orthographically before a consonant, MT would produce a string of citation forms complete with paragogic vowels, or simply get confused. We therefore altered the orthography by removing *t* and *n* in these cases, making it more phonetically transparent. MT's results appear compatible with LS's, but we do not report them here.

Our experimental work focuses on two related questions: whether *post-lexical* geminates are of comparable duration to *lexical* geminates; and whether the word-medial *contrast* between singleton and geminate is comparable to the word-initial *alternation* between lenited and "protected" consonants. In a preliminary study (Ladd and Scobbie 1996) we reported on semi-systematic recordings of MS and LS. Our preliminary conclusion, later cited by Bolognesi (1998:159), was that *post-lexical geminates are on average rather shorter than lexical geminates*. Consequently we favoured an analysis employing gestural overlap.

However, there is a problem with this conclusion, namely that the prosodic context of the typical PLG is quite different from that of the typical lexical geminate. PLGs are word-initial and therefore by definition they precede the lexically stressed syllable. Lexical geminates, on the other hand, are most commonly encountered immediately following lexically stressed vowels. Moreover, because underlying geminates (with one or two marginal exceptions) never occur in word-initial position, they will always occur nearer to the end of the word than PLGs. Both of these factors — position relative to stress, and position in word — seemed to have substantial effects on duration in our preliminary data, especially at the end of an utterance: *ceteris paribus*, post-tonic consonants are longer than other consonants, and consonants at the end of a word are longer than medial ones. We also discovered that phrase-final post-tonic consonants should be subdivided into (a) those which were absolutely the last consonant in the phrase (because they were heavily lengthened in words like /manu, mannu, issu, fattu, kaddu/) and (b) all others. We do not have the space to report further details but see Tables XX.1 and XX.2 below.

In the experiments reported here we have thus tried to use materials in which the lexical geminates and the putative PLGs occur in the same prosodic context.

However, there is a potentially significant dilemma here — the workings of the language make it almost impossible to design such materials. That is, our preliminary conclusion may well have been an “artefact” of our experimental materials, yet it does nevertheless represent a valid observation about Sardinian phonetics. The statistical patterns of the language are not the same as the structural patterns. Clearly, both need to be considered as we work toward an understanding of the phonology/phonetics interface and the utility of an experimental approach to phonology (cf. Pierrehumbert, Hay and Beckman’s paper in this volume).

Experiment 1 deals with post-lexical geminates and lexical geminates, comparing them to each other and to the relevant singletons. Experiment 2 is a follow up in which we consider post-lexical and word-medial underlying consonant sequences.

XX.3.2 Experiment 1: geminates and singletons

XX.3.2.1 Method

Our materials were a set of 120 sentences, read aloud twice. Alveolar nasals were chosen as representatives of the sonorants: the materials elicited singleton and geminate /n/ in word-medial position, and intervocalic word-initial /n/ in both lenited and nonlenited (PLG) alternants. Obstruents were also mostly represented by alveolars. Initial /f/ and /m/ in putative PLG environments were also included (permitting comparison with the post-lexical sequences of Experiment 2). The word-final consonants which gave rise to PLGs were contained in /non/ ‘not’, /a^C/ ‘to’, /at/ ‘have-3rdsg’, and /as/ ‘have-2ndsg’.

We were careful to provide a variety of prosodic contexts for the consonants. Specifically, consonants appeared either immediately preceding the lexically stressed vowel (“tonic onset”), immediately following it (“post-tonic”) or elsewhere (“non-tonic”). Additionally, we distinguished between phrase-medial and phrase-final position. Unless mentioned, all consonants were phonetically intervocalic, and none were utterance-initial.

Consequently, we do not collapse prosodic position in reporting our results of mean consonantal duration, as we did in Ladd and Scobbie (1996). (We do, however, combine PLGs resulting from “fake geminate” sequences like /s#s/ or /t#t/ with those resulting more clearly from assimilation, such as /t#s/.) This strategy often results in only small numbers of tokens in each cell, which makes statistical analysis inappropriate, especially given the fact, mentioned in Section XX.3.1, that the language makes it impossible to fill all the cells in a full factorial design. Nevertheless, many of our crucial conclusions are supported by t-tests on selected pairs of means. In Experiment 2 we have enough tokens in each

cell to make the reporting of standard deviations appropriate. Otherwise, only the number of tokens is indicated in the tables of results along with the mean.

XX.3.2.2 Results and Discussion

The durational basis of medial gemination in sonorants is illustrated in Table XX.1 for /n/ vs. /nn/. Singleton /n/ has approximately half the duration of /nn/, a ratio that remains stable despite the effect of prosodic position on absolute duration. The singleton/geminate contrast is comparable, in absolute and relative terms, to the word-initial alternation between intervocalic [n] and post-lexical geminate [n]: word-initial singleton /n/ is about half the duration of the post-lexical geminate.⁸

Table XX.1. Mean duration (ms) of alveolar nasals. Initial nasals are tonic onset; medial nasals are post-tonic. The number of tokens is in italics.

Position	Init. /n/ [n]	PLG /n/ [n:]	Med. /n/ [n]	/nn/ [n:]
Non-tonic	58 , 2	83 , <i>12</i>		
Phrase-medial, tonic	62 , 3	111 , 5	48 , <i>11*</i>	100 , 9
Phrase-final, tonic	55 , 2	130 , 8	55 , 2	139 , 3
Last consonant in phrase			78 , <i>13</i>	165 , 1

*Also, tonic *onset* /n/ was 52ms, *n*=10.

Table XX.2. Duration (ms) of word-medial obstruents.

Position	[d]	[d:]	[t]	[z]	[s:]
Non-tonic			97 , 2		132 , 5
Phrase-medial, tonic onset		79 , <i>18</i>			
Phrase-medial, post-tonic	55 , <i>15</i>	79 , 3	99 , <i>35</i>		138 , <i>12</i>
Phrase-final, tonic onset			121 , 7		
Phrase-final, post-tonic		129 , 9	133 , <i>14</i>		182 , 5
Last consonant in phrase	62 , 8	153 , 9	203 , 4	135 , 8	194 , 2

The word-medial obstruent system is illustrated in Table XX.2. Consider the stops first. The stops [d:] and [t:] have a fairly stable of duration ratio of nearly 1:1, suggesting they could both be analysed as geminate. This leaves the much

shorter [d̥] as a likely singleton, though whether it is to be analysed as /t/ or /d/ is problematic. On either analysis the putative geminate/singleton ratio is highly variable across prosodic context, being largest (and most noticeable) word- and phrase-finally, e.g. in citation versions of many words (6c-e). The medial [d̥] (Table XX.2) is comparable in duration to lenited word-initial singleton /t/ and /d/ (Table XX.3). Table XX.3 also indicates that PLG word-initial /t/ is comparable to putative medial geminate /tt/ (Table XX.2). Consequently, our conclusion about the nasals is applicable to stops too: the contrast between medial geminate and singleton is categorically the same as the initial alternation between lenited singleton and PLG.

Table XX.3. Duration (ms) of word-initial coronal stops.

Position	/t/ [d̥]	/d/ [d]	PLG /t/ [t]
Non-tonic	46, 4	48, 6	100, 6
Phrase-medial, tonic onset	49, 12	55, 8	
Phrase-final, tonic onset	55, 4	56, 6	119, 13

We only have a small amount of data on the medial fricative contrast (Table XX.2), but rather more information on word-initial /s/ (Table XX.4). Lenited /s/ and /f/ are fairly short, while PLG [s:] is comparable to the medial geminate.

Table XX.4. Duration (ms) of word-initial lenited /f/ & /s/, and of PLG [s:].

Position	[v]	[z]	as#s	non#s	at#s	a ^c #s
Phrase-medial, non-tonic	75, 5	87, 43	143, 8		140, 6	122, 7
Phrase-medial, tonic onset	69, 11			152, 6	153, 4	
Phrase-final, tonic onset	95, 2					156, 8

Our conclusion based on these data is that structurally *there is a clear durational equivalence between lexical and post-lexical geminates*. Our results therefore confirm the position which Sardinian native speaker linguists have generally taken for granted (e.g. Pittau, 1991; Bolognesi, 1998; Molinu, 1998). The PLGs resulting from external assimilation in Sardinian are not like the phonetic coarticulation cases in English discussed above. Rather, in the majority of

cases there appears to be a categorical alternation word-initially between singletons and geminates, the same categories that are contrastive word-medially. Word-final consonants alternate, on the whole, with zero — they do not condition the residual extra duration which, as Browman (1995) has argued, occurs in English when extreme gestural overlap leads to the apparent deletion of the word-final consonant.

XX.3.3 Experiment 2: coda-onset sequences

XX.3.3.1 Introduction

As mentioned in Section XX.2, there are cases in which word-initial consonants are protected from lenition by a preceding word-final consonant that is *overtly present* phonetically. It is present as residual nasalisation in the case of final /n/, and as an (unassimilated) independent segment in the case of variable continuant codas /s/ and /r/. Recall that these final continuants surface as [l] in some cases, such as before /f/ (16a), and as [s] before a word-initial voiceless stop (16b). It is clear that a complete examination of how initial segments are protected from lenition requires that, in addition to considering post-lexical geminates (16cd), we must look at the post-lexical sequences and their relationship to word-medial lexical ones (cf. Molinu ms).

(16)	a. [alfatu]	/as fattu /	“you [sg] made”
	b. [sɔskɑdːɔzɔ]	/sos caddos/	“the horses”
	c. [afiatu]	/at fattu/	“s/he made”
	d. [nɔfiagɛɖɛ]	/non faget/	“it doesn’t make”

Presumably post-lexical sequences such as [lf] and [sk] are structurally coda-onset, with the onset being an unlenited singleton segment. In the categorical autosegmental analysis illustrated in (14), such protected singletons should be comparable in duration (all things being equal) to other singletons, and not to PLGs. This is because PLGs are formed by double linking as the result of assimilation. In the post-lexical sequences there is no assimilation and no double linking, and there should therefore be no geminate duration.

XX.3.3.2 Method

In the dataset prepared for Experiment 1 we were able to include only a few materials eliciting post-lexical sequences. Specifically, we collected data on final /n/ before /s/, and on final /s/ before initial /f/. As with the other materials, it was not possible to get tokens in all environments. For example, *medial* [lf] sequences are very rare and are mostly loans, so were not suitable for analysis. Note also that though there is preconsonantal neutralisation of word-final /s/ and /r/, there is no such neutralisation word-medially (illustrated by the near-minimal pair [oltu] /ortu/ ‘garden’ vs. [postu] /postu/ ‘place’). Consequently we

collected no materials on medial sequences at this stage. Ultimately, however, supplementary material from LS was collected to enable comparison between medial and initial consonant sequences. The sequences used were [lm] and [s] before voiceless stops, and the second consonant was always tonic onset.

XX.3.3.3 Results and Discussion

At the time of the oral version of this paper, the post-lexical [lf] sequences were the only cases of variable continuant coda plus onset included purposely in the materials. Contrary to our expectations, the singleton fricative in /s#f/ [lf] (on the fourth row of Table XX.5) is *comparable* in duration to the PLG in /t#f/ and /non#f/, previously transcribed [f]. One possible explanation would be that both structures conditioning word-initial [f] (sequence and PLG) do so in the same way. Since gemination cannot be responsible for lengthening in the sequence, we considered the possibility that some sort of domain-initial strengthening of a singleton was responsible in PLGs and singletons alike. In fact, there is in fact no single source of [f], as our results comparing initial and medial sequences, given below, make clear.

Table XX.5 Duration (ms) of phrase-medial word-initial /f/, /n/, /m/ in intervocalic position and when following word-final /t/, /n/ and /s/.

context	f	non-tonic	tonic	n	non-tonic	tonic	m	non-tonic	tonic
vowel	v	75, 5	69, 11		58, 2	62, 3		67, 2	72, 2
/t/	f	127, 7	137, 4		112, 3			96, 5	
/non/	f	142, 2	125, 8						104, 5
/s/ [l]	f	121, 5	138, 2		128, 2			78, 4	

Before reporting the results for such comparisons, we will make use of post-lexical sequences which happened to be contained in the materials prepared for Experiment 1. There were a handful of examples of two further post-lexical sequences, namely /s#n/ and /s#m/. From Table XX.5 it appears that word-initial /m/ is rather different from /f/. At 78ms, the duration of post-lexical (non-tonic) [m] in a sequence is *intermediate between singleton and PLG*. These data are worth reporting, since in the supplementary materials we targeted medial [lm] sequences and both post-lexical sources of [lm] (namely /s#m/ and /r#m/).

Table XX.6 confirms the result in Table XX.5 that word-initial /m/ following a variable continuant coda is intermediate in duration between intervocalic singletons (72ms) and PLGs (104ms). Moreover, the duration of word-medial and word-initial /m/ (and [l]) is comparable, just as was observed for PLGs and

Sardinian External Sandhi

geminates. Table XX.6 and Table XX.5 make a strong case that lexical and post-lexical [lm] sequences contain a singleton /m/ which has a somewhat greater duration (as measured by acoustic segmentation) than an intervocalic singleton. Since this greater duration is not domain-initial, it cannot be implicated in the external sandhi system.

Table XX.6. Duration (ms) of variable continuant coda + /m/ (n=8) and word-medial /lm/ (n=9). NB, the figures in parentheses are standard deviations.

Position	[l]	[m]
Word-initial, phrase-medial, tonic onset	70 (11)	92 (10)
Word-medial, phrase-medial, tonic onset	67 (11)	89 (8)

Table XX.7 demonstrates that post-lexical sequences of variable continuant coda and voiceless stop are also comparable in duration to medial sequences (of invariant /s/ and voiceless stop). Fricative duration, stop closure duration and VOT are very similar in each condition.

Table XX.7. Duration (ms) of variable continuant coda + voiceless stop (n=13) and word-medial /s/ + voiceless stop (n=10). Standard deviations in parentheses.

Position	[s]	closure	VOT
Word-initial, phrase-medial, tonic onset	81 (14)	72 (11)	23 (13)
Word-medial, phrase-medial, tonic onset	85 (17)	68 (8)	29 (12)

Structurally, the stops are most plausibly singletons. Comparison with Table XX.3 indicates that these tonic singletons are *shorter* in duration than PLGs and the medial geminate [t:] (/tt/), and comparison with Tables XX.2 and XX.3 indicates that the singleton stops following [s] are *greater* in duration than the voiced lenited allophone of singleton /t/ (initial and medial). In other words, voiceless stops following [s] are intermediate in duration between PLGs and singletons. These results confirm that the behaviour of /m/ reported in Table XX.6 is not an aberration. In fact, it is the behaviour of /f/ (and the two tokens of /n/) in Table XX.5 which is difficult to explain. It may be that unlenited [f] is simply inherently of greater duration in all contexts, and that (if the two tokens

that we have measured are representative) it is the homorganicity of the [ln] cluster which leads to a geminate-like [n:]. Clearly, these results remain problematic and require further investigation.

Note that word-final [s] (from underlying /s/ or /r/) is a great deal shorter than medial /ss/ (even non-tonic /ss/) and PLG /s/. In fact, this singleton segment is entirely comparable in duration with initial and medial [z], a final piece of evidence in favour of the analysis of [z] as the lenited allophone of singleton /s/.

Finally, we return to materials collected at the same time as Experiment 1 in order to consider the case of final /n/, present in a few words such as the prepositions /kun/ ‘with’ and /in/ ‘in’. Final /n/ may condition residual nasalisation in some tokens, and hence is a prime candidate for a gestural overlap analysis. As far as we can tell, on the basis of a few tokens (Table XX.8), the duration of /s/ following final /n/ is intermediate between lenited singletons and PLGs. (Note also that protected /f/ following /in/ was only 89ms ($n=2$) in phrase-medial non-tonic position.) Just as in the more overt sequences [sp st sk] and [lf lm ln], the initial consonant in these /n#s/ cases seems to be a slightly lengthened singleton, though a closer analysis is clearly required.

Table XX.8. Duration (ms) of word-initial /s/. Number of tokens in italics.

Prosodic position	/kun#s/	/in#s/
Phrase-medial, non-tonic	105 , 5	110 , 6
Phrase-medial, tonic onset		130 , 2
Phrase-final, tonic onset		141 , 4

In summary, in post-lexical position, therefore, initial voiceless stops (following [s]) and /m/ (following [l]) are not lenited, because they are not intervocalic, and at the same time they are not geminates, because the preceding word-final consonant has not assimilated to them totally. They are unlenited singletons, which, because they are part of a cluster, are intermediate in duration between lenited singletons and geminates. The place and manner of the initial consonant appear to affect the extent of this increase in duration quite markedly. Similarly, final /n/ protects a following consonant from lenition even though /n/ is only present impressionistically in the form of a little residual nasalisation. The only information we have on a consonant following /n/ realised in this way relates to /s/: as we would now expect, it appears to be a singleton whose duration is intermediate between intervocalic singletons and post-lexical geminates. We conclude that coda-onset sequences do not involve categorical post-lexical assimilation.

XX.4 Summary and conclusions

When prosodic context is controlled for, the absolute duration of post-lexical geminates is very similar to that of lexical geminates. The ratios of medial geminate to singleton and word-initial PLG to singleton are also similar. This is true for sonorants, which have two clearly distinct durational categories, *and* for obstruents, in which the singleton category is expressed mainly through lenition, and the geminate category is not particularly long but is unlenited. The similarity between medial and initial position extends to consonant sequences.

From these results we conclude two things. First, we argue that gestural overlap is on the whole *not* a suitable model of most of the assimilatory external sandhi phenomena in Sardinian, and more generally that accounts of gestural overlap in some cases of English external sandhi cannot be carried over into all aspects of post-lexical phonology. The major difference between Sardinian and English is that Sardinian final consonants are generally lost with no residual effect on acoustic consonant duration and no observable residual effect on quality. In English assimilatory external sandhi, as noted above, some residual duration from “deleted” word-final consonants can be detected even when there is no residual quality (Browman 1995). Such tokens have also been used as evidence that gestural overlap and reduction are not exclusively responsible for external sandhi in English (Nolan and Holst 1995; Holst *et al.* 1996), but such examples generally appear at one extreme of a continuous spectrum of behaviour (though see Ellis and Hardcastle 1999). Phonetic variability of this type, which is so characteristic of English sandhi (cf. Browman 1992), is not seen in Sardinian.

Our second major conclusion arises from the fact that the *alternation* between post-lexically lenited and post-lexically protected word-initial consonants is phonetically comparable (in transcription and in acoustic segment duration) to the phonological word-medial *contrast* between singletons and geminates, in both sonorants and obstruents. We conclude that it is possible to make identifications of phonetic segment type across different positions in structure.⁹ We therefore support the theory that a language has a single phonological system of recurring categories, and find against a strict interpretation of the Firthian notion of polysystematicity (e.g. Robins 1957). These categories are not, however, necessarily phonemic at every place in structure: allophonic alternations which appear in post-lexical alternations may make use of the *same categories* as were established for phonological contrasts elsewhere in the system. For stops, for example, a three term medial system has, as its phonetic exponents, certain constellations of gestures (i.e. segments) which function also to express a word-initial two term system of contrast and the post-lexical alternation between singleton and geminate arising from external sandhi.

One model of this categorical identity across different places in structure and between systems with different numbers of contrasting members is a phonological (specifically, autosegmental) one, in which feature spreading and delinking

generate multiply-associated structures that are the same as underlying geminates (Hayes 1986, and, specifically for Sardinian, Bolognesi 1998, Molinu 1998). This model, illustrated in (14), is sufficient for fake geminates, the phantom consonant and final consonants generally. The only obvious problem is the residual nasalisation resulting from “assimilated” final /n/, which might be taken as motivating an extended autosegmental model using complex and contour segments (Hayes 1992). However, we have already reviewed briefly the arguments against such an extension (cf. Nolan 1992; Scobbie 1995; Zsiga 1997), and instead we favour a mixed analysis of external sandhi involving only simple phonological processes combined with gestural overlap. In Sardinian, gestural overlap will be *exclusively* responsible for the residual nasalisation cases. The categorical cases have a language-specific gestural component too, to account for the phonetic characteristics of intervocalic singleton obstruents and the effects of prosodic position. At heart, though, the external sandhi system of Sardinian is truly phonological.

Acknowledgements

Our first debt is to our speakers, Luisa Sorace, Monica Tarantini, and Marcella Sardu. Luisa in particular has spent many hours answering questions and making recordings, well beyond the call of the family duty that results from having one of the authors (DRL) as her son-in-law. We are also grateful to Roberto Bolognesi and Lucia Molinu for comments, encouragement, and practical assistance in creating materials, and to Steven Bird, Mike Broe, Nick Clements and Lucy Ellis for discussion at various points between 1993 and 1999. Extensive comments on a draft of this paper, from Amalia Arvaniti, Roberto Bolognesi, and an anonymous referee are gratefully acknowledged. This is a joint paper, and the authors names are listed alphabetically. We blame each other for any errors or other shortcomings in the paper.

Endnotes

- ¹ Ellis and Hardcastle (1999) show that this may be over-simplistic. In their study of English assimilatory external sandhi, some speakers never assimilate, while others show total assimilation in all cases. Crucially, there are also speakers who have variable output, and while some appear to vary the amount of coarticulation gradually, others appear to vary *categorically* between no assimilation and total assimilation. The implications of Ellis and Hardcastle’s study are somewhat similar to our own.
- ² The phenomena addressed here have been extensively described elsewhere, in part because they pose problems for the classical conception of the phoneme (cf. Lütke 1953). We summarise only the most relevant aspects here. For an excellent short

sketch of Sardinian in general, including the current sociolinguistic situation, see Jones (1988). The classic works on the language are by Wagner (e.g. 1941, 1951, 1960-64). Recent traditional grammars are Blasco Ferrer (1986) and Pittau (1991). A comprehensive instrumental phonetic study of Sardinian dialectology is Contini (1987). There are two recent book-length accounts, of syntax (Jones 1993) and phonology (Bolognesi 1998). A useful general resource is Mensching (12/10/1999).

- ³ Lenited /p/ is something like [b]~[β], /t/ is [d]~[ð], and /k/ is [g]~[ɣ]. In (2c'-d') and henceforth we use the symbols [b̥ d̥ g̥] to indicate the weak occlusion and phonetically variable quality of intervocalic "stops".
- ⁴ The retracted diacritic in [d̠:] [n̠:] and [ŋ̠] indicates retroflex articulations; see footnote 5. See Section XX.2.2 on the phonetic basis for our use of the length diacritic. The realisation of the sequences of underlying final /t/ and word-initial consonants in (4b) and (4c) are discussed in Section XX.2.3.2 below.
- ⁵ Further evidence against treating PLGs and lexical geminates as completely equivalent comes from the fact that lexical /dd/, /nn/ and /nd/ are retroflex or apico-alveolar while the corresponding post-lexical sequences are lamino-dental (Pittau 1991). The status of retroflexion in Sardinian and various southern Italian dialects (e.g. Sicilian) is a well-known problem which is unfortunately beyond the scope of this paper.
- ⁶ Two of the speakers, LS and MT, are elderly women, sisters, from Pozzomaggiore (some 40km south of Sassari, in the Common Logudorese dialect region) but now both living in Rome. They use Sardinian with each other in daily visits or telephone conversations but Standard Italian in the rest of their daily lives. MS is a woman in her thirties from Bosa (on the coast, west of Pozzomaggiore), but who works as an English teacher in Sassari. As with most younger speakers, her lexicon is more Italianised than LS's and MT's but she is nevertheless a fluent native speaker.
- ⁷ The experimental recordings were made on professional equipment in the Department of Theoretical and Applied Linguistics at Edinburgh University. Acoustic analysis of segment duration (using standard annotation strategies) from the digitised recordings was done using the Kay Elemetrics Multispeech system, in the Department of Speech and Language Sciences at Queen Margaret University College, Edinburgh.
- ⁸ We also have a little data on initial /m/ but not medial /m/ (or /mm/, which is rare). In phrase-medial position, non-tonic /m/ is 67ms (n=2), while the PLG is 96ms (n=5). Tonic onset /m/ is 72ms (n=2) while the PLG is 115ms (n=8). Phrase-finally, non-tonic /m/ is 71ms (n=2) and tonic /m/ is 63ms (n=10). The ratio of singleton to PLG is therefore smaller than for /n/, but since we have no information on medial /mm/ we do not know whether this is also true of the lexical contrast. See also Table XX.5.
- ⁹ Phonetic similarity does not necessarily indicate phonological identity, of course, and nor does phonological identity guarantee phonetic similarity. As we remarked in Section XX.3.1, the statistical and prosodic patterns of a language operate together to reduce the superficial phonetic similarity of structurally different versions of the same category. It is precisely because the prosodic contexts for initial and medial consonants are not typically comparable that, *on average*, Sardinian PLGs are shorter than lexical geminates.

References

- Barry, M.C. 1985. A palatographic study of connected speech processes. *Cambridge Papers in Phonetics and Experimental Linguistics* 4, 1-16.
- Barry, M.C. 1992. Palatalisation, assimilation and gestural weakening in connected speech. *Speech Communication* 11, 393-400.
- Blasco Ferrer, E. 1986. *La Lingua Sarda Contemporanea. Grammatica del Logudorese e del Campidanese. Norma e Varietà dell'uso: Sintesi Storica*. Cagliari: Edizioni della Torre.
- Bolognesi, R. 1998. *The Phonology of Campidanian Sardinian: A Unitary Account of a Self-Organizing Structure*. The Hague: Holland Institute of Generative Linguistics. HIL Dissertations, no. 38.
- Browman, C.P. 1992. Comments on chapter 10. In G.J. Docherty and D.R. Ladd (eds.), *Papers in Laboratory Phonology II. Gesture, Segment, Prosody*. Cambridge: Cambridge University Press, 287-289.
- Browman, C.P. 1995. Assimilation as gestural overlap: comments on Holst and Nolan. In B. Connell and A. Arvaniti (eds.), *Phonology and Phonetic Evidence. Papers in Laboratory IV*. Cambridge: Cambridge University Press, 334-342.
- Browman, C.P. and L.M. Goldstein. 1989. Articulatory gestures as phonological units. *Phonology* 6, 201-251.
- Browman, C.P. and L.M. Goldstein. 1990. Tiers in articulatory phonology, with some implications for casual speech. In J. Kingston and M.E. Beckman (eds.), *Papers in Laboratory Phonology I. Between the Physics and Grammar of Speech*. Cambridge: Cambridge University Press, 341-376.
- Clements, G.N. 1976. The autosegmental treatment of vowel harmony. In W.U. Dressler, O.E. Pfeiffer and T. Herok (eds.), *Phonologica 1976*. Innsbruck: Institut für Sprachwissenschaft der Universität Innsbruck, 111-119.
- Clements, G.N. 1987. Phonological feature representation and the description of intrusive stops. In A. Bosch, B. Need and E. Schiller (eds.) *Papers from the 23rd Annual Regional Meeting of the Chicago Linguistic Society. Part 2: Parasession on Autosegmental and Metrical Phonology*. Chicago: CLS, 29-50.
- Contini, M. 1987. *Etude de géographie phonétique et de phonétique instrumentale du sarde*. Alessandria: Edizioni dell'Orso.
- Ellis, L. and W.J. Hardcastle (1999) An instrumental study of alveolar to velar assimilation in fast and careful speech. *Proceedings of the XIVth International Congress of Phonetic Sciences*. Volume 3, 2425-2428.
- Goldsmith, J. 1979. The aims of autosegmental phonology. In D.A. Dinnsen (ed.), *Current Approaches to Phonological Theory*. Bloomington: Indiana University Press, 202-222.
- Hayes, B. 1986. Assimilation as spreading in Toba Batak. *Linguistic Inquiry* 17, 467-499.
- Hayes, B. 1992. Comments on chapter 10 [i.e. Nolan (1992) – DRH & JMS]. In G.J. Docherty and D.R. Ladd (eds.), *Papers in Laboratory Phonology II. Gesture, Segment, Prosody*. Cambridge: Cambridge University Press, 280-286.
- Holst, T. and F. Nolan. 1996. The influence of syntactic structure on [s] to [ʃ] assimilation. In B. Connell and A. Arvaniti (eds.), *Phonology and Phonetic Evidence. Pa-*

Sardinian External Sandhi

- pers in Laboratory IV*. Cambridge: Cambridge University Press, 315-333.
- Jun, J. 1996. Place assimilation is not the result of gestural overlap: evidence from Korean and English. *Phonology* 13, 377-407.
- Jones, M. 1988. Sardinian. In M. Harris and N. Vincent (eds.), *The Romance Languages*. London: Routledge, 314-350.
- Jones, M. 1993. *Sardinian Syntax*. London: Routledge.
- Kühnert, B. 1993. Some kinematic aspects of alveolar-velar assimilations. *Forschungsberichte des Instituts für Phonetik und Sprachliche Kommunikation der Universität München (FIPKM)* 31, 263-272.
- Ladd, D.R. and J.M. Scobbie. 1996. Sardinian geminates. Oral paper presented at British Association of Academic Phoneticians Colloquium, University of York.
- Lüdtke, H. 1953. Il sistema consonantico del sardo logudorese. *Orbis* 2, 411-422
- Mensching, G. 1994. *Einführung in die Sardische Sprache* (3rd edition).
- Mensching, G. (12/10/1999) *Limba e Curtura de sa Sardigna / Sardinian Language and Culture*. [WWW site] <http://www.spinfo.uni-koeln.de/mensch/sardengl.html>
- Molinu, L. 1998. *La syllabe en sarde*. Unpublished PhD Thesis, Université de Grenoble.
- Molinu, L. ms. Il raddoppiamento fonosintattico in sardo: un esempio di analisi sperimentale e fonologica. Université de Grenoble III (1998).
- Nolan, F. 1992. The descriptive role of segments: evidence from assimilation. In G.J. Docherty and D.R. Ladd (eds.), *Papers in Laboratory Phonology II. Gesture, Segment, Prosody*. Cambridge: Cambridge University Press, 261-280.
- Nolan, F., T. Holst and B. Kühnert. 1996. Modelling [s] to [ʃ] accommodation in English. *Journal of Phonetics* 24, 113-137.
- Pierrehumbert, J.B., J. Hay and M. Beckman. This volume. Speech perception, well-formedness and lexical frequency.
- Pittau, M. 1991. *Grammatica della lingua sarda (varietà logudorese)*. Sassari: Edizioni Carlo Delfino.
- Robins, R.H. 1957 Aspects of Prosodic Analysis. *Proceedings of the University of Durham Philosophical Society. Series B*. 1, 1-12.
- Scobbie, J.M. 1995. What do we do when phonology is powerful enough to imitate phonetics? Comments on Zsiga. In B. Connell and A. Arvaniti (eds.), *Phonology and Phonetic Evidence. Papers in Laboratory IV*. Cambridge: Cambridge University Press, 303-314.
- Wagner, M.L. 1941. *Fonetica storica del sardo*. Cagliari: Trois.
- Wagner, M.L. 1951. *La lingua sarda: storia, spirito, e forma*. Bern: Francke.
- Wagner, M.L. 1960-64. *Dizionario Etimologica Sardo*. Heidelberg: Winter. 3 vols.
- Wright, S. and P. Kerswill. 1989. Electropalatography in the study of connected speech processes. *Clinical Linguistics and Phonetics* 3, 49-57.
- Zsiga, E.C. 1995. An acoustic and electropalatographic study of lexical and post-lexical palatalisation in American English. In B. Connell and A. Arvaniti (eds.), *Phonology and Phonetic Evidence. Papers in Laboratory IV*. Cambridge: Cambridge University Press, 282-302.
- Zsiga, E.C. 1997. Features, gestures, and Igbo vowel assimilation: an approach to the phonology/phonetics mapping. *Language* 73, 227-274.