On the cross-linguistic avoidance of rhotic plus high front vocoid sequences

In this article we present evidence from several languages that rhotic plus high front vocoid sequences (e.g. /rj ri/ or the reverse /jr ir/) exhibit various avoidance strategies; e.g. either the /r/ or the vocoid changes into some other sound or deletes, or these sequences simply do not occur. We demonstrate that the avoidance of such sequences does not always follow from more general co-occurrence constraints banning sequences of any sonorant consonant (or liquid) plus any glide. The avoidance of /rj/ etc. will also be argued not to be a consequence of sonority sequencing or any other abstract phonological entities (such as distinctive features). Instead, we claim that the tendency in many languages to avoid /rj/ etc. requires specific constraints (e.g. *rj), which are grounded in articulatory phonetics.

1. Introduction

When one considers the phonotactics of the languages of the world it is not difficult to find examples of languages which permit consonant plus /j/ sequences (e.g. /lj nj mj sj tj/) under the condition that the consonant not be a rhotic sound, i.e. /r/. In some languages the sequence of /r/ plus /i/ is avoided as well, even though other consonants can precede /i/. The avoidance of sequences like /rj/ and /ri/ can be observed in languages in which the rhotic is a trill, tap/flap or approximant. Although the place of articulation of /r/ in the type of languages we are describing is typically alveolar (or dental), the avoidance of /rj/ can also be observed in languages in which the rhotic is uvular.

We argue that the avoidance of /rj/ (and /ri/) has an explanation grounded in articulatory phonetics which we capture with a constraint abbreviated here simply as '*rj'. Significantly, our articulatory explanation for the avoidance of sequences like /rj/ holds for all of the different r-types referred to in the preceding paragraph. Furthermore, our explanation also holds for the avoidance of the mirror-image sequences /jr/ and /ir/, which in some languages can also be under the domain of '*rj'.

Our explanation for the avoidance of sequences like /rj/ and /ri/ is very different from the traditional approach to phonotactics in generative phonology which sees morpheme-structure constraints operating not on the concrete phonetic representations but instead on abstract phonological entities such as distinctive features (e.g. Chomsky and Halle, 1968) or sonority (e.g. Clements, 1990). While we do not reject either distinctive features or the phenomenon of sonority in general, our point is that neither of these two approaches offers a truly explanatory account of the phenomenon we discuss in the present paper. Our treatment also differs from more current approaches (e.g. Steriade, 2001) which argue that phonotactic restrictions follow from the principle that phonological contrasts only appear where they are auditorily distinct.

In the present study we show that there are three logical avoidance strategies languages use, which we have summarized in (1). One can think of these three strategies as belonging to three language types, which we refer to below as Type A, Type B and Type C.

(1) Three avoidance strategies:

a. Type A: /rj/ does not occur

b. Type B: /rj/ is blocked from being derived

c. Type C: /rj/ is derived by rule but the output is repaired to something else

In Type A languages a consonant (C) plus glide (G) sequence /CG/ occurs under the condition that /G/ not be /j/ and that the /C/ not be a rhotic. In Type B languages there is a phonological process which creates /Cj/ sequences, e.g. surface [Cj] derives from /Ci/ by a rule of Glide Formation, but the process is blocked from applying if it would produce surface [rj]. Type B can be contrasted with Type C: In some languages processes which apply to create /Cj/ sequences also apply to create /rj/, but the change to /rj/ triggers some independent process which has the function of preventing the /rj/ sequence from surfacing as [rj]. For example, /ri/ might change into /rj/ by Glide Formation, but then some independent process applies to the /rj/ sequence created by Glide Formation to prevent /rj/ from surfacing as such.

An examination of the typology in (1) reveals that there is no inherent contradiction between Type A and Type B/Type C. Thus, it would be possible in theory for a language to be

Type A *and* Type B or Type A *and* Type C. Should this situation obtain then it would mean that Type B and Type C languages have /r/ and /j/ in their inventories and both allow /Cj/ sequences in their phonotactics with the exception of /rj/. In addition to this phonotactic restriction there would also be a ban on /rj/ from being derived (Type B) or a condition that derived /rj/ has to be repaired (Type C). Note that there are two additional language types, which we could call Type D and Type E: In the former /Cj/ is allowed as a cluster, including /rj/, and yet some phonological process blocks /rj/ from being derived. In Type E /Cj/ (including /rj/) is likewise allowed and yet derived /rj/ is repaired in such a way that it cannot surface. We discuss a marginal example of Type D in section 3.4. No example of language Type E is known to us.

In principle, we expect Type C languages to exhibit one of the following three repair strategies:

(2) Three repair strategies in Type C languages:

a. the /r/ in /rj/ deletes or changes into a different sound

b. the /j/ in /rj/ deletes or changes into a different sound

c. a vowel is inserted between /r/ and /j/

We discuss below cases of Type C languages, although we do not claim to have examples illustrating all three repair strategies in (2).

The general observation that there are languages in which sequences like /rj/ or /ri/ are avoided is itself not new; see for example, Hall (2003, 2004). What is more, Hall argues that there is an articulatory explanation for the avoidance of /rj/. Denton (1998) similarly observes that /rj/ can be avoided but her explanation is very different from the articulatory one advanced by Hall (2003, 2004), which we further refine below. See also Walsh Dickey (1997) and Hall (2000), who offer very different explanations for the avoidance of palatalized rhotics like /r^j/ cross-linguistically.

A number of studies of single languages show that /r/ is avoided when adjacent to the high front vowel /i/ or the palatal glide /j/ and propose an articulatory explanation for this avoidance; see for instance Delattre and Freeman (1968) and Hall (2003) for English, Chao (1968:46), Cheng (1973:25), and Duanmu (2000:30) for Mandarin, Kristoffersen (2000:34) for Norwegian, Downing (2001:3f.; 2007) for Jita, Żygis (2005) for Polish and Czech, and Gussenhoven (2009) for Dutch. While we are in agreement with the articulatory-based explanation for the avoidance of /rj/ and/or /ri/ presented in some of the earlier studies, the present study can be seen as an important addition to the list of articles on this topic for at least three reasons. First, we consider not only the examples discussed by the linguists cited above, but also additional ones. Second, none of the authors mentioned above have recognized the three-way typology we posit above in (1). Third, our explanation is not always identical with the explanations given by the authors listed above.

The present article is structured as follows. In section 2 we provide some background information on the phonetics of rhotics which we refer to in the subsequent sections and discuss our methodology. In section 3 we provide several short case studies of languages which avoid /rj/ while permitting /ri/. The languages discussed there include those in which /rj/ simply does not occur (Type A; section 3.1), those in which /rj/ is blocked from being derived (Type B; section 3.2) and those in which derived /rj/ is repaired (Type C; section 3.3). Some marginal examples of languages avoiding /rj/ are presented in section 3.4. In section 4 we provide a similar set of case studies for languages which avoid /ri/ and /rj/ (or the mirror-image /ir/ and /jr/). In section 5 we argue that the avoidance of sequences like /rj/ cannot have an explanation based on sonority or distinctive features. In section 6 we argue that the avoidance of sequences like /rj/ has an articulatory explanation and in section 7 we discuss some unanswered questions posed by our articulatory explanation. Section 8 concludes.

2. Methodology

As noted above, the avoidance strategies for sequences like /rj/ and /ri/ hold for a variety of different rhotics, or ‘r-sounds’. The rhotics in the languages we investigate can differ in place and manner of articulation. In (3) we provide a section of the IPA table (International Phonetic Association, 1999) with the different types of rhotic sounds (see also Laver, 1994:553).

(3) *r*-sounds covered by the present article:

<table>
<tr><th></th><th>dental/alveolar</th><th>retroflex</th><th>uvular</th></tr>
<tr><td>trill</td><td>r</td><td></td><td>ʀ</td></tr>
<tr><td>flap/tap</td><td>ɾ</td><td>ɽ</td><td></td></tr>
<tr><td>fricative</td><td></td><td></td><td rowspan="2">ʁ</td></tr>
<tr><td>approximant</td><td>ɹ</td><td>ɻ</td></tr>
</table>

The sounds in (3) are all pulmonal and usually voiced; devoiced realizations can be encountered in positions that favor devoicing. A precise definition of rhotic sounds proves notoriously difficult as these sounds do not share a unique phonetic property (see Lindau, 1985, and Ladefoged and Maddieson, 1996 chap. 7 for a discussion). In the following, we use ‘r’ as a cover symbol for all the sounds listed in (3), regardless of the manners and places of articulation. The reason we use a single symbol for these different articulations is that many languages tend to avoid sequences like /rj/, regardless of the manner and/or place of the rhotic. In our short case studies of languages which avoid /rj/ (and /ri/) in sections 3 and 4 we describe the realization of the rhotics in detail. In section 6 we discuss our phonetically-based explanation for the avoidance of /rj/ and/or /ri/. In section 7.1 we return to the phonetic variation among rhotics implicit in the table in (3) and discuss some of the non-traditional rhotics sounds that are assumed (such as the so-called 'bunched' r in American English and the labiodental approximant in some British English varients).

Although we reject an explanation of the avoidance of /rj/ in terms of sonority, we do not reject the notion of a sonority hierarchy in general. According to many versions of the sonority hierarchy, r-sounds are grouped together with laterals to form liquids, which are situated between glides and nasals (e.g. Clements 1990). We accept this approach because the sonority hierarchy is necessary to account for phenomena we do not discuss below.

We argue that Type A-C languages require reference to one of the phonotactic constraints in (4):

(4) Phonotactic constraints (including the mirror image constraints):

a. $*_{\sigma}$(rj: [rj] is disallowed in syllable-initial position

b. *rj: [rj] is disallowed

c. $*_{\sigma}$(rj-ri: [rj ri] are disallowed in syllable-initial position

d. *rj-ri: [rj ri] are disallowed

Constraint (4a) bans only those /rj/ sequences in syllable-initial position (or the mirror image in syllable-final position), while (4b) is more general in the sense that it bans any linear sequence of /rj/. Constraint (4c) prohibits both /rj/ and /ri/ in syllable-initial position (or, in the cases where the mirror image holds, in syllable-final position), whereas (4d) is a more general version banning any linear sequence of /rj/ and /ri/. To the best of our knowledge there is no language in which /ri/ is banned but /rj/ permitted. We make some speculative comments below in section 6.2 on why this should be the case.[1]

[1] Constraints (4b) and (4d) probably ban a /rj/ sequence within a phonological word. The reason for this prosodic restriction is that in many languages which avoid /rj/, this sequence is possible in connected speech,

The constraints we posit in (4) are intended to be theory neutral. Thus, one could easily interpret them to be specific markedness constraint in the sense of Optimality Theory (Prince and Smolensky, 1993 and much subsequent work). However, we contend that the languages we discuss below require constraints like the ones in (4) even if one were to adopt a rule-based approach.[2] We also do not attempt to present a formal account of the typology referred to above in section 1. Instead, we utilize the language types in (1) and the repair strategies in (2) merely as a way of classifying the languages we discuss below. We therefore leave open for future work how the typology we refer to throughout this paper should be captured formally.

Significantly, we argue that the avoidance of /rj/ does not follow from more general constraints, e.g. the avoidance of all glides (i.e. /j/ and /w/) after /r/ or the avoidance of all sonorant consonants (i.e. /m n l r/) or all liquids (i.e. /r/ and /l/) before /j/. The avoidance of /ri/ in (4c-d) will be shown to be necessary for some language, while in others the avoidance of /ri/ makes more sense as the avoidance of /r/ plus any high front vowel sequence.

The avoidance of /rj/ or /rj ri/ can be observed in the synchronic or diachronic phonology. In addition, we advance the claim that the constraints in (4) can hold in the regular (i.e. postlexical) phonology, but also for the highly morphologized (i.e. lexical) level. Thus, we show below that it is not necessarily the case that the avoidance of /rj/ has to be surface true.

Throughout the transcriptions of the examples in sections 3 and 4 we use the IPA-symbol [j] for the palatal glide. We have therefore changed the transcriptions of this sound in the

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i.e. if the /r/ ends the first word and the /j/ begins the second word. It is also not unusual to find languages with constraint (4b) or (4d) which have compound words in which the first part ends in /r/ and the second part begins with /j/. The existence of compound words of this structure makes sense if one makes the uncontroversial assumption that in those languages each part of a compound word is its own phonological word (Nespor and Vogel, 1986). No language is known to us which avoids all /rj/ sequences, i.e. those within and across phonological words.

2 Many pre-OT analyses accept (negative) filters like the ones in (4) in order to account for systematic gaps in phonotactics. See, for example, Clments and Keyser (1983), who posit a number of language-specific 'negative syllable structure conditions'. A non-OT analysis of the languages we discuss below would have to incorporate the negative constraints in (4) in order to account for the restrictions governing the (non)occurrence of [rj].

original sources accordingly. Furthermore, we use this glide to transcribe the second segment of a diphthong ending in a high front vocoid, and changed the transcriptions in the original sources accordingly.

3. Languages which avoid /rj/

The languages discussed in this section have in common that they avoid sequences of /rj/, while permitting /ri/. In some languages we examine below the avoided /rj/ sequence is syllable-initial, while in other ones there is a more general prohibition against any word-internal linear sequence of /rj/. We therefore see the constraint $*_{\sigma}$(rj in (4a) as a constraint necessary for the former languages, while the latter ones have constraint (4b), i.e. *rj. In section 3.1 we present two case studies (Norn and English) of Type A languages. In section 3.2 we discuss Modern German and Proto-West Germanic as examples of Type B languages and in section 3.3 Cypriot Greek as Type C. Finally, we turn to a couple of marginal examples involving the avoidance of /rj/ in section 3.4.

3.1 Type A: /rj/ does not occur

3.1.1 Norn

Norn was a North Germanic language spoken on the Orkney and Shetland islands until (at least) the early 14th century. In Shetlandic Norn word-initial /Cj/ clusters occur in examples like the ones listed in (5). All data are from Jakobsen (1928, 1932) and Kostakis (2006).

(5) Word-initial Cj clusters in Norn:

a. Stop + [j]:	[pjol]	‘a small grassy swamp’
	[bjart]	‘cold and dry’
	[kjod]	‘to show fondness’

	[gjo]	'a cleft in a rock'
b. Fricative + [j]:	[fjunks]	'slovenly'
	[vjolin]	'insipid, stale'
	[sjolki]	'a lump'
c. Nasal + [j]:	[mjat]	'to move'
	[njad]	'immature corn'
d. Lateral + [j]:	[ljog]	'to bathe'
	[lju]	'to spread out for drying'

The data in (5) are organized into four classes, depending on the nature of the first consonant in the word. According to the sources listed above many words can be found in Shetlandic Norn beginning with /Cj/, where /C/ is a stop, fricative, nasal or lateral. By contrast, the one r-sound in the language (which is usually assumed to be an apical trilled /r/) cannot occur in the /C/ position in a word-initial /Cj/ cluster. Significantly, the prohibition on word-initial /rj/ cannot be attributed to a general ban on /r/ in word-initial position because Norn has many words which begin with /r/ plus vowel, e.g. [riv] 'a reef', [ripəl] 'strip of land'.

Norn also has words with word-internal /Cj/, although they do not seem to be as plentiful as the word-initial examples in (5). (One example is *skammjok* [skamjok] 'a yoke carried by the two middle oxen'). There are no examples of words containing /rj/ in word-medial position. What this suggests to us is that Norn is a language in which the general constraint *rj in (4a) is operative as a phonotactic constraint.[3] Norn has one other glide, namely /w/, which also does not occur after /r/. However, the *rw gap is due to a general prohibition of sonorant consonant plus /w/, i.e. all nasals, the one lateral and /r/ are all prohibited from occurring before /w/, while obstruents can occur in this position.

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[3] In Norn the reverse sequences /jr/ seem to be non-occurring.

3.1.2 English

Most varieties of English have a central approximant rhotic we transcribe in the following as /r/. In its most common pronunciation, this sound is either alveolar or retroflex, although it can surface as a ‘bunched’ sound (Delattre and Freeman, 1968). There are two glides, namely /j w/, and four high vowels, i.e. /iː ɪ uː ʊ/.

In (6-7) we provide a list of occurring and non-occurring /Cj/ and /Cw/ sequences in word-initial position in the Received Pronunciation (henceforth RP). That the vowel after /j/ in (6) is always /uː/ is not important for purposes of this article. We account for this cooccurrence restriction by analyzing the /j/ in words like the ones in (6) (in contrast to the [w] in the words in 7) as being in the syllable nucleus, see Davis and Hammond (1995).

(6) Word-initial /Cj/ sequences in Modern English (RP):

Sequence:	*Examples:*
a. stop + j:	puny, beautiful, tune, duty, cute
b. fricative + j:	fuse, view, suit
c. nasal + j:	music, news
d. lateral + j:	lewd, ludicrous, luminous
e. rhotic + j:	-------

(7) Word-initial /Cw/ sequences in Modern English (RP):

Sequence:	*Examples:*
a. stop + w:	twin, dwindle, quit
b. fricative + w:	swim, thwart
c. nasal + w:	-------

d. lateral + w: -------

e. rhotic + w: -------

In (6a-c) we can observe that stops, fricatives and nasals respectively can precede the palatal glide in initial position. By contrast, the examples in (7) show that only stops and fricatives can occur before [w]. Note that there are gaps within each of the occurring categories in (6) and (7) which are irrelevant for the present analysis. For example, within the (6b) category there are no words beginning with /θj ðj/ and within the (7b) category there are no words with /ðw/.

The gap relevant for our purposes can be observed in (6e), i.e. there are no word-initial /rj/ sequences. To the best of our knowledge the avoidance of word-initial /rj/ is true not only for RP, but for all dialects of Modern English.[4] In other varieties of English, e.g. American English, the only attested sequences are (6a-c); that is, the class of liquids (L) does not occur before /j/. We account for these gaps with the constraints $*_{\sigma}$(rj, which holds for RP, and $*_{\sigma}$(Lj, which holds for American English, where the latter is not further discussed in the present study.

We follow Davis and Hammond (1995), who argue that the gaps in (7c-e) follow from a constraint banning two sonorant segments in the syllable onset, i.e. $*_{onset}$([+sonorant] [+sonorant]). Note that this constraint accounts for the gaps in (6c-e) while allowing for words like *music* and *lewd* in (6c-d) because the [j] in these words is in the nucleus and not in the onset (see above). We assume that this constraint also accounts for the gaps involving /Cw/

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4 Wells (1982:206) notes that there are certain conservative dialects of Welsh and north-of-England, and American accents in which the diphthong /ɪʊ/ can surface after an onset /r/, e.g. Welsh *threw* [θrɪʊ]. It is not clear from the discussion in that source whether or not the diphthong /ɪʊ/ is rising (i.e. /ɪ̆ʊ/) or falling (i.e. /ɪʊ̆/) in words like *threw*. If the rising diphthong /ɪ̆ʊ/ (which we regard to be the same as /jʊ/) can occur in examples like these then these varieties would be ones in which /rj/ surfaces in syllable-initial position.

found in intervocalic position. For example, there are words like *acquire* and *jaguar* with [kw gw], but there appear to be few examples with a sonorant consonant plus [w].[5]

The following data consist of two sets of heterosyllabic /C.j/ sequences in which the /C/ portion is not a rhotic. The /Cj/ sequences in data like these can be found not only in RP but in most – if not all – modern dialects.

(8) /C.j/ sequences in Modern English:

a. nasal + j:	onion	[ʌn.jən]
	opinion	[ə.pɪn.jən]
	continue	[kən.tɪn.ju]
	amulet	[æm.ju.lət]
b. lateral + j:	value	[væl.ju]
	million	[mɪl.jən]
	stallion	[stæl.jən]
	volume	[vɑl.jum]

According to Borowsky (1986), Jensen (Jensen, 1993) and Davis and Hammond (1995) the syllable break in examples like the ones in (8) falls between the /C/ and the glide and not before the /C/. For reasons of space we do not repeat their arguments here.

The examples in (9) consist of words with /r.j/ contacts in Modern English. There are two possible pronunciations for these words, which we refer to henceforth as Variety I and Variety II.

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[5] One example with [lw] that comes to mind is the high frequency word *always*. Examples containing [nw mw rw] are difficult to find (with the exception of proper names like *Irwin* and *Darwin*).

(9) /r.j/ sequences in Modern English:

Example	*Variety I*	*Variety II*
erudite	[Vr.jV]	[V.rV]
virulent	[Vr.jV]	[V.rV]
garrulous	[Vr.jV]	[V.rV]
querulous	[Vr.jV]	[V.rV]

In Variety I we see the /r.j/ contact surfacing as such and in Variety II the palatal glide does not surface. Variety I and Variety II can be found in RP (Jones, 1958) and in American English (Kenyon and Knott, 1953 and Borowsky, 1986:289), respectively.[6]

What is significant in (9) is that in Variety II there are *no* examples of word-internal /r.j/ syllable contacts, but what is equally important is that there are many words containing non-rhotic /C.j/ contacts (in 8). It should also be noted here that even for speakers of Variety I the /r.j/ contacts in (9) are highly unusual. One reason why this is so is that there are very few examples like *erudite* with heterosyllabic /r.j/ sequences, in contrast to the numerous examples of non-rhotic /C.j/ contacts in (8). A second reason for considering the /r.j/ contacts in Variety I to be unusual is that they only surface in highly learned words with an extremely low frequency. By contrast, many common everyday words can be found with the non-rhotic /C.j/ contacts in (9).[7]

What we can conclude up to this point is that the phonotactics of English require the constraint $*_{\sigma}$(rj in (4b), which holds for speakers of Variety I and that speakers of Variety II

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6 There is apparently no dialect of English in which /r.j/ contacts occur immediately before a stressed vowel, cf. *garrulous* with /r.j/ vs. *garrulity* without /j/. See Hall (2003) for discussion.

7 The sequence /jr/ is non-occurring in English, i.e. words like *fire* are disyllabic. We consider the avoidance of syllable-final /jr/ to be due to a general restriction on any glide plus /r/ because /wr/ is avoided in this context as well.

have a more general constraint, i.e. *rj in (4a). Since there are no constraints on [ri] sequences, e.g. *read, ear*, constraint (4c) is not correct for English.[8]

3.2 Type B: [rj] is blocked from being derived

3.2.1 German

In German the palatal glide [j] is usually assumed to derive from an underlying short, (unstressed) /i/ by a process of Glide Formation. We will see below that this process creates surface [Cj] in syllable-initial position unless the /C/ is /r/, in which case the rhotic and glide are heterosyllabified. German /r/ is uvular in the variety we discuss. The manner of articulation can either be an approximant, a trill, or a fricative. What we conclude from the German data is that the constraint $*_{\sigma}$(rj is active in the German phonology as a constraint that blocks processes from creating syllable-initial [rj].

The process of Glide Formation referred to above can be motivated as an optional process applying in casual speech. We state the rule linearly in (10) so that it applies to both /i/ and /u/:

(10) German Glide Formation: /i u/ → [j w] / __ V

[8] Many linguists see the ban on syllable-initial /rj/ in (American) English as a consequence of a general prohibition of any sequence of syllable-initial coronal consonant plus /j/ (e.g. Borowsky, 1986:285ff., Davis and Hammond, 1995:163, Hall, 1997:5, Hammond, 1999:242-243). According to this interpretation syllable-initial /rj/ does not occur because all other syllable-initial /Cj/ clusters are banned in which /C/ is a coronal, i.e. */ tj dj θj ðj sj zj ʃj ʒj nj lj/. There are two reasons why this is not the correct explanation for the /rj/ gap in (6e). First, the ban on syllable-initial coronal + /j/ is restricted to American English, but the prohibition on syllable-initial /rj/ holds for all dialects of English. Second, the explanation for the non-occurrence of most – if not all – non-rhotic coronals before /j/ is auditory, but the explanation for the /rj/ gaps is articulatory (see section 6). Auditory explanations for the coronal-j gaps in American English referred to above have been proposed by Ohala and Busà (1995) and Flemming (1995/2002:120-125). According to the latter author coronal-palatal sequences (e.g. /tj/) are auditorily similar to plain coronals (e.g. /t/) because palatal glides are characterized by a high F2, and plain coronals typically have a relatively high F2 at release. Since the non-rhotic-coronal plus /j/ gap and the /rj/ gap have two different phonetic explanations it makes sense to express this with two separate constraints.

See Kloeke (1982), Hall (1992), Wiese (1996), Hamann (2003b) and Hall (2007) for analyses of German Glide Formation in various theoretical frameworks.

The following words illustrate that /i/ can (optionally) surface as [j] in the context /VCiV/. We have placed the examples in (11) into five categories, depending on the nature of the /C/ in /Cj/, i.e. stop, fricative, nasal, lateral and rhotic.[9]

(11) Words illustrating the optional realization of /VCiV/ as [VCjV]:

a. stop + j:	labial	[la.ˈbjaːl]	‘labial’	
	Studium	[ˈʃtuː.djʊm]	‘studies (sg.)’	
b. fricative + j:	trivial	[tʁɪ.ˈvjaːl]	‘trivial’	
	Flexion	[fle.ˈksjoːn]	‘inflexion’	
c. nasal + j:	Linie	[ˈliː.njə]	‘line’	
	Prämie	[ˈpʁeː.mjə]	‘bonus’	
d. lateral + j:	Familie	[fa.ˈmiː.ljə]	‘family’	
	Dahlie	[ˈdaː.ljə]	‘dahlia’	
e. rhotic + j:	Ferien	[ˈfeː.ʁi.ən]	‘holidays’	~ [ˈfeːɐ̯.jən]
	Bakterie	[bak.ˈteː.ʁi.ə]	‘bacterium’	~ [bak.ˈteːɐ̯.jə]

The [ɐ̯] in the examples in (11e) illustrate the process of r-Vocalization, whereby coda /r/ vocalizes to [ɐ̯] (e.g. *Tier* [tiɐ̯] ‘animal’ vs. *Tier-e* [tiː.ʁə] ‘animals’). See Mangold (2005),

[9] In many words [j] *must* surface as [j], e.g. *Union* is pronounced [ʊ.njo:n] and not [ʊ.ni.o:n]. The distinction between optional glides like the ones in (11) and ‘obligatory’ glides like the one in *Union* is peripheral to the present article.

Hall (1993) and Wiese (1996) for a discussion on r-Vocalization. According to the first source listed, r-Vocalization is obligatory after a long vowel but optional after a short vowel. In colloquial speech (which is the variety of German on which our analysis is based) /r/ is vocalized in coda position after any vowel.

An examination of the syllable parsing in (11a-d) reveals that the surface [Cj] sequence is syllable-initial. This parsing derives motivation from the fact that the [C] will never undergo (syllable) Final Devoicing if it is a voiced obstruent; see, for example *Studium* in (11a). The examples relevant for the present discussion are ones in which surface [j] is preceded by /r/, i.e. the examples in (11e). It can be observed here that the /ri/ sequence is heterosyllabic. Phonological evidence for this parsing is that the /r/ shows the effects of r-Vocalization, which only occurs in coda position. Data like the ones in (11e) are therefore important because they show that [Cj] in (11a-d) is syllable-initial unless the /C/ is a rhotic (11e), in which case the [Cj] sequence is heterosyllabic.[10] In procedural terms, the /i/ in a sequence /VCiV/ converts to [j] by Glide Formation and Syllabification creates surface syllable-initial [Cj] clusters; Syllabification is blocked from creating a syllable-initial [rj] by the constraint $*_{\sigma}$(rj.

Glide Formation also optionally affects prevocalic /u/, as indicated in the examples in (12). Words in which /u/ occurs before a vowel are impressionistically less common than words like the ones in (11); see Moulton (1962:66–67) and Kloeke (1982:38) for discussion on the realization of /u/ as a glide.[11] In (12) we have presented the examples as in (11), with five categories (12a–e):

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10 Mangold (2005) consistently transcribes words like *Ferien* in (12e) with an intervocalic /rj/ with consonantal [r], e.g. [feːrjən]. Since that source transcribes the vocalized [r] as [ɐ̯], the implication is that for Mangold (2005) words like *Ferien* have syllable-initial [rj]. Since we have yet to encounter a native speaker with this pronunciation and since native speakers consider this sequence to be virtually unpronounceable it will be assumed below that the ban on syllable-initial [rj] holds for German.

11 It is possible to find words in which prevocalic /y/ optionally surfaces as the corresponding glide [ɥ], e.g. *Zyanid* [zɥa.ˈniːt] 'cyanide'. We omit examples like these from our discussion because of their rarity.

(12) Words illustrating the realization of /V(C)CuV/ as [V(C)CwV]:

a. stop + w:	Statue	[ˈʃtaː.twə]	‘statue’
	Beduine	[bə.ˈdwiː.nə]	‘beduine’
	Linguist	[lɪŋ.ˈgwɪst]	‘linguist’
b. fricative + w:	Jesuit	[je.ˈzwiːt]	‘jesuite’
	prozessual	[pʁo.tse.ˈswaːl]	‘procedural’
c. nasal + w:	Januar	[ˈja.nwaːɐ̯]	‘January’
	genuin	[ge.ˈnwiːn]	‘genuine’
	Inuit	[i.ˈnwɪt]	‘Inuit’
d. lateral + w:	Evaluation	[e.va.lwaː.ˈtsjoːn]	‘evaluation’
e. rhotic + w:	Altruist	[al.ˈtʁwɪst]	‘altruist’
	konstruieren	[kɔn.ˈstʁwiːɐ̯t]	‘to construct’
	peruanisch	[pe.ˈʁwaː.nɪʃ]	‘Peruvian’

Note that Glide Formation applies to the /u/ in all of the examples in (12), including the ones in (12e). This fact is important because the output of Glide Formation in the latter data set created syllable-initial [rw]. The examples in (12e) therefore contrast with the ones in (11e), which show that syllable-initial [rj] is avoided.

Further evidence that syllable-initial [rj] cannot be derived (but initial [rw] can) is illustrated with the data set in (13) below. These words contain a prevocalic /i/ which can potentially undergo Glide Formation. In contrast to the examples in (11–12) the ones in (13) have a glide that is preceded by a word-initial consonant or sequence of consonants. Examples of word-initial /CiV/ sequences are not plentiful, but we hold these examples to be representative for words of this structure; in (13a) we provide such examples in which the /C/ is an obstruent, nasal or lateral. The optionality of Glide Formation in these forms can be contrasted with its ungrammaticality in the example in (13b), in which the initial consonant is /r/. The examples in (13a–b) can now be compared with the ones in (13c), in which the underlying high vowel is /u/. Note that Glide Formation is optional in these examples.

(13) Words illustrating the realization of word-initial /C(C)GV/:

a.	Piano	[ˈpjaː.no]	‘piano’		
	Tiara	[ˈtjaː.ra]	‘tiara’		
	Viole	[ˈvjoː.lə]	‘viol’		
	Miasma	[ˈmjas.ma]	‘miasma’		
	Liane	[ˈljaː.nə]	‘liana’		
	Guave	[ˈgwaː.və]	‘guava’		
b.	Rialto	*[ˈʁjal.to]	‘id.’		
	Triade	*[ˈtʁjaː.də]	‘triad’		
c.	ruinieren	[ʁu.i.ˈniː.rən]	‘to ruin’	~	[ʁwi.ˈniː.rən]
	Ruanda	[ʁu.ˈan.da]	‘id.’	~	[ˈʁwan.da]
	Druide	[dʁu.ˈiː.də]	‘druid’	~	[ˈdʁwiː.də]

The examples in (13c) are important because they illustrate that German does not have a general restriction on syllable-initial /r/ plus glide sequences (i.e. $*_{\sigma}$(rG), since the high vowel /u/ in these words can be glided to [w] in casual speech.

In sum, the data from German show that the surface syllable-initial [rj] sequence cannot be derived; thus, German requires constraint (4a), i.e. $*_{\sigma}$(rj.[12] Significantly, the avoidance of syllable-initial [rj] cannot be attributed to a general ban of syllable-initial r-sound plus any glide (i.e. [j] or [w]), nor from a ban of sonorants or liquids plus [j]. Since [j] and [i] are identical featurally, it is important to note that German permits sequences of [ri], e.g. *Riet* [ʁiːt] 'reed', *irisch* [ˈiː.ʁɪʃ] 'Irish', as well as [r] plus other high front vowels, e.g. *Rübe* [ˈʁy.bə] 'turnip'. The existence of data like these mean that German cannot have a constraint banning syllable-initial [rj ri].

3.2.2 Proto-West Germanic

Like Modern German, Proto-West Germanic is an example of a language in which $*_{\sigma}$(rj is active as a constraint which blocks surface syllable-initial [rj] from being derived. Specifically, the process referred to as West Germanic Consonant Gemination, which applies in a /VC.jV/ sequence to produce [VC$_a$.C$_a$jV], will not go into effect if the /C/ is /r/. We follow the many scholars of Germanic who have argued that /r/ at this stage in Germanic was an alveolar trill.

The data in (14) illustrate that in West Germanic (WG), represented below by Old High German (OHG), Old English (OE), and Old Saxon (OS), there is a pattern of gemination not attested in East Germanic, represented below by Gothic (Go.), or North Germanic, represented by Old Norse (ON). The generalization is that a consonant following a short stressed vowel is a geminate in WG before the palatal glide /j/ – represented orthographically in the WG examples in (14) and below as *i*. The contrast between the non-geminate forms in

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[12] The mirror image sequence [jr] is also avoided in German, but this gap follows from a more general ban on any glide (i.e. [j] or [w]) plus [r] in the coda. See Hall (1992:142ff.) for data and discussion. Recall from note 7 that the data are the same in English.

the first column and the corresponding ones with geminates in the second column are explained historically by positing that in Proto-Germanic all of these words were originally VCjV and that a historical process of the form VCjV > VCCjV – referred to below as WG Gemination – occurred before the WG daughter languages broke off (see Simmler 1974 for additional data and references).[13]

(14)	*East/North Germanic*		*West Germanic*	*Gloss*	*Geminate*
a.	Go.	*skapjan*	OS *skeppian,* OE *scieppan*	'to create'	[pp]
	Go.	*bidjan*	OS *biddian,* OE *biddan*	'to ask for'	[bb]
b.	Go.	*hafjan*	OHG *heffan,* OE *hebban*	'to lift'	[ff]
c.	ON	*fremja*	OHG *fremmen,* OE *fremman*	'to carry out'	[mm]
d.	Go.	*halja*	OS *hellia,* OHG *hella*	'hell'	[ll]

In the WG data above we see that the consonant that geminates can be a stop (in 14a), a fricative (in 14b), a nasal (in 14c) or the lateral /l/ (in 14d).

The gemination facts in (14) can be contrasted with the data in (15) below, which show that /r/ does not geminate before /j/ in WG, and that it surfaces as the singleton [r] instead:

(15)	*East/North Germanic*	*West Germanic*	*Gloss*
	ON *sverja*	OE *swerian*, OHG *swerien*	'to swear'
	Go. *farjan*	OE *ferian,* OS *ferian*	'to go by boat'
	Go. *warjan*	OS *werian*	'to defend'
	Go. *arjan*	OE *erian*	'to plow'

[13] In several of the examples in (14) and below there is no *i* after the geminate consonant, e.g. in all of the OE and OHG words. In these cases the general assumption is that the palatal glide was once present and that it was deleted after triggering WG Gemination.

/w/ underwent WG Gemination before /j/ as well, e.g. OHG *frouwe* 'lord', in which the *uw* sequence is /ww/, which presumably derives historically from /...wwj.../ (cf. Got. *frauja*). In the present article we are only concerned with examples in which WG Gemination was triggered by a following /j/ and therefore ignore examples of WG Gemination before /w/ because the only consonants that lengthened in this environment were /k/ and /h/ (see Simmler, 1974:329ff., Murray and Vennemann, 1983:521, note 6). In addition to the context in (14), the gemination of voiceless stops before liquids also occurred, e.g. /VkrV/ became /VkkrV/ (cf. OS *akkar* vs. Go. *akrs* 'acre').

In the North Germanic branch the only consonant which productively geminated before /j/ was /k/. See Denton (1998) for a phonetic explanation of this change.

Although there is consensus that /r/ was the only consonant that blocked WG Gemination, there remains disagreement concerning the reason for this blockage (see, for example, Murray and Vennemann, 1983, Ham, 1998, Denton, 1998, Hall, 2004).

For purposes of this study we can think of Proto-WG as consisting of two stages called here ‘Early WG’ and ‘Late WG’, which are defined in terms of WG Gemination. Thus, a form like [skapjan] in (14a) surfaced in Early WG with a non-geminate [p] but the same form in Late WG was [skappjan]. This is illustrated in (16):

(16) skapjan Early (Proto) WG

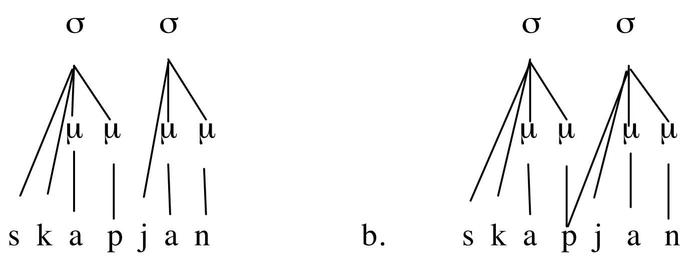
←WG Gemination

skappjan Late (Proto) WG

OS skeppian OE scieppan

Following Murray and Vennemann (1983) and Hall (2004), an explanation for WG Gemination can be found primarily in the Syllable Contact Law (‘In $C_a.C_b$ the sonority of C_a is greater than the sonority of C_b’) – a process which improves the ‘bad’ C.j syllable contacts in Early WG (e.g. the [p.j] sequence in 17a) with the one in Late WG, in which the Syllable Contact Law is satisfied (e.g. in 17b):

(17) a. b.



The structures in (17a) and (17b) represent Early WG and Late WG respectively. Thus, in the approach we adopt here WG Gemination can be seen as a process which repairs bad syllable contacts.[14]

Consider once again the data in (15), e.g. an Early PG word like [swer.jan] surfaced in Late WG as [swer.jan], without geminate. We hold that the non-gemination of /r/ in examples like this one is that if it had occurred, the unfavoured sequence [rj] would have been in syllable-initial position, i.e. [swer.rjan]. By contrast, the [rj] sequence in [swer.jan] is uncontroversially considered to be heterosyllabic.[15] Cases where /rj/ sequences are avoided within syllables but accepted across syllable boundaries are further discussed in section 7.3 below.

It is important to note that /ri/ sequences were common in the older WG daughter languages in (14). For example, the OHG word *rīfi* 'reif' has the OS and OE cognates *rīpi* and *rīpe* respectively (Simmler, 1974:249). What we conclude from this is that the corresponding WG word can be assumed to have begun with /ri/. The upshot is that the constraint $*_{\sigma}$(rj in (4a), which is necessary to block WG Gemination, does not hold for /ri/ sequences.[16]

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[14] This explanation also explains why WG Gemination did not take place after a long vowel. In an early WG word like [fo:.djan] the Cj sequence is syllable-initial (see the references cited above, in which arguments are presented for this parsing) and hence the Syllable Contact Law is satisfied.

[15] The explanation for the non-gemination of /r/ is different from the one proposed by Murray and Vennemann (1983), Hamm (1983) and Denton (1998).

The two other logical ways of parsing /VrrjV/ were (a) [Vrr.jV] and (b) [V.rrjV]. The syllabifications in (a) and (b) were rule out because geminates could only occur when heterosyllabified.

[16] In Proto-WG the sequence /ir/ was probably occurring on the basis of cognate words in modern West Germanic languages. By contrast, /jr/ was non-occurring. We interpret this gap as a general restriction on any glide plus /r/ in the coda (recall notes 7 and 12 for English and German respectively).

3.3 Type C, derived /rj/ is repaired: Cypriot Greek

In Cypriot Greek there is a sound which Newton (1972) transcribes as [r] and describes as 'an alveolar, voiced flap or trill' (p. 24). The only glide in the language is [j] (which Newton transcribes as [y]). The latter sound is described as 'an apico-post-alveolar voiced semivowel'.[17] According to Newton's description the language has two high vowels (/i u/) and no diphthongs. We show below that Cypriot Greek is an example of a language which bans any surface [rj] sequence, regardless of whether or not [r] and [j] are tauto- or heterosyllabic. The general constraint *rj in (4b) will be shown to be necessary not only to capture gaps in the phonotactics, but also to trigger a phonological process known as Glide Hardening, which converts /j/ to [k] after [r].

In Cypriot Greek clusters of two non-syllabic segments (i.e. consonants or the glide /j/) occur both word-initially and word-internally (see Newton 1972:32, 36). In the following we employ the symbol 'C' to represent a non-syllabic segment. The special behavior of /r/ and /j/ can be observed when we consider the occurring /CC/ clusters in Cypriot Greek which consist of two non-syllabic sonorants. The non-syllabic sonorants in this language include the four consonants /m n l r/ plus /j/.

If the second /C/ in a /CC/ sequence is /j/ then the first one can only be /m n l/, as shown in (18a). In the second column of (18a) we see the three attested clusters /mj nj lj/ in word-initial position and in the fourth column one can observe that the same clusters surface in intervocalic position. The examples in (18b) show the same three clusters /nj mj lj/ between a consonant and a vowel.[18] The data presented up to this point in (18a–b) are important because they illustrate a gap: /rj/ is non-occurring across the board, i.e. word-initially, between two vowels and between a consonant and a vowel. That Cypriot Greek avoids /rj/ derives additional

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[17] It is not clear what Newton means when he describes [j] as 'apical'. An examination of any phonetics textbook reveals that palatal sounds like [j] are predorsal and not apical.

[18] Newton (1972:36) writes that clusters with /Clj/ are "not available", although it is clear from his discussion on the previous page that he considers /Clj/ to be well-formed medially.

support from the examples in (18c), which show that /CC/ clusters can occur in which /r/ is the first member. An inspection of these examples reveals that the second member of /rC/ clusters is a non-syllabic sonorant, i.e. /m n l/. The important point with respect to (18c) is that /j/ cannot occur after /r/. In (18) and below we have refrained from transcribing the diacritics for stress which are present in the original source.

(18) /Cj/ and /CCj/ clusters in Cypriot Greek, in which /C/ is a non-syllabic sonorant:

a.	/nj/	[njata]	'youth'	[enja]	'nine'
	/mj/	[mjalos]	'big'	[psumja]	'loaves'
	/lj/	[ljonni]	'it melts'	[rialja]	'money'
b.	/rmj/	[kormja]	'bodies'		
	/pnj/	[kapnja]	'smoke'		
	/knj/	[oknjaris]	'lazy'		
	/mnj/	[stamnja]	'jars'		
	/rnj/	[arnjume]	'I deny'		
c.	/rm/	[kormin]	'body'		
	/rn/	[ornixa]	'hen'		
	/rl/	[zorlis]	'obstinate'		

The examples discussed above involve /CC/ sequences in which the second /C/ is /j/. Based on the examples presented in Newton (1972) none of the obstruents of Cypriot Greek can occur as /C/ in /Cj/ either. (The surface cluster [zj] occurs but only across word boundaries; see Newton 1972:29). This gap also apparently holds for /CCj/ clusters, i.e. the second /C/ in /CCj/ must be a sonorant (Newton 1972:35-36). Clearly, an independent phonotactic constraint is necessary to account for gaps like these, i.e. *[–sonorant] j (in addition to the *rj constraint).

Consider now the examples in (19) (from Newton 1972:52 and Hume and Odden, 1996:366). The words in (19a) illustrate alternations between [i] and [j] which motivate a rule of Glide Formation, whereby /i/ surfaces as [j] before vowels (Newton's rule P8, p. 52). In these examples we see Glide Formation affecting the stem-final /i/ before the affix [u] in the genitive; by contrast, stem-final /i/ surfaces as [i] before the nominative suffix [n]. Note that the consonant preceding the /i/ in (19a) is /n l/; no examples could be found in which /m/ occurs in this position, a gap we consider to be accidental. The additional examples in (19b) show that a separate process of Glide Hardening converts the /j/, which is the output of Glide Formation, into [k̺] – a sound Newton describes as a 'lamino-domal stop' (p. 23) – after obstruents. The example that is relevant in the present context is the one presented in (19c). Here we can observe that Glide Formation affects stem-final /j/ (from /i/) after /r/, but that this /j/ hardens to a stop [k].[19]

(19) Glide Formation and Glide hardening in Cypriot Greek:

a.	*nominative*	*genitive*	
	[mantilin]	[mantilju]	'handkerchief'
	[tianin]	[tianju]	'frying-pan'
b.	[xorafin]	[xorafk̺u]	'field'
	[ammatin]	[ammθk̺u] ~ [ammatk̺u]	'eye'
	[xappin]	[xapk̺u]	'pill'
c.	[psarin]	[psarku]	'fish'

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[19] There is an apparent depalatalization of [k̺] to [k] after [r] which is not relevant for the present analysis. It is clear from Newton (1972:52-53) that the example in (19c) is representative of a general pattern. Another example he cites in which /i/ becomes [k] (via a [j] stage) after /r/ is /vari-ume/ [varkume] 'I'm bored'.

What is the motivation for Glide Hardening in (19c)? We showed above that surface [rj] is banned across the board by the constraint *rj (in order to account for the gaps involving /rj/ in 18). The constraint *rj holds not only at the level of phonotactics, but also at the level in which Glide Hardening applies. Thus, in procedural terms the /ri/ sequence in (19c) converts to /rj/ by Glide Formation, and then into [rk] because the [rj] in the intermediate stage would be ill-formed, should it surface as such. Note that this explanation for the avoidance of surface [rj] is very different from the one presented in the preceding section for Modern German and Proto-West Germanic. In the latter two languages the constraint $*_{\sigma}$(rj blocks processes from creating it, but in Cypriot Greek *rj does not have this function because /rj/ is created by Glide Formation only to be eliminated from surfacing by Glide Hardening.[20]

Up to this point we have only examined /CC/ clusters in which the second consonant is /j/. We consider now the reverse, i.e. are there constraints on the type of consonant which can occur in /jC/? In his list of heterogeneous (i.e. non-geminate) two-consonant clusters, Newton (1972:29) lists none in which /j/ is the first member. We see this gap as a general one saying that glides cannot occur before a consonant, i.e. *jC.[21] This constraint holds word-initially, i.e. there are no words in this language beginning with /jC/, and it also holds word-internally, i.e. there are no words of the form /VjCV/. The latter gap might be attributed to a general ban on diphthongs (i.e. tautosyllabic /Vj/ sequences), but this constraint would not be enough to ban /VjCV/, since the sequence could be parsed [V.jCV]. What we conclude is that the *jC

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[20] We offer a similar explanation for Glide Hardening in (19b): The constraint *[–sonorant] j we posited above to account for the gaps in (18) triggers Glide Hardening after Glide Formation creates obstruent plus /j/ sequences. It is worth noting that Newton (1972:52-53) himself posits two separate Glide Hardening rules for (19b) and (19c), i.e. his rules P13b and P13c.

Hume and Odden (1996:367) argue that Glide Hardening applies in response to the constraint *Cj, which says: “The palatal glide y may not be preceded by a non-syllabic segment, other than a sonorant stop.” The effects of this constraint are the same as ours, i.e. [rj] is banned (because [r] is a sonorant continuant), as are sequences of obstruent plus [j] (because obstruents are by definition not ‘sonorant stops’).

We offer no explanation for the variation between [k̯] in (19b) and the [k] in (19c).

[21] Recall that in this language [j] is the only glide. Hence, we cannot know if the *jC constraint is really a more general constraint banning all glides before a C.

constraint is necessary to rule out both word-initial /jC/ and word-internal sequences like /V.jCV/.[22] A constraint banning diphthongs is necessary in any case to account for the lack of word-final /Vj/.

Let us now consider whether or not /r/ has co-occurrence restrictions with a preceding or a following vowel. In his discussion of the distribution of single consonants Newton (1972:28) writes that ‘all twenty consonant phonemes occur utterance-initially and intervocalically within the utterance, the only restrictions being that /k/ and /ɣ/ never occur before front vowels’. From this statement we can conclude that /r/ also occurs before front vowels. An example is [rifin] ‘kid’ (p. 34). No statement is made concerning the distribution of single consonants after a vowel, but it is clear from Newton’s examples that sequences like [ir] are possible, e.g. [irten] ‘he came’ (p. 32).

To summarize, the examples in (18a-b) show that the sequence /rj/ does not occur at all in Cypriot Greek – a conclusion which derives further support from the data in (19), which illustrate that Glide Hardening applies in order to avoid surface [rj] sequences. Since Cypriot Greek permits /ri/ sequences, the language requires the general constraint *rj in (4b).

3.4 Marginal examples

We have encountered two examples of languages which appear to illustrate language type (1b), i.e. /rj/ is blocked from being derived, namely French and Spanish. We classify these languages as being ‘marginal’ either because there are not enough examples (French) or because we cannot confirm the robustness of the data cited by an independent source (Spanish).

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[22] One could argue that the *jC constraint holds only syllable-initially, but it is important to stress that it cannot be reduced to the Sonority Sequencing Generalization (SSG). The reason is that Cypriot Greek has a number of other (word-initial) CC clusters which blatantly violate the SSG, e.g. [rka] ‘old woman’, [mporo] ‘I can’.

In French there is a general process of Glide Formation which is similar to the equivalent German rule in (10): Any high vowel /i y u/ is converted to the equivalent glide before a vowel. Tranel (1987:121) observes that there are no examples of word-initial [ʀj] in which the [j] is derived by Glide Formation. He illustrates this point with forms based on the verb *rire* 'to laugh', e.g. *rieur* 'cheerful', which is typically pronounced with [i] and not [j], e.g. [ʀiœʀ]. Given that French has words like *rien* [ʀjɛ̃] 'nothing' with an underlying /rj/, it appears that French is an example of a Type D language (referred to in section 1). The reason why we consider this to be only a marginal example of a Type D language is that [ʀiœʀ] appears to be the only word that illustrates that syllable-initial [rj] cannot be derived. It is also worth noting that words like *rien* referred to above are extremely rare. See Hall (2006) for discussion.

Another example of a language in which /r.j/ is unstable but non-rhotic /C.j/ is not, is the variety of Spanish discussed by Denton (1998:226). According to Denton /j/ surfaces after a (non-rhotic) consonant and before a glide in words like *palacio* [pa.la.θjo] 'palace' but is often pronounced as [i] (followed by [j]) after /r/, e.g. *misterio* [mi.ste.ri.jo] 'mystery' ([r] is an apical alveolar tap). This example therefore looks like an example of a Type B language because a /Cj/ sequence is normally parsed into syllable-initial position unless the /C/ is /r/. When /rj/ are adjacent, syllabification is bled by a process of Vowel Epenthesis. We have been unable to confirm the one example cited above (Harris, 1983:38 provides examples with [rj]) and therefore classify Spanish as a marginal example. Should future research reveal that there are speakers of Spanish who robustly avoid syllable-initial /rj/ as described above, then the data can be classified as a true example of a Type B language.[23]

[23] According to an anonymous referee, examples like Denton's *misterio*, with Vowel Epenthesis applying between a rhotic and a high front vocoid, are otherwise unattested in the relevant literature on Spanish. According to the same referee, what has been noted for Spanish is the tendency for word-initial apical alveolar trills to block gliding of a following prevocalic /i/ or /u/. For example, Hualde (1999:191) cites *R[u.á]nda* 'Rwanda' and *r[i.é]l* 'track' but at the same time acknowledges the existence of *r[jé]sgo* 'risk'. Cabré and Prieto (2006:218) do not observe this general tendency in the data they collected via survey,

4. Languages which avoid /rj ri/ (or /jr ir/)

In contrast to the languages discussed in the previous section, the following languages all avoid sequences of /rj/ *and* /ri/ (or the mirror image /jr/ and /ir/). We show below that there are languages in which the facts require either the constraint *rj-ri in (4c) (or the mirror image thereof: *jr-ir). In section 4.1 we discuss a Type B language, namely Norwegian. Section 4.2 provides data from Mandarin and Jita as Type C languages. Marginal examples are presented in section 4.3.[24]

4.1 Type B: [jɽ iɽ yɽ] are blocked from being derived in Norwegian

Norwegian, or more precisely the variety termed Urban East Norwegian and described by Kristoffersen (2000:9f.), is an example of a language in which the derivation of sequences with high front vocoids and a following retroflex flap are blocked. Recall from section 2 that we subsume flaps under the category of r-sounds.

This variety of Norwegian has two rhotic sounds, [ɾ] and [ɽ]. The surface retroflex flap [ɽ] occurs as an alternative pronunciation of the apical tap [ɾ] in words in which Old Norse had /rð/, e.g. *bord* [buːɾ] ~ [buːɽ] 'table', or as alternative pronunciation to [l], see the examples in (20a) (from Kristoffersen 2000:24).[25] Alternative pronunciations of /l/ as [ɽ] are

either word-initially (e.g. *r[wí]do* 'noise', *r[wi]na* 'ruin') or word-finally (e.g. *fanfarr[ja]* 'bluster', *bandurr[ja]* 'bandurria'). The reviewer agrees that our classification of Spanish as a marginal example of a Type B language remains justified because the data are inconclusive and because word-initial trills seem to block gliding of /u/, a high back vowel, as well as the high front vowel /i/.

24 At present we have no examples of a Type A language, i.e. a language in which /rj ri/ or the mirror image simply does not occur. We assume that this gap is purely accidental.

25 Very few words can be pronounced *only* with an [ɽ]. Kristoffersen (2000:24) mentions one example, *møl* [møɽ] 'things strongly disliked', which contrasts with *mør* [møɾ] 'tender'. The phonemic status of the retroflex rhotic can thus be called "precarious" (Kristoffersen ibid.).

not possible after the high front vowels, i.e. /i(ː) y(ː)/, as the examples in (20b) show (Kristoffersen 2000:34, 90f., Lorentz, p.c.).[26]

(20) a.	sol	[suːl]	~ [suːɽ]		'sun'
	kål	[koːl]	~ [koːɽ]		'cabbage'
	dal	[dɑːl]	~ [dɑːɽ]		'valley'
	folk	[fɔlk]	~ [fɔɽk]		'people'
	valp	[ʋɑlp]	~ [ʋɑɽp]		'puppy'
b.	mil	[miːl]	*[miːɽ]		'10 km'
	syl	[syːl]	*[syːɽ]		'awl'
	stilk	[stilk]	*[stiɽk]		'stalk'
	vill	[ʋil]	*[ʋiɽ]		'wild'
c.	feil	[fæjl]	*[fæjɽ]		'error'
	steil	[stæjl]	*[stæjɽ]		'steep'
	kveile	[kvæj.lə]	*[kvæj.ɽə]		'to coil'
	bøyle	[bœj.lə]	*[bœj.ɽə]		'clotheshanger'

Though the words in (20b) only provide examples for the avoidance of tautosyllabic [y(ː)ɽ i(ː)ɽ] sequences, this avoidance also holds for heterosyllabic cases, as the addition of the definite article illustrates, e.g. *mil+a* [miː.lɑ] but not *[miː.ɽɑ].

[26] The words with short vowels in (20b) can be alternatively pronounced with a retroflex lateral, i.e. as [stiɭk] and [ʋiɭ].

The examples in (20c) show that the alternative pronunciation of /l/ as [ɽ] is also banned from occurring after the diphthongs /æj/ and /œj/ (Lorentz, p.c.). The third diphthong of Norwegian, /æw/, allows a following retroflex flap, e.g. *maule* [mæw.ɽə] 'to pick food', which can alternatively be pronounced with the labiodental glide [mæʋ.ɽə]. This example illustrates that the avoidance of [jɽ] is specific to the palatal glide and not to diphthongs or glides in general. Norwegian is thus a language that has the constraint *jr-ir, which is the mirror image of the constraint in (4d). Since the reverse sequences of /ɽ/ plus high front vocoid occur in Norwegian, e.g. *skli* [skɽiː] (~ [skɭiː] ~ [skliː]) 'to glide', *fly* [fɽyː] (~ [fɭyː] ~ [flyː]) 'air plane', and *helg* [hæɽj] 'weekend', we conclude that the constraint as stated in (4d) cannot be correct.[27]

The avoidance of [jɽ] and [i/y(ː)ɽ] holds only for the retroflex flap, since other retroflex consonants can occur after the high front vocoids, as in (21).[28]

(21) lys-sky [ˈlyʂ̩.ʂyː] 'photophobic'
yrt [yːʈ] 'drizzled'
lirt [liːʈ] 'cranked'

Besides the retroflex flap, Norwegian has an additional rhotic, namely the apical tap [ɾ]. This segment does not show the same restrictions as [ɽ] because it can occur after a high

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27 A further restriction in Urban East Norwegian is that the retroflex flap cannot occur after /e(ː)/. The flap causes a vowel lowering to [æː] in this context, e.g. *hæl* [heːl] ~ [hæːɽ] 'heel'. This lowering not only holds for the retroflex flap but tends to hold for all apical consonants, including the apical tap, e.g. *merr* [mær] 'mare' (see Kristoffersen 2000:105-109 for discussion of e-Lowering in Norwegian). To account for this process, an independent, more general constraint such as *e-apical is necessary in addition to *jr-ir.

28 We are not aware of any examples in which the diphthongs [æj œj] are followed by a retroflex but assume that this is an accidental gap.

vocoid, e.g. *dirre* [diɾ.ɾə] ‘to tremble’, *kyr* [çyːɾ] ‘cows’ and *leir* [læjɾ] ‘camp’. These examples therefore imply that the constraint *jr-ir is specific to [ɽ] and that it cannot subsume both rhotic sounds.

To summarize, Norwegian does not allow sequences of a high front vocoid followed by a retroflex flap to be derived from /l/. This avoidance holds for all high front vocoids in Norwegian, namely [i(ː) y(ː) j]. It holds only for the retroflex variant of the rhotic, since there are no such restrictions for the apical tap [ɾ]. A possible explanation for the restriction to the retroflex rhotic is given in section 7.1 below.

4.2 Type C: Derived /rj ri/ are repaired

4.3.1 Mandarin: repair of derived [ir yr jr]

Mandarin Chinese, often referred to as Standard or Beijing Chinese, has a process of r-Suffixation which can result in a sequence of high vocoid /i y j/ plus /r/. Since these sequences are repaired, the mirror image of constraint (4c), i.e. *ir-jr)$_\sigma$ is operative in Mandarin.

The only Mandarin rhotic phoneme is a voiced retroflex sound, which is usually described as an approximant (Chao, 1968, Duanmu, 2000:26, Lee and Zee, 2003:109), or a fricative (Karlgren, 1915-1926, Shi, 2004:6),[29] e.g. *rén* [ɻən] ‘man’ and *rù* [ɻu] ‘to enter’.[30] In the present study we treat this sound as an approximant for two reasons, cf. Duanmu (2000:26): First, it has phonetically little friction, and second, if treated as a fricative it would

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29 Although most authors agree that the rhotic in Mandarin is a retroflex approximant, this classification is not always consistent with its transcription. For example, Duanmu (2000) transcribes it as [r], and Lee and Zee (2003:109) as [ɹ̺].

Cheng (1973:20) considers the sound to be a strident retroflex fricative in syllable-initial position, and a non-strident retroflex liquid otherwise.

The Mandarin retroflex sounds are articulated further front than the sublaminal postalveolar/palatal sounds that can be found e.g. in Dravidian languages (see the discussion by Ladefoged and Maddieson, 1996:150f. of the Mandarin fricatives). For this reason the Mandarin sounds are sometimes not referred to as retroflex, see e.g. Lee and Zee (2003).

30 Tone is omitted from the phonetic transcriptions of Mandarin.

be the only voiced obstruent in Mandarin. A syllabic variant of this sound exists, too, but can only follow syllable-initial retroflexes [ʂ ʈʂ ʈʂ^h ɻ] in open syllables, e.g. *zhī* [ʈʂɻ̩] 'know' and *rì* [ɻɻ̩] 'sun' (Duanmu 2000:36).

Though coda consonants in Mandarin are almost always nasals, the rhotic can occur in coda position as the diminutive suffix –r, which is realized as [ɻ] or as the rhotacization of the preceding vowel (Shi 2004:15).[31] r-Suffixation results in an incorporation of the retroflex into the syllable if the syllable ends in a back or low vocoid, e.g. /ku +ɻ/ [kuɻ] 'drum' or /t^{h}ow+ɻ/ [t^{h}owɻ] 'head'. The incorporation also holds for syllable-final nasals in the stem, which are deleted under r-Suffixation, e.g. /kan + ɻ/ [kaɻ] 'pole'. If *r* is added to a high front vocoid, then the output sequences [iɻ yɻ jɻ] are avoided. For vowels, the avoidance strategy is schwa insertion, as in (22a), and for the diphthongs ending in /j/ the avoidance strategy is deletion of /j/, as in (22b). The examples in (22) have been drawn from Cheng (1973:25, 29), Duanmu (2000:195f.) and Goh (2003:568).

(22) *r-Suffixation in Mandarin for words ending in high front vowels:*

a.	i	+ ɻ	iəɻ	'clothes'
	tɕi	+ ɻ	tɕiəɻ	'chicken'
	tɕ^{h}y	+ ɻ	tɕ^{h}yəɻ	'song'
b.	p^{h}aj	+ ɻ	p^{h}aɻ	'signboard'
	taj	+ ɻ	taɻ	'bag'
	lej	+ ɻ	leɻ	'tear'

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[31] See Shi (2004:15) for a discussion of the meanings of the r-suffix. Goh (2003) argues that r-suffixation is not an active phonological process, but that the suffixed forms are listed in the mental lexicon along with the unsuffixed forms. We do not follow his argumentation in the present article.

We can see from these examples that Mandarin has a constraint *ir-yr-jr)$_\sigma$ (the mirror image of 4c) that operates on the output of r-suffixation, so that sequences like /ir/ are blocked from surfacing. Across syllable boundaries, there is no restriction on the sequence /r/ plus high front vocoid, e.g. *ér ǐ* [ɻ̩.i] ‘only’ and *èr yuè* [ɻ̩.ɥɛ] ‘February’. The reverse sequence, high front vocoid plus /r/, also occurs across syllable boundaries, e.g. *nǚ rén* [ny.ɻən] ‘woman’ and *bì rán* [bi.ɻan] ‘inevitable’. These examples therefore require the constraint for Mandarin to refer specifically to the sequence ‘high vocoid plus rhotic’ in syllable-final position.

In sum, Mandarin does not allow tautosyllabic sequences of a high front vocoid followed by a retroflex approximant to be derived; hence the mirror image constraint (4c) is active in the language.[32]

4.3.2 Jita: repair of heteromorphemic /rj ri/

An example of a language in which syllable-initial /rj/ and /ri/ are repaired is the Bantu language Jita (Downing, 2001, 2007). Jita has the rhotic tap [ɾ], which is an allophone of /l/.[33] This rhotic tap changes to an [s] by a process of Spirantization when certain morphemes that start with /i/ or /j/ are added. Spirantization is illustrated in the data in (23) (from Downing 2007:58–60):[34]

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32 Mandarin also does not allow the tautosyllabic sequence of [r] plus a high front vocoid. However, the ban on sequences like [ri] holds not only for [r] but also for all other retroflex ([ʂ ʈʂ ʈʂʰ ɻ]) and dental ([t tʰ ts tsʰ n s l]) consonants. In addition, the palatal and labio-palatal glides [j ɥ] never occur after retroflexes or velars. The constraints capturing these restrictions are very general and therefore of no further interest for the present study.

33 Morpheme-initially, only the lateral occurs, elsewhere, the tap and the lateral are in free variation.

34 Tone has been omitted from the phonetic transcriptions of Jita.

(23)		*Base infinitive*	*Causative*	*Agentive*	*Gloss of infinitive*
	a.	oku-saɾ-a	oku-sas-j-a	omu-sas-i	‘to go mad’
		oku-leɾ-a	oku-les-j-a	omu-les-i	‘to raise children’
		oku-koɾ-a	oku-kos-j-a	omu-kos-i	‘to work’
		oku-guɾ-a	oku-gus-j-a	omu-gus-i	‘to sell’
	b.	oku-mweːg-a	oku-mweːg-j-a	omu-mweːg-i	‘to shave’
		okw-aik-a	okw-aik-j-a	omw-aik-i	‘to talk’
		oku-βiɾim-a	oku-βiɾim-j-a	omu-βiɾim-i	‘to run’
		oku-menj-a	oku-menj-j-a	omu-menj-i	‘to know’
		oku-luːβ-a	oku-luːβ-j-a	omu-luːβ-i	‘to follow’
		oku-geːnd-a	oku-geːnd-j-a	omu-geːnd-i	‘to go’

In (23a) we see words with stems that end in the tap. For example, the base infinitive of ‘to go mad’ consists of the prefix /oku-/ plus the stem /saɾ/ followed by the suffix /-a/. The stem-final /ɾ/ is spirantized to [s] when the causative morpheme /j/ (see the second column) or the agentive morpheme /i/ (see the third column) are added. The examples in (23b) illustrate that Spirantization does not occur with stems ending in obstruents, glides or nasals.

Agentive and causative are the only morphemes with a high front vocoid in Jita that trigger Spirantization. For example, the applicative /iɾ/ and the perfective /iɾe/ do not cause Spirantization, as the following data show:

(24)	*Base infinitive*	*Applicative*	*Perfective*	*Gloss of infinitive*
	oku-saɾ-a	oku-saɾ-iɾ-a	-saɾ-iɾe	‘to go mad’
	oku-leɾ-a	oku-leɾ-iɾ-a	-leɾ-iɾe	‘to raise children’
	oku-koɾ-a	oku-koɾ-iɾ-a	-koɾ-iɾe	‘to work’
	oku-guɾ-a	oku-guɾ-iɾ-a	-guɾ-iɾe	‘to sell’

The fact that only certain morphemes beginning with /i j/ trigger Spirantization is discussed in section 6. See also section 7.4 on various lexical exceptions.[35]

[35] For a few words, exceptional Spirantization of non-rhotics occurs, for instance [oku-loga] ‘to bewitch’ vs. [omu-losi] ‘witch’ and [okw-iːβa] ‘to steal’ vs. [omw-ifi] ‘thief’ (Downing 2001:4).

Morpheme-internal /ɾi/ sequences occur in Jita, e.g. [emi-sumaːɾi] 'nails', [eci-juːɾi] 'chicken coop'. The reverse (tautomorphemic) sequence /iɾ/ also occurs, e.g. in the applicative and perfective markers and in [oku-βiɾima] 'to run'. Jita has neither coda consonants, nor diphthongs; thus heterosyllabic /ɾj/ and tauto- and heterosyllabic /jɾ/ cannot occur.

In sum, Jita is an example of a language where the constraint *rj-ri as in (4d) holds for certain heteromorphemic contexts.

4.4 Marginal examples

According to Ross (1988), there were a number of sound changes which affected various Oceanic languages which are relevant for the present study because they appear to be motivated by the avoidance of /ri/. We provide some of Ross's sound changes below, but we do not discuss them in detail because he does not provide enough examples to determine whether or not these changes are regular phonological processes or sporadic ones.

According to Ross (1988:267) the following two Meso-Melanesian Cluster languages deleted /r/ in the neighborhood of /i/. Here and below, POC stands for Proto-Oceanic.

(25)	Tiang	POC *r > Ø / __ i (or i __)
	Kara	POC *r > Ø / __ i (or i __)

By contrast, POC */l/ stayed /l/ in the two languages above.

In several Oceanic languages /r/ became /s/ before /i/. Two examples from the Admiralities Family are presented in (30) (from Ross 1988:324):

(26)	Titan	Proto-East Admiralities *r > s / __ i
	Sori-Harengan	Proto-East Admiralities *r > s / __ i

Proto-East Admiralities */r/ shifted to /l/ in the elsewhere case. Proto-East Admiralities */l/ stayed /l/ even before /i/.

In the North New Guinea Cluster grouping the same process can be observed (see 27, from Ross 1988:168).

(27)	Kilenge	Proto-Mengan *r > s / __ i
	Sio	Proto-Mengan *r > s / __ i
	Mangap	Proto-Mengan *r > s / __ i
	Lukep	Proto-Mengan *r > s / __ i
	Malasanga	Proto-Mengan *r > s / __ i

What the sound changes in (25-27) suggest is that /ri/ was avoided in these languages and that the specific languages had various repair strategies for avoiding this sequence (POC did not have clusters consisting of /Cj/, including /rj/).

5. Against a phonological explanation

The most plausible phonological explanation for the avoidance of a sequence of sounds like /rj/ involves sonority, although one could alternatively make a case for a non-sonority based explanation which relies on distinctive features. In this section we reject both explanations.

5.1 Sonority

Consider first the sonority-based argument.[36] According to this view, languages which avoid syllable-initial /rj/ like Proto-West Germanic and Modern German would require a particular

[36] As an anonymous reviewer pointed out to us, the sonority-hierarchical account can be argued to be phonetic rather than phonological. Several studies have discussed the phonetic basis of sonority, see e.g. Ladefoged

version of the sonority hierarchy and a language-specific statement to the effect that two member syllable-initial clusters must be separated by a certain minimum sonority distance. The approach described here has been proposed for various languages by Selkirk (1984), Levin (1985) and Hall (1992). This treatment is only possible if the two segments /r/ and /j/ are assigned unique points on the sonority hierarchy (i.e. points separate from /l/ and /w/) and if the categories in the sonority hierarchy are assigned a unique numerical value. An example of such a sonority hierarchy is presented in (28):

(28) *Hypothetical sonority hierarchy:*

stops	fricatives	nasals	l	r	j	w	vowels
1	2	3	4	5	5.5	7	8

Given the hierarchy in (28), a language which avoids syllable-initial /rj/ (e.g. Modern German) would have a language-specific requirement that two syllable-initial segments cannot be separated by a sonority distance of at least one. Given this minimal sonority distance requirement, sequences like /lj nj/ are allowed and /rj/ is banned because the former two sequences are separated by a sonority distance of at least one and a half, but /r/ and /j/ are only separated by a sonority distance of one half. Glides other than /j/ (e.g. /w/) can combine with /r/ because /w/ and /r/ are separated by a sonority distance of two.

There are several problems with the sonority-based explanation described above. First, it is not clear how other illicit syllable-initial clusters (e.g. in West Germanic and Modern German) are ruled out. A case in point is the absence of nasal plus /l/ and nasal plus /r/

(1975), Price (1981) and Ohala (1992); and Parker (2002) illustrates that intensity is a reliable acoustic correlate of sonority. However, Jany et al. (2007) used Parker's intensity measure in their comparison of four languages and show that there are language-specific differences in the order of segments based on their intensity (e.g. differences in the order of laterals and rhotics). We interpret these findings as evidence that the sonority hierarchy is phonetically based but nevertheless a phonological concept.

clusters, neither of which is tolerated in these two languages. Nasals and /l/ are separated by a minimal sonority distance of one and therefore should be allowed. One might be inclined to alter the numerical value for one of the segments involved; hence, if the value ‘3’ for nasals were changed to ‘3.5’, then /nl ml/ would be ruled out by the same minimal sonority distance requirement that rules out /rj/. The obvious problem with this approach is that it cannot rule out clusters like /nr mr/. Note that similar problems arise in attempting to rule out other impermissible syllable-initial clusters, e.g. /lr/ and /jw/.

A second problem with the sonority-based approach is that it only works for languages in which syllable-initial /rj/ is banned but it is not clear how it works for languages in which word-internal /rj/ are disallowed (e.g. Norn, English (Variety II), Cypriot Greek). A proponent of the sonority-based explanation might argue that in Norn word-internal /rj/ clusters (were they to exist) would have to be syllable-initial. If a sonority hierarchy like the one in (28) holds for Norn, then the avoidance of word-initial and word-internal /rj/ could therefore be attributed to the minimal sonority distance requirement. The problem with this approach is that it will not work for English (Variety II), since word-internal /rj/ in that language is uncontroversially considered to be heterosyllabic.

A third problem with the sonority-based approach in (28) is that it is not clear how this treatment accounts for the languages discussed in section 4, in which /ri/ is avoided (in addition to /rj/). One possible solution is to modify the sonority hierarchy in (28) in such a way that /i/ is treated separately from the other vowels by occupying a niche between the glides /j/ and /w/. An example of a sonority hierarchy along these lines is presented in (29). The category /i/ is understood to be a variable, which can also stand for all high front vowels (including /y(:)/, as in Norwegian and Mandarin).

(29) *Hypothetical sonority hierarchy:*

stops	fricatives	nasals	l	r	j	i	w	other vowels
1	2	3	4	5	5.5	5.75	7	8

Given the hierarchy in (29) one could account for languages which disallow /ir jr/ in the rhyme (e.g. Norwegian) by positing a minimal sonority distance of one. Given this requirement, syllable-final /jr ir/ are not allowed because the minimal sonority distance requirement is not satisfied, but /r/ could combine with a preceding /w/ or with some other vowel. Note that the analysis will only work if /i/ is assigned a value that is less than one away from /r/ (to prevent /i/ from combining with /r/).

The sonority hierarchy in (29) is unconventional from a cross-linguistic perspective as it requires one particular vowel (i.e. /i/, or the natural class of high front vowels) to be split up from the other vowels. Although other versions of the sonority hierarchy split up vowels (e.g. high vowels > mid vowels > low vowels; see Vennemann, 1988:9, Goldsmith, 1990:111), it is unusual to see one particular vowel (or group of vowels) being separated from the other vowels by some other category (i.e. the glides /w/ in (29)).[37]

A further problem with the hierarchy in (29) (and also with the one in (28)) is that it cannot cope with the fact that in Norwegian it is only the retroflex variant [ɽ] of the rhotic that does not occur after /i y/ and /j/, while the tap [ɾ] does not show such a restriction. In order to incorporate such a difference between rhotic articulations, the hierarchy in (29) could be modified by splitting the rhotic category in two, and assigning /ɽ/ the value 5 and /ɾ/ the value 4.5. To apply such a hierarchy to the other languages discussed in sections 3 and 4, the rhotic trill would have to occupy the same place as the retroflex /ɽ/. Such a hierarchy would then

[37] In addition, there seems to be no phonetic evidence for this order, i.e. the vowel /i/ has not been reported to have a lower intensity than the glide /w/, see the discussion in footnote 36.

distinguish between an apical tap/flap rhotic and a retroflex rhotic, with the tap/flap being further away from /j/ than the other rhotics. Apart from the unconventional splitting up of rhotics into two categories, this hypothetical sonority hierarchy could not account for Cypriot Greek or Jita, in which the rhotic undergoing the restriction is an alveolar flap/tap.

Unless we allow language-specific sonority hierarchies to solve these problems (see e.g. the sonority scale Levin 1985 proposed specific to Klamath), we must reject a sonority hierarchy as explanation for the co-occurrence restrictions on rhotic and high front vocoids. The obvious drawback with language-specific sonority hierarchies like the ones described above is that they obscure significant cross-linguistic generalizations.

5.2 Features

Consider now a possible phonological explanation for the gaps described in this article involving /rj ri/ etc. not in terms of minimal sonority distance requirements, but instead in terms of negative filters consisting of distinctive feature matrices (cf. Chomsky and Halle, 1968). In this approach, a language which disallows syllable-initial /rj/ would state the relevant constraint (in this case 4a) in terms of features, as in (30). It is assumed here that /r/ is [+continuant] and that /l/ is [–continuant]. Assuming that neither feature matrix in (30) is moraic, the filter in (30) would rule out /rj/ while allowing /ri/. By contrast, in languages which ban /rj/ and /ri/, there would be no requirement that the two feature matrices in (30) cannot be moraic.

(30) $*_{\sigma}[\begin{bmatrix} +\text{ consonantal} \\ +\text{ coronal} \\ +\text{ sonorant} \\ +\text{ continuant} \end{bmatrix} \begin{bmatrix} -\text{ consonantal} \\ +\text{ coronal} \\ +\text{ sonorant} \\ +\text{ continuant} \end{bmatrix}$

If the features for /r/ and /j/ are correct in (30), then one might argue that the ban on /rj/ can be attributed to the OCP, since the two segments in (30) have identical specifications for the final three features.

While the constraint in (30) correctly rules out syllable-initial /rj/, it brings up several unanswered questions. First, the segment /j/ is assumed to be [+continuant] but this feature is uncontroversially redundant for sonorants; thus, (30) presupposes a theory which allows obviously redundant features to play a role in phonotactic constraints. Second, it is not clear why the final three features in the two matrices (i.e. [+coronal, +sonorant, +continuant]) trigger an OCP violation, while other adjacent, identical features do not. For example, the occurring syllable-initial cluster /tr/ has two matrices which are both [+coronal], [+consonantal] and [+anterior]. Third, to account for the contrastive behavior of the two rhotics in Norwegian we would have to add to the first matrix (30) an additional feature, e.g. [anterior], in order to distinguish /ɾ/ ([+anterior]) from /ɽ/ ([–anterior]). Thus, for Norwegian (30) would only hold for the [–anterior] rhotic. However, this additional restriction poses a problem for languages like Cypriot Greek and Jita, in which the rhotic undergoing the restriction is alveolar ([+anterior]). A language-specific featural restriction (i.e. [+anterior] for Greek and Jita and [–anterior] for Norwegian) is weak because it obscures the common motivation behind these restrictions.[38]

6. An explanation in terms of phonetic grounding

In the present section we propose an articulatory explanation for the observed avoidance strategies of rhotic and front high vocoid-sequences (section 6.1). Section 6.2 extends this

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[38] An anonymous referee points out that another possible weakness with (30) is that rhotics are analyzed as [+continuant]. It is conceivable that flaps in American English are [–continuant] based on their alternations with coronal stops. One could also argue that apical alveolar trills are [–continuant] in Spanish because the trill has the same distribution of the [–continuant] allophones of /b d g/.

explanation to account for the differences in the languages described above. In section 6.3 we reject an account in terms of perceptual salience.

The articulatory explanation for the avoidance of /rj/ we propose below cannot predict which avoidance strategy (recall (1)) is found in which language. In our view, other factors influence the choice of repair strategy, e.g. independently occurring processes and auditory similarity to other sounds. Since an account of these factors would involve a detailed discussion of the sound inventory and the phonological processes of every single language discussed above, it goes beyond the scope of the present paper and we therefore leave this issue open for further study.

6.1 Articulatory incompatibility of apical rhotics and high front vocoids

Several studies on languages which avoid /ri rj/ and /ir jr/ sequences propose some kind of explanation for this restriction based on articulation, namely the difficulty of articulating the rhotic gesture and the gesture for the high front vocoid in sequence, as elaborated below.

It has often been noted that dental and alveolar rhotics are articulated with the tongue tip as opposed to the tongue blade (see e.g. Ladefoged *et al.* 1977:49, Catford, 1988:154, Ladefoged and Maddieson 1996:218, Recasens, 1991, Recasens and Pallarès, 1999:144). A reason for this is that the tongue tip is lighter and more flexible than the tongue blade and therefore more favourable for the articulation of rhotics, especially trills, which require very quick and precise movements (see e.g. Solé, 1998). Apical rhotics are articulated with a lowered tongue blade and a lowered and retracted tongue dorsum (see Recasens and Pallarès, 1999), thus the whole tongue is in a concave shape. This posture is opposed to the convex tongue shape for the articulation of high front vocoids, where both the tongue blade and the front dorsum are raised and fronted (Recasens, 1990, Recasens et al., 1993:225, Recasens and Pallarès, 1999 call this an “antagonistic” articulation to the rhotic). Again, the whole tongue is involved in this position.[39] Consequently, the successive articulation of /r/ and /i j/ involves a rapid change of the concave tongue posture with a raised tongue tip to a convex tongue posture with a raised tongue blade, which involves large articulatory effort and is therefore often avoided. Besides the opposing gestures, the variability of both articulations plays a role in the avoidance of the sequence. Rhotics consist of more restricted articulations than other coronals (Dart, 1991, Recasens, 1991); because of the strict requirements on the exact tongue position (especially for the trills) they allow less carry-over effects from preceding vowels, and at the same time cause more assimilation in the adjacent vowels. This observation lead Recasens (1991:280) to speak of the alveolar trill as a "consonant which is specified for a high degree of articulatory constraint". High front vowels, on the other hand, have also been reported to be resistent to co-articulation, and to be the least variable of all vowels in their tongue dorsum gesture (Hoole et al., 1990, Recasens, 1999), "presumably since the tongue body becomes highly constrained when fronted and raised simultaneously" (Recasens, 1999:81). The combination of these two invariable articulations accounts for the fact that, instead of showing coarticulatory effects on one or both segments, we find the repair strategies listed in (2), as elaborated in the previous sections. A last factor contributing to the avoidance of sequences with rhotics and high front vocoids is the quick movement of the tongue tip or velum required for rhotics (especially trills), which leaves little time for a transition between rhotic and adjacent segment, especially if the adjacent sounds have antagonistic tongue shapes and involve slow articulators like the tongue dorsum.

Various explanations based on the antagonistic gestures have been proposed for the avoidance of /r/ plus high front vocoids in single languages, amongst others, by Delattre and

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[39] Note that the present approach, where we consider the front part of the tongue to strongly influence the position of the tongue dorsum (and vice versa), contrasts with approaches such as Articulatory Phonology (Browman and Goldstein, 1986), in which the tongue tip/blade and the tongue dorsum are considered independent articulators. Support for our approach comes from Laver (1994): "Any setting of the body of the tongue will tend to affect the settings of the other sub-parts of the tongue, namely the tip/blade sub-system and the tongue-root sub-system" (p. 411).

Freeman (1968) and Hall (2003) for English, Hamann (2003b) for German, Chao (1968:46), Cheng (1973:25), and Duanmu (2000:30) for Mandarin, Kristoffersen (2000:34) and Hamann (2003a) for Norwegian, Downing (2001:3f., 2007) for Jita, and Denton (1998) for Greek.[40] While we agree with the general observation made by all of these authors, we show below that our explanation (which includes not only antagonistic gestures, but also the invariability of both articulations and the requirement for a quick transition) is more general because it holds for several different realizations of /r/ (section 7.1), and it can account for other sequences that involve the same opposing gestures, to the exclusion of sequences that seem to involve similarly antagonistic articulations but are not avoided (section 7.5).

Evidence for the articulatory explanation comes from the fact that the avoidance strategy is usually extended to the rounded high front vocoids [y(ː) ɥ] if the language under investigation has such segments in its segment inventory, e.g. Norwegian (section 4.1) and Mandarin (section 4.2). Neither high, back vocoids such as [u(ː) w ɯ ɰ ʉ ɨ], nor mid front vowels [e ɛ ø œ] undergo the articulatory restriction because all of these sounds involve tongue gestures that differ much less or – in the case of the back vocoids – hardly at all from the rhotic tongue gesture.

Our articulatory account derives further support from the fact that it can explain the unusual situation in Jita, in which certain morphemes starting with /i/ trigger Spirantization of the rhotic, whereas others also starting with /i/ do not. This language stems from Proto-Bantu, which had a seven-vowel system with a distinction between */i(ː)/ (belonging to the so-called Degree 1, or superhigh, vowels) and */ɪ/ (belonging to the so-called Degree 2 vowels).

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40 Gussenhoven (2009) proposes the articulatory incompatibility of tongue postures as reason for a lengthening of [i] before [r] in Dutch: “the articulatory transition from a vocalic posture to that required for [r] will thus take more effort than a transition to the position for post-vocalic [t, s, n, l], for which the front of the tongue may, but need not be concave” (p. 7). A similar articulatory explanation of the cetralizing of diphthongs before /r/ in Dutch is given by Booij (1995:34). However, Gussenhoven’s account cannot explain why the lengthening before /r/ affects all high vowels in Dutch, including [u].

Sequences of Proto-Bantu */ri/ lead to Spirantization, whereas sequences of Proto-Bantu */rɪ/ did not. Articulatorily, the difference in tongue shape between /r/ and /i/ is greater than that between /r/ and /ɪ/. It is therefore not surprising that /ri/ in Proto-Bantu was avoided, whereas the less articulatory-challenging /rɪ/ was not. This phonetically-motivated difference in behavior became obscurred by the subsequent collapse of Degree 1 and Degree 2 vowels in numerous Bantu languages. The interaction of the occurrence of Spirantization and the reduction of the Proto-Bantu seven-vowel system to a five-vowel system has been discussed in detail by Schadeberg (1995) and Labroussi (1999). For a further discussion of the Jita case, see section 7.4 below.

A difference in the tongue gestures like the one in Proto-Bantu between /i/ and /ɪ/ also accounts for the distinction in Norwegian between a retroflex flap, which avoids front vocoids, and an apical alveolar flap, which does not. Here it is the difference in tongue shape between alveolar and postalveolar (retroflex) rhotic that is responsible for the non-homogeneous behaviour of the two rhotics. The concave tongue shape that we described for alveolar apicals above is even more extreme and resctricted for the segmental class of retroflexes (apical postalveolars), which therefore avoid the front vocoid context more rigorously, see the discussion in Flemming (2003) and Hamann (2003a). This articulatory explanation for the avoidance of retroflex vocoids raises the question why it is not the case that all retroflex segments in Norwegian avoid the high front vocoids. We assume that the answer lies in the different manners of articulation: a retroflex flap, with its very short and unstable manner of articulation, is more susceptible to the high front vocoid context than retroflex stops, nasals, fricatives or laterals, which are rather stable articulations due to their steady-state contact with the hard palate (Boersma and Hamann, 2005).

6.2 Possible differences between glide and vowel

Many languages avoid /rj/ sequences but not /ri/ (see the examples in section 3), and languages that avoid /ri/ seem to avoid /rj/ as well (see the examples in section 4). This can be expressed in the avoidance hierarchy in (31), where ‘<’ stands for ‘is implied by’; hence, the avoidance of /ri/ implies the avoidance of /rj/.

(31) */rj/ < */ri/

The articulatory explanation proposed so far does not include an explanation for the hierarchy in (31). One possible solution is to assume that there is a systematic articulatory difference between /i/ and /j/ similar to the one between lax /ɪ/ and tense /i/ discussed above: The glide is articulated with a higher tongue position than /i/, therefore the distance the tongue has to travel between the rhotic and /j/ is larger than the distance between the rhotic and /i/.

However, studies which could potentially provide articulatory evidence for (31) by comparing the high front vowel to its corresponding glide are scarce and inconsistent, see for instance the discussion on the Polish and German high front vocoids in Hall et al. (2006). Most studies comparing /i/ and /j/ infer the position of the articulators and the degree of constriction on the basis of the acoustic signal, more precisely the formant frequencies, but do not provide articulatory data. This is the case in the study by Maddieson and Emmorey (1985), which compared the formant frequencies of /j/ and /i/ in Amharic, Yoruba, and Zuni. They found that in all three languages the glide has a lower first formant than the vowel, indicating that /j/ is produced with a more narrow constriction than /i/. Apart from the fact that this is only indirect evidence, Maddieson and Emmorey recorded /j/ only in the context of the vowel /i/, where it is probably articulated with a closer constriction than in other vocalic contexts in order to maintain a perceivable difference between glide and vowel, as pointed out by Hall et al. (2006:73). A generalization concerning the articulatory characteristics of /j/ in other vowel contexts can therefore not be made. Chitoran (2003) in a study on Romanian high front vocoids found a lower second formant for the glide, and interprets this as target undershoot of the glide, i.e., the glide is articulated with a lower tongue position and less constriction than the vowel (p. 3016). From the findings in these studies we conclude that the articulatory difference between /i/ and /j/ might not be consistent across languages, and therefore that there might not be an articulatory basis for the hierarchy in (32).

Another possible explanation for the hierarchy in (32) might be the durational difference between glide and vowel. Catford (1988:72) refers to [j] as an “ultra-short [i]”. To move from the tongue configuration for /r/ to the opposing configuration of a high front vocoid is more difficult if the following segment is of short duration (as for the glide) and therefore provides not enough time for this articulatory change. This explanation is similar to the one provided by Gussenhoven (2009) on the observed lengthening of /i/ before /r/ in Dutch: the longer duration of the long vowel allows the articulatory movement towards the following rhotic, whereas a short vowel impedes it. A similar argument is provided by Hall (2003:254) as explanation for why /ri/ occurs in English and /rj/ does not.

6.3 Alternative phonetic account: Licencing by cue

In section 5 we showed that phonological accounts for the observed typological restrictions on sequences of rhotic plus high front vocoids cannot capture all the processes we described. We have argued instead that a restriction grounded in articulation can account for them. An alternative to the proposed articulatory account is to explain the avoidance of sequences like /rj/ in terms of perception. Steriade (1995, 1999, 2001) argues that phonotactic restrictions reflect the relative perceptability: featural contrasts occur more often in positions where they are better perceivable (i.e. positions where they are perceptually salient) than in those positions where their perceptual cues are obscured. Stops, for instance, have strong cues for place of articulation in the post-release interval, namely burst and CV transitions, but less salient cues in the pre-release interval. This can explain why place-contrasts for stops regularly occur pre-vocalically but are often neutralized in pre-consonantal position.[41]

Steriade has applied her so-called *licensing by cue* approach to successfully explain several cases in which a featural contrast can occur in one context but is banned from another context. Such cases are different from the present phonotactic restriction in which the co-occurrence of two segments is banned. An explanation of the constraints in (4) in the licensing by cue approach would have to state that sequences of /rj/ and /ri/ are avoided because the perceptual cues of an /r/ leading out of the consonant cannot be easily distinguished from the perceptual cues of a /j/ leading into the consonant, and furthermore, the cues leading into an /r/ and those leading out of a /j/ are not salient enough to distinguish the respective segments. However, the acoustic characteristics of the two segmental classes do not support this hypothesis. High front vocoids like /i j/ are characterized by a high first and second formant (F1 and F2, caused by the fronted and raised tongue, respectively). Rhotics, on the other hand, have a lowered F2 and (usually) a lowered F3.[42] The reason the licensing by cue approach cannot account for the avoidance of sequences like /rj/ is that a sequence of high F2 (i.e. /r/) and low F2 (i.e. /j/) perceptually enhances the difference in F2 rather than making it inaudible.

The application of licensing by cue to the constraints in (4) creates a further problem. Such an approach cannot explain the fact that /rj/ is more often avoided in tautosyllabic than in heterosyllabic sequences, since the main idea of licensing by cue is to avoid referring to syllable positions. We conclude that Steriade's perceptual account cannot explain the co-occurrence restrictions involving sequences like /rj/.[43]

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41 For a retroflex place of articulation there are stronger cues leading into the stop closure and consequently retroflex contrasts occur more often in VC- than in CV-position in the languages of the world.

42 As has been pointed out by an anonymous reviewer, not all rhotics show a lowered F3, see the discussion in Lindau (1985) and Ladefoged and Maddieson (1996:244-245).

43 In a psycholinguistic study, Hamann and Ernestus (submitted) found that Dutch listeners who had to acquire an artificial language in which a rhotic occurred only before the front vowels /i ɛ/ but not before /a u/, the

7. Challenges for the articulatory explanation

There are several challenges for our explanation for the avoidance of /rj/ proposed in section 6.1. For example, the explanation given above holds only for apical rhotics and it cannot account for the fact that sequences of rhotic plus high front vocoid are avoided more often than the reverse order. Furthermore, our account does not consider the role of syllable boundaries or lexical exceptions to the phonetically motivated restrictions. Finally, our articulatory explanation predicts the avoidance of more sequences than just /rj/. These challenges are discussed in sections 7.1 to 7.5 below.

7.1 Non-apical rhotics

Articulatory and acoustic studies have shown that the articulation of rhotics can vary within a language between coronal and uvular place of articulation, and also between trill, fricative and approximant manner. (Recall the German uvular /ʁ/ discussed in section 3.2.1 above). The rhotic /r/ in American English, for instance, can be either apical (with alveolar or retroflex place) or ‘bunched’ (where the tongue blade is raised to the palatal region), see Delattre and Freeman (1968). The choice of allophone is partly conditioned by the context (Guenther et al., 1999) and by region (Delattre and Freeman, 1968), but is also speaker-dependent (Westbury et al., 1998). British English /r/ has a labiodental approximant variant transcribed as [ʋ] which is typologically unusual and not considered a rhotic sound (recall the table in (3)). This variant is regionally and socially dependent, marking working-class speakers from south-eastern but also northern England (Docherty and Foulkes, 2000; Trudgill, 1999).

Such variation in the pronunciation of rhotics is problematic for the explanation of their articulatory incompatibility with front vowels proposed above, which is based solely on apical

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participants performed best for the legitimate sequence /ri/. This finding is further evidence against a perceptually motivated restriction, according to which one would expect the listeners to perform worst for the supposedly non-salient /ri/.

rhotics. If we compare the articulation of apical rhotics first to uvular rhotics, we can observe a similar tongue shape. Uvular rhotics require a retracted tongue back and concomitant lowering of the tongue middle. This gesture is similar to that of an apical rhotic (apart from the tongue tip, which is lowered for the uvular and raised for the apical sound). Our argument that a sequence of alveolar rhotic plus a high vocoid is avoided because the tongue has to change quickly from one gesture to an opposite one, where both are quite inflexible gestures, can thus be easily extended to uvular rhotics: Regardless of the position of the tongue tip, the tongue has to change from the retracted and lowered tongue dorsum (which is accompanied by a retracted and lowered tongue blade) of the rhotic to the raised and fronted tongue blade of the high front vocoid. Precisely this line of argumentation is pursued by Hamann (2003b) in her treatment of the non-occurrence of German /ʁj/ sequences.

The labiodental variants of /r/ in British English can also be subsumed by the articulatory explanation. An acoustic study by Jones (2005) shows that these allophones involve secondary velarization or pharyngealization. We see the secondary gesture of a retracted tongue dorsum as being very different from the tongue gesture for high front vocoid articulations. Hence, we hold that our explanation for the avoidance of /rj/ or /ri/ sequences also holds for labiodental realizations of the rhotic.

An apparently problematic case for the general articulatory explanation is the ‘bunched r’ in American English, which has a tongue configuration that resembles the one for /j/, since the front part of the dorsum is raised. We suggest tentatively that the proposed articulatory constraint against /ri/ sequences is phonologized in American English, that is, the constraint holds on a more abstract, phonemic level, and thus it encompasses all articulatory realizations of the rhotic. Further cases with a loss of phonetic conditioning are discussed in 7.4 below.

7.2 Asymmetry in ordering: */rj/ more often avoided than */jr/?

A second challenge for our articulatory explanation for the avoidance of /rj/ is the question of whether there is an asymmetry in the occurring avoidance strategies, and whether this asymmetry can be attributed to the type of rhotic involved. Six of the languages in the present study avoid syllable-initial *and* heterosyllabic /rj/ sequences. In all six languages the rhotics are non-retroflex. By contrast, in two languages discussed above, coda /jr/ and heterosyllabic /jr/ sequences are avoided (where /j/ stands for all high front vocoids). In both of these languages the rhotics are retroflex. Though our observations probably only reflect a mere tendency and they clearly need to be confirmed with a larger set of languages, we provide a possible explanation for it based on the difference in overlap of gestures.

If we consider the gestures involved in the /rj/ sequence and their possible overlap in timing, we can observe that /j/ requires a raising and fronting of the tongue dorsum, which is a massive articulator that needs more time to move than the small and quick tongue tip that is involved in the apical /r/. While planning the articulation of the /r/, the speaker thus has to plan at the same time the articulation of a following /j/ to ensure a smooth transition from /r/ to /j/ (see Gracco, 1988 on the coordination of lip and jaw movements). This large overlap in planning results in contradictory commands for the tongue dorsum, namely to stay in rest position (or to be slightly lowered) for the rhotic, and to be raised and fronted for the /j/. This contradiction leads to avoidance strategies. For the reverse order (i.e. /jr/), the slow gesture of the tongue body is followed by a quick one of the tongue tip; they are hardly overlapping, and the latter can be planned and executed when the first is nearly finished. Thus, the articulators do not receive any contradictory orders, and the sequence is therefore not avoided. The gesture-overlap explanation as elaborated up to now only holds for apical rhotics. It can be extended to uvular rhotics by arguing that uvulars involve quicker tongue body movements than /j/ because they only require a retraction of the tongue dorsum compared to the fronting and raising of the tongue dorsum involved in /j/. Hence, there is more gestural overlap in /ʁj/ than in /jʁ/, again explaining why /ʁj/ is avoided more often than its mirror image /jʁ/.

An additional factor that can account for the observed asymmetry is the type of rhotic involved. The two languages that avoid /jr/ sequences in our study both have a retroflex rhotic (flap or approximant), namely Norwegian and Mandarin Chinese. The avoidance of /jr/ sequences (instead of /rj/) might therefore be correlated with the specific characteristics of retroflex rhotics. For retroflex sounds, the movement of the tongue tip towards the postalveolar or palatal region often starts during the preceding sound, observable as long and prominent transitions in a preceding vowel. Retroflex stops, flaps and approximants show a change during their articulation from this (sub-)apical postalveolar position to a more fronted, apical alveolar position, a phenomena sometimes referred to as 'flapping out' (Ladefoged, 1964, see Boersma and Hamann, 2005:19f. for a discussion of articulatory and acoustic data). This asymmetry in articulation can be held responsible for the direction of high-vocoid avoidance: high vocoids preceding retroflex rhotics are affected by the retroflex, or the retroflex by the vocoids, whereas following high vocoids are not affected or do not affect the retroflex sound. This observation is borne out in Norwegian, which allows the sequence [ɽj] (both in syllable-initial and -final position), whereas [jɽ] in coda position is not allowed. Mandarin neither allows $_{\sigma}($rj nor rj$)_{\sigma}$, but the constraint on this syllable-initial sequence is part of a more general constraint including all coronal consonants, while *rj$)_{\sigma}$ is unique to this sequence. Further studies are of course necessary to prove or disprove the present proposal.

7.3 Tauto- versus heterosyllabic sequences

All languages discussed in the present study avoid tautosyllabic sequences of /rj/ or /jr/ (where /j/ stands for front high vocoids). Some of these languages (Norn, Cypriot Greek, Jita) also avoid rhotic-high vocoid sequences when they are heterosyllabic. The purely articulatory explanation we presented in section 6 cannot account for this observation, and at present we have no clear answer to the influence of the intervening syllable boundary on /rj/ and /jr/ sequences.[44]

An anonymous reviewer claims that the difference between hetero- and tautosyllabic /rj/-sequences could be explained in terms of the sonority hierarchy because sonority distance is only computed within but not across syllables. We do not agree on this point. Numerous studies on the Syllable Contact Law (e.g., Murray and Vennemann, 1983, Vennemann, 1988, Bat-El, 1996, Gouskova, 2001, Baertsch, 2002) have shown that sonority distance across syllable boundaries can account for restrictions on heterosyllabic consonant clusters.

7.4 Lexicalisation of phonetic restrictions

As elaborated in section 6.1 above, Proto-Bantu distinguished */i(ː)/ (Degree 1 or superhigh vowels) and */ɪ/ (Degree 2 or high vowels). Only the former caused Spirantization of a preceding rhotic and we argued above that this restriction on the rule's trigger can be attributed to the fact that the sequence /ri/ is articulatorily more challenging than /rɪ/. In present-day Jita, morphemes that cause Spirantization (namely the causative and the agentive suffixes) contain high front vocoids that derive historically from Degree 1 vowels, whereas the vowels in the non-spirantizing morphemes have their origins in Degree 2 vowels. However, Jita and numerous other Bantu languages have lost the transparency of the phonetic motivation for rhotic Spirantization by collapsing the two types of vowels into one category /i(ː)/. As a result, we assume that present-day learners of Jita have to store in their mental

[44] There are numerous studies on differences in articulatory timing between onset and coda segments and on the influence of prosodic domains on the realization of segments, see e.g. Fougeron (1999) and Byrd et al. (2005) for overviews. However, we are aware of only one study (Byrd, 1996) where the articulation of heterosyllabic clusters is compared to the same clusters in tautosyllabic position. Byrd only observed for stop-stop sequences a greater coproduction in coda clusters than in heterosyllabic sequences. We leave it open for future work to test whether there is an articulatory difference between tauto- and heterosyllabic rj.

lexicon which morphemes trigger Spirantization, and that they therefore do not have a phonetically-motivated constraint *rj and *ri. Two facts support this lexicalisation. First, the perfective morpheme -*ire* also had an initial Degree 1 front vowel in Proto-Bantu but – contrary to expectations – it does not trigger Spirantization in present-day Jita (Downing 2007). Second, a few Jita words show Spirantization of non-rhotics (recall footnote 35). Such exceptions are only possible if there is no longer a phonetic relation between Spirantization and vowel quality, and if the morphemes that cause and the lexical items that undergo Spirantization are learned individually.[45]

An additional language in which a once active phonetic constraint *ri is no longer active is Polish. Polish has no tautosyllabic sequences of /ri/ in native words; only loanwords allow this sequence, e.g. [rʲi.sɔ.tɔ] 'risotto' and [grʲil] 'grill'.[46] This situation can be accounted for if we assume that Polish had a phonetic constraint *ri at a certain point in time, which resulted in an unrestricted avoidance of this sequence. At a later stage, the constraint failed to be active and thus loanwords do not obey this restriction.[47]

For both Jita and Polish we therefore assume that a once general, articulatorily motivated restriction *rj-ri was responsible for the processes that are at the present stage of the language only observable in certain morphological contexts.

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[45] Downing (2007:60ff.) accounts for the exceptional behaviour of the perfective morpheme in Jita by proposing that it attaches at a different domain, namely the root, and is included in the Prosodic DStem of the verb, whereas the spirantizing causative and agentive suffixes attach at the Prosodic DStem.

[46] The secondary palatalization of the rhotic is due to the front high vowel, which causes secondary palatalization of all hard consonants, i.e. those that do not diachronically stem from palatalized consonants.

[47] At the point in time in which the restriction was still active in Polish, it also caused a morphological alternation: the Polish nominative plural morpheme –i, when attached to male nouns ending in [r], triggered palatalization and fricativization of the rhotic. At a later stage a backing of both fricative and vowel occurred, resulting in present-day alternations like [kɛl.nɛr] – [kɛl.nɛ.ʐɨ] 'waiter sg. – pl.' (see Klemensiewicz, 1985). This output contrasts with other nouns ending with [r], such as [mur] 'wall', in which the addition of the plural morpheme –i simply causes retraction of the vowel: [mu.rɨ]. This retraction is not only triggered by r but by all so-called 'hard' (i.e., non-palatalized) consonants (Rubach, 1984), and thus is due to a different constraint, which came about at a later historical stage.

7.5 Other sequences of 'antagonistic' gestures

A legitimate question concerning our articulatory explanation is whether or not the avoidance of opposing gestures also applies to other sequences.[48] We henceforth distinguish three types of sequences with opposing gestures: (a) rhotics and front coronals (e.g. /rt/ with a laminal /t/), (b) sequences of a segment with a retracted tongue body (the one characteristic that we assume is shared amongst all rhotic articulations) and a high front vocoid (e.g. /ɫi/, /qi/ or /ħi/), and (c) sequences that are not similar to /rj/ but which have in some sense opposing gestures (such as /aj/ or /ak/ with a sequence of /a/ plus either a retracted or a raised dorsum).

Let us consider first (a) sequences. A typical example is /rt/ with a laminal coronal preceded or followed by a rhotic. According to our explanation, these sequences should be difficult to articulate and hence avoided. Since only a small set of languages differentiates front coronals by their apicality/laminality only, this prediction is difficult to test. A case at hand is the so-called 'retroflex rule' of Urban East Norwegian, according to which morphologically derived sequences of an apical tap and a laminal consonant are realized as a retroflex consonant (Kristoffersen 2000:88–102). Even languages that do not have separate apical and laminal front coronals and which show variation in the articulator for the front coronals show assimilation of their front coronals to adjacent rhotics: For example, Clements (1985:235f.) illustrates the retracting effect of a rhotic on a preceding [t d n] within the same onset cluster in English, and a similar effect has been reported for [t d] (with concomitant assibilation of the rhotic) in some dialects of Latin American Spanish by Bradley (2006:20–21).[49]

With respect to (b) sequences, Gick and Wilson (2006) investigated the occurrence of epenthetic schwa in many English dialects in sequences of high front vowel and velarized

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[48] We thank an anonymous reviewer for drawing our attention to this question. We discuss that reviewer's examples below.

[49] We thank another anonymous reviewer for bringing the Norwegian retroflex rule and the data from Latin American dialects to our attention.

lateral, as in words like *feel* [fi:əɫ], and provided a similar articulatory explanation as the one provided here: “[a] specific conflict […] between an advanced tongue root/dorsum target for the palatal vowel or glide, and a retracted target for the following uvular/upper pharyngeal constriction for /l/” (p. 636). See also Recasens and Pallarès’ (1999:144) comparison of a trill and /ɫ/, both involving “much tongue predorsum lowering and tongue postdorsum retraction”. In a similar way, Laver (1994:327, 412) accounts for vowel lowering and retraction caused by pharyngealization in high vowel plus pharyngealized coronal sequences in Algerian Arabic, e.g. /bɪ̠t̠/ [be̠t̠ˤ] ‘eggs’. Further evidence for the lowering and/or retracting influence of pharyngealized or pharyngeal consonants on high front vowels is given by Al-Ani and El-Dalee (1984) for Egyptian Arabic, Norlin (1985) for Cairo Arabic, and by Bessell (1988) for Interior Salish languages.

In the sequences discussed up to now we have dealt with segments that show strong restrictions on the overall tongue body configuration (a rhotic, a velarized or pharyngealized segment and a palatal segment), i.e. segment types that are opposed to co-articulation or assimilation (Recasens, 1999:91-93), and, though superficial because of lack of space, we could mention that there are several languages in which these sequences are reported to be avoided. Consider now the (c) sequences referred to above, in which we see a lowered and retracted tongue dorsum for [a] followed or preceded by the antagonistic gesture of a raised tongue predorsum as in [j] or a raised postdorsum as in [k]. Both types of sequences, i.e. the diphthong [aj] and sequences like [ak] or [ka], are quite common in the languages of the world, so there must be an inherent difference between these and the sequences discussed above. We argue that this difference lies in the less restricted nature of the gesture necessary for [a] (and [k]). While [a] involves a retraction of the tongue dorsum, it is succectible to coarticulation of adjacent segments. For example, MacNeilage and DeClerk (1969), Kiritani *et al*. (1977), and Recasens (1999) show that an adjacent velar heavily influences the articulation of [a] because it causes a raising of the postdorsum in the vowel. We assume that the same holds for the influence of an adjacent high front vocoid on [a]. In addition, both [a] and the velar/palatal articulations do not require quick articulations as is the case for rhotics. The diphthong [aj] in particular allows a long transition from one segment to the other, as the transition only perceptually enhances the diphthong-like nature of the combination.

In sum, we argue that there are certain segmental combinations such as /rj/, /ɫi/ and /ħi/ which are articulatorily incompatible and therefore cross-linguistically avoided, whereas other combinations such as /aj/ and /ka/, though they also require the articulators to cover some distance, allow repair mechanisms such as long transitions and co-articulation which do not change the involved segments in a drastic way and still render them recognizable.

8. Conclusion

In this article we have presented evidence from a number of languages that rhotic plus high front vocoid sequences (e.g. /rj ri/ or the reverse /jr ir/) exhibit various repair strategies. Specifically, either the /r/ or the vocoid deletes, changes into some other sound, or these sequences simply do not occur. We have argued that the tendency to avoid sequences like /rj/ requires specific constraints grounded in articulatory phonetics. Significantly, we have also shown that the avoidance of sequences like /rj/ is not a consequence of perceptual salience, sonority sequencing or any other abstract phonological entities such as distinctive features.

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