

GESTURES AND SEGMENTS: VOWEL INTRUSION AS OVERLAP

A Dissertation Presented

by

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ABSTRACT

GESTURES AND SEGMENTS: VOWEL INTRUSION AS OVERLAP

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This dissertation focuses on a phenomenon that I call *vowel intrusion*. There are cases where a vowel can be heard between two consonants, yet the phonology behaves as if no vowel is present. These “intrusive vowels” are non-syllabic, and native speakers are often unaware of their existence.

I argue that intrusive vowels are a percept resulting from the organization of articulatory gestures. When two consonant gestures have little overlap with one another, there is an acoustic release between them; vowel gestures typically overlap neighboring consonants considerably, and it is possible for an overlapping vowel gesture to be heard in this period of release.

Intrusive vowels are not segments. They behave unlike true epenthetic vowels. A typological survey reveals that vowel intrusion happens in consonant clusters that contain a sonorant or a guttural, and that it is always the vowel adjacent to the sonorant or guttural that is heard during the release. Intrusive vowels occur primarily in heterorganic clusters, especially next to geminates; they often disappear at fast speech rates, and in some languages, they occur only within or only between syllables. I argue that these characteristics are best explained in a theory that uses Articulatory Phonology representations (Browman & Goldstein 1986 et seq.).

I develop a theory called Timing-Augmented Surface Phonology (TASP), cast within the framework of Optimality Theory. TASP contains constraints on the alignment of neighboring gestures (Gafos 2002) and on the permitted degree of overlap between different gestures. The theory requires a segmental representation as well as a gestural representation. Syllables organize segments rather than gestures, and that inter-segmental gestural alignment is universally non-contrastive.

The same gestural framework describes both the short, schwa-like intrusive vowels often described as “excrement”, and also a longer type found in Scots Gaelic and Hocank (Winnebago), in which the vowel is heard in two long parts on either side of the sonorant. In the latter cases the sonorant and vowel together behave like a bimoraic nucleus, and are adjoined in a structure similar to vocalic diphthongs. The theory also has implications for the analysis of Hocank accent.

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CHAPTER 1. GESTURES AND SEGMENTS: THE STRUCTURE OF NON-SEGMENTAL VOWEL SOUNDS

1.1. Introduction

1.1.1. The intrusive vowel syndrome

This dissertation concerns a phenomenon that was first pointed out by Sanskrit grammarians about 2500 years ago. The *praticakhyas*, ancient Indian commentaries on Pānini, contain descriptions of a type of vocalic interval that the writers call not a vowel, but a ‘vowel-fragment’—*svarabhakti* in Sanskrit. This vowel-fragment is described as appearing between an [r] and a following consonant, or according to one commentator an [r] or [l] and a following consonant, and as having one-eighth to one-half the length of a normal vowel. This vowel-fragment is not described as adding a syllable to the word (Allen 1953:73-80).

This is the earliest description of a phenomenon that I will call ‘vowel intrusion’. In many languages, a sonorant or guttural is separated from an adjacent consonant by either a short schwa or a vowel whose quality is identical to that of the vowel next to the sonorant or guttural. Some examples are given in Figure 1, with the intrusive vowel underlined. Throughout, I will use the term sonorant to include gutturals as well (following Halle 1995, where gutturals are [+sonorant]).

The inserted vowels in these processes are often described in the linguistic literature as epenthetic, but they have a group of characteristics in common that set them apart from other epenthetic vowels. The following list of properties can be called the “vowel intrusion syndrome”.

- (1) Vowel intrusion diagnostics
 - a. Vowel intrusion is triggered by a consonant cluster that includes a sonorant. Gutturals are considered sonorants.
 - b. The intrusive vowel has the same quality as the vowel that is adjacent over the sonorant. (This is usually true even when [ə] is transcribed.)
 - c. Vowel intrusion is usually restricted to heterorganic clusters.
 - d. The intrusive vowel behaves as if it does not add a syllable to the word.
 - e. In many languages, the intrusive vowel may disappear at fast speech rates.

I propose in this thesis that this is not a chance collection of properties. What underlies the vowel intrusion syndrome is a representation in which these vowels are not segments. Rather, they are percepts resulting from a particular timing of articulatory gestures within the syllable, and constraints on articulatory organization cause the trends seen in environment and vowel quality.

Languages with intrusive vowels in RC or CR clusters (R = sonorant)

| | | | | | |
|----------------------------|-----|-----------------|---|--|-----------------|
| Arbore | | /leh-t-atto/ | → | lefi _e 'tatto | 'that ewe' |
| Bedouin Arabic dialects | | qahwa | > | ga'hawa | 'coffee' |
| Chamicuro | | /tuʔlu/ | → | 'tuʔulu | 'chest' |
| Dutch | | /kalm/ | → | 'kalə _m | 'quiet' |
| English (various dialects) | | /arm/ | → | 'arə _m | 'arm' |
| Finnish | | /kalvo/ | → | 'kaləvo | 'transparency' |
| German (S. Hamburg) | | /bʁatən/ | → | bə _ʁ atən | 'to fry' |
| Hausa | | /kurkutu/ | → | k ^w ur ^u k ^w u:tu | 'small drum' |
| Hocank | I. | /sni/ | → | s _i n ⁱ | 'cold' |
| | II. | /ho:tʃāk+ra/ | → | ho:tʃāg ^ʁ rə | 'the Hocank' |
| Irish Gaelic | I. | /agla/ | → | 'agə _l | 'fear' |
| | II. | gorm | → | 'gorə _m | 'blue' |
| Kekchi | | /paʔt/ | → | paʔat | 'twins' |
| Lakhota | | /gla/ | → | g ^a la | no gloss |
| Late Latin | | <i>scriptum</i> | > | <i>sci</i> ri _i ptum | 'a writing' |
| Mamaindé | | /mih-takʔu/ | → | mih _i takʔu | 'it is cloudy' |
| Mono | | /gàfrū/ | → | gàf _u rū | 'mortar' |
| Oscan | I. | <i>Mulcius</i> | > | <i>Mulukiis</i> | name |
| | II. | <i>patri</i> | > | <i>paterēi</i> | 'patri' |
| Popoluca | | /itʔa/ | → | it ^a ʔa | 'your father' |
| Saami | | /skuol:fi:/ | → | skuol:ə _f i: | 'owl, nom. sg.' |
| Sanskrit | | /darʃata/ | → | darə _ʃ ata | no gloss |
| Scots Gaelic | | /ʃaLk / | → | 'ʃaL _a k | 'hunting' |
| Spanish (Chilean) | | /kronika/ | → | ko' _r onika | 'chronicle' |
| Tiberian Hebrew | | /yaʃmod/ | → | yaʃ _a 'mod | 'he stands' |

Notes: '→' indicates synchronic processes; '>' indicates diachronic processes. When a vowel is written in superscript, this follows a convention used by the source to emphasize the vowel's short duration. When two examples are given for a single language, they illustrate distinct types of vowel intrusion.

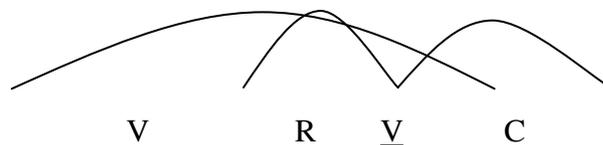
Sources: Dutch- Booij 1995:127; English- Wright 1905:206; Finnish- Harrikari 1999:6; German-Jannedy 1994:113; Hausa- Hodge 1947:12; Hocank (a.k.a. Winnebago)- Miner 1992:30, Miner 1979:27; Irish- Ó Siadhail 1989:21,22; Lakhota- Albright 1999:1; Late Latin- Schuchardt 1867 vol 3:421; Mono (Niger-Congo, Congo)- Olson 2003; Oscan- Buck 1904:51-3; Saami- Bye 2001:164; Sanskrit- Allen 1953; Scots Gaelic- Borgström 1940:153; Spanish- Garcia-Bellido 1999:8; Arbore (East Cushitic)- Hayward 1984:72; Chamicuro (Arawakan, Peru)- Parker 1994:266; Kekchi (Mayan, Guatamala)- Campbell 1974:270; Mamaindé (Nambiquára, Brazil) - Eberhard 1995:17; Popoluca (San Juan Atzingo Puebla)- Krumholz, Dolson, & Ayuso 1995:282; Tiberian Hebrew- McCarthy 1979:34.

Figure 1: Vowel Intrusion

1.1.2. Vowel intrusion¹ as gestural overlap

Working in an Articulatory Phonology framework, Steriade 1990 proposes that copy vowels in Winnebago (Hocank), Late Latin, and Sardinian are formed through overlapping the gestures of a sonorant and an adjacent vowel. (Sardinian is omitted from the list in Figure 1 because the process there seems historical and sporadic.) When two consonant gestures become separated in time, an overlapping vowel gesture can be heard briefly in the interval between them, sounding like [ə] if it is short or like a copy vowel if it is longer. Below, each curve represents the dynamic cycle of one gesture. The intrusive vowel is underlined.

(2) Gestural score of vowel intrusion



Steriade points out that this analysis explains the copied quality of the vowel: the inserted vowel has the same quality as the adjacent vowel because they are a single gesture. I argue that the gestural approach explains the rest of the cluster of properties in (1) as well.

In other respects, the gestural analysis of intrusive vowels presented here differs considerably from Steriade's. Steriade views these vowels as segmental and syllabic, but evidence presented in chapters 2–5 will show that this is not the case. Intrusive vowels, despite their phonetic prominence, are completely invisible to a wide range of phonological patterns that count syllables, such as stress, templatic reduplication, syncope, licensing of segmental contrasts, ablaut, and language games.

Incidentally, the idea that one gesture can surround another goes back at least to Grammont 1933:244–9, who uses it to describe a type of metathesis that he calls 'inversion by penetration'. Grammont proposes that while some metatheses are a simple flipping of segments, other metatheses, especially those involving liquids, can result from one segment 'penetrating' another.

In Indo-European *wr* became *rw* or *ru* between consonants and even before vowels when initial ... This is not transposition pure and simple; the *w* doesn't pass over the *r* but through it. First the *r* assimilates to the *w*, without this requiring that the *r* take the *w*'s place of articulation; it can keep pretty much its usual place, while taking the timbre of the *w*, meaning that it is articulated with the resonator of the *w*, raising of the dorsum towards the velum, protrusion and

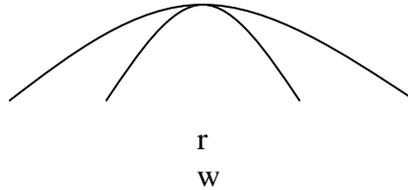
¹Intrusive vowels include many that have been described as "excrecent" (Levin 1987), "transitional", or "svarabhakti". I have chosen the term "intrusive" (Harms 1976) because I wish to argue for the existence of a class of vowels that is not precisely captured by the commonly understood definition of any of those terms. This class includes some vowels that are fairly long and hence not usually called excrecent or transitional, and it does not necessarily include all vowels that have been called svarabhakti.

rounding of the lips. Once the *r* is thus impregnated with *w*, the *w* springs up again in the form of *w* or *u* (as the case may be) on the side where its appearance will make a better syllable:

Zend *rvāta* ‘dogma’, cf. Sanskrit *vratām* ‘precept’; Zend *rvīnat* ‘compressing’, cf. Sanskrit *vlīnāti, vlināti* ‘he compresses’. These Zend forms seem to represent a phase where the *r* is still submerged in the *w*: it has *w* before and after it and is full of *w* itself. The *urva* of the texts, of which *rva* is an interpretation that in other respects seems correct, is only one syllable. (244; my translation.)

In this passage, Grammont essentially proposes that [rw] metathesis involves a historical stage where the segments have a gestural coordination like the following.

(3) Grammontian “penetration”



Grammont’s claim that a phonetic [ʷrva] is monosyllabic agrees with a claim that I will make about vowel intrusion: that a vocalic-sounding interval produced by gestural overlap, as opposed to insertion of a segment, is not the nucleus of a syllable.

Articulatory phonology, which treats gestures as objects manipulated by the grammar, provides a way to formalize Grammont’s idea and model the role of gestural timing in the grammar. Section 2 introduces this approach to phonology, including its implementation in Optimality Theory, and a basic gestural analysis of vowel intrusion. In section 3 I develop an Optimality-Theoretic Articulatory Phonology framework called Timing-Augmented Surface Phonology (TASP). Section 4 discusses particular gestural constraints needed to produce the vowel intrusion typology. Section 5 compares gesture-based theories to feature-based theories.

1.2. Articulatory phonology representations

1.2.1. Structure of gestures

Articulatory phonology (Browman & Goldstein 1986 et seq., Byrd 1996, Gafos 2002) is a model where the phonological grammar directly regulates the organization of abstract gestures. A gesture is essentially an instruction for an articulator to achieve a particular constriction in the vocal tract: for example, an opening of the velum, a closing of the glottis, or a raising of the tongue body. At the same time, a gesture is a unit of contrast that plays a role in representations similar to that of the feature.

Formally, a gesture consists of settings for one of the vocal tract variable sets. Examples of variables and settings they can take are listed below.

| | | | |
|-----|------------------|-----------------------------------|--------|
| (4) | ARTICULATOR SETS | VOCAL TRACT VARIABLES | |
| | tongue body | tongue body constriction location | (TBCL) |
| | | tongue body constriction degree | (TBCD) |
| | tongue tip | tongue tip constriction location | (TTCL) |
| | | tongue tip constriction degree | (TTCD) |
| | lips | lip aperture | (LA) |
| | | lip protrusion | (LP) |
| | glottis | glottal aperture | (GLO) |
| | velum | velic aperture | (VEL) |

CONstriction DEGREE VALUES (Gafos 2002:275)

| | |
|------------|-----------------------------|
| [closed] | stops |
| [critical] | fricatives |
| [narrow] | some vowels |
| [mid] | approximants and mid vowels |
| [wide] | some vowels |

CONstriction LOCATION VALUES: [labial], [dental], [alveolar], [post-alveolar], [palatal], [velar], [uvular], [pharyngeal]².

Segments in traditional phonological analysis are considered by Articulatory Phonology to be a combination of gestures. For example, an [n] is associated with the following tract variable settings:

| | | | | |
|-----|-----|---------------------|-----------------------------------|-----------------------|
| (5) | [n] | Tongue tip gesture: | tongue tip constriction location: | alveolar |
| | | | tongue tip constriction degree: | closed |
| | | Velum gesture: | velic aperture: | open |
| | | Glottis gesture: | glottal aperture: | critical ³ |

For the other tract variables, an [n] specifies no target, since no constriction of the tongue body or lips is involved. The position these articulators actually take during production of an [n] is affected by at least two factors. The first is the influence of other active articulations. If a vowel gesture overlaps the production of [n], it will affect the position of the tongue body. The other factor is a tendency of articulators to return to a neutral, resting state when not activated. In the absence of any other active gestures or influences, non-activated articulators will assume their resting positions while [n] is articulated.

Gestures are spatiotemporal units. Each gesture has a duration in time and an internal cycle. This cycle begins with the onset of movement, progresses to the point when the target is reached, then to the release, where movement away from the

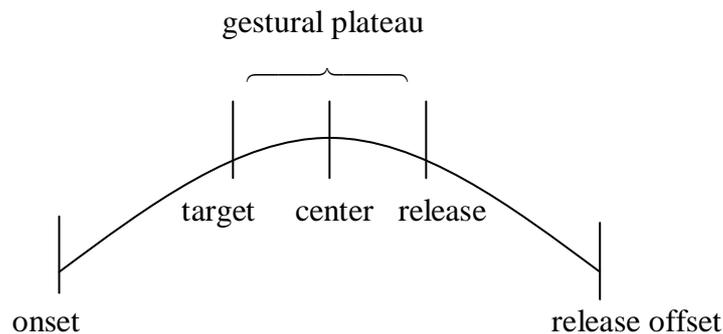
² The [pharyngeal] location characterizes not only pharyngeal consonants but also low vowels. A low back vowel involves a [narrow pharyngeal] gesture; a low front vowel a [wide pharyngeal] gesture.

³ Browman & Goldstein, however, do not show any glottal gesture for voiced segments.

constriction begins, and finally to the offset, the point where the articulator ceases to be under active control of the gesture. Between release and offset, there is a period when there is active control of movement away from the constriction (Browman 1994). After the offset, the articulators either continue moving back to their resting positions, or begin moving towards a new target specified by another gesture. A cycle can be shown by a curve, as below.

(6) Landmarks in a gestural cycle

Gafos 2002:271



The vertical axis represents the movement of an articulator in space; the horizontal axis represents time. Between the target and release is a period when the constriction is actively held, called the ‘gestural plateau’. The middle of the gestural plateau is called the c-center.

For visual clarity, the landmarks can be shown with angles rather than marks on a smooth curve. The two representations below should be understood to be equivalent.

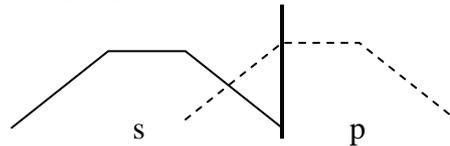


These particular five landmarks are a hypothesis, chosen in order to allow simulations; it is an open question how many landmarks are actually needed in the theory.

1.2.2. Phasing of gestures

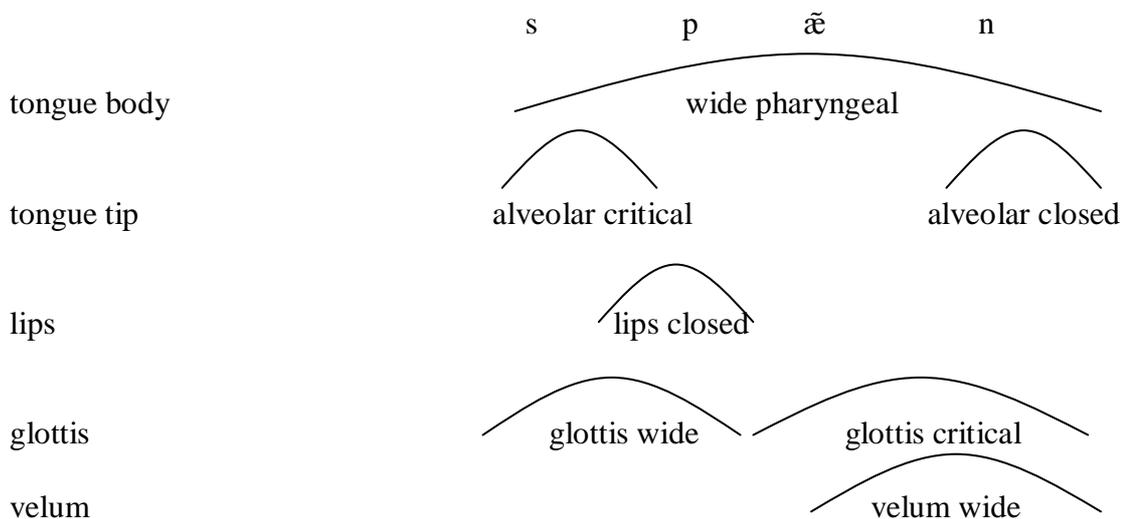
Gestures do not simply fall in a linear order like segments or features; they overlap one another greatly. Even as speech rates change, gestures tend to bear certain consistent relations to one another: for example, one gesture may consistently begin at the point where another gesture reaches its target or release. These intergestural timing relations are called phasing. The grammar specifies the phasing of gestures with respect to one another by aligning landmarks of different gestures. For example, the segments in the onset cluster [sp] might have the phasing relationship $OFFSET = TARGET$, meaning that the target of the [p] must be reached as the offset of the [s] occurs, as in (8). The bold line indicates the point in time when both these landmarks are reached.

- (8) OFFSET = TARGET (sample phasing relationship)



The organization of gestures over time is represented in a ‘gestural score’, consisting of the settings of the tract variable parameters and the timing relations between them. Below is a rough gestural score for an utterance of *span*.

- (9) Gestural score of English *span* [spæn]
adapted from Browman & Goldstein 1992b: 158



Gestures can overlap considerably, but with certain limits. Browman & Goldstein 1990 propose, based on X-ray evidence, that “consonant articulations are superimposed on continuous vowel articulations, which themselves minimally overlap.” A topic of current research is which gestures have specified phasing relationships with one another. There is evidence that phasing relationships are dependent on syllable structure: the same sequence of gestures will show different timing relations depending on whether they are tautosyllabic or heterosyllabic. This will be useful in explaining why vowel intrusion appears only in heterosyllabic clusters in some languages, and only in tautosyllabic clusters in others.

1.2.3. From abstract gestures to articulatory trajectories

A gestural score is part of a larger model of speech production developed at Haskins Laboratories called GEST (Browman & Goldstein 1990, Saltzman et al. 1988). GEST includes (among others) the following modules and stages of representation.

(10) Components of GEST

| | |
|---------------------------|--|
| Linguistic gestural model | contains language-specific principles of intergestural phasing |
| Gestural score | representation of gestural units and their organization over time, produced by the linguistic gestural model for each utterance |
| Task-dynamic model | calculates pattern of articulatory motions based on the gestural score, according to universal (not language-particular) principles of task dynamics |
| Articulatory trajectories | the pattern of movements generated by the task-dynamic model |

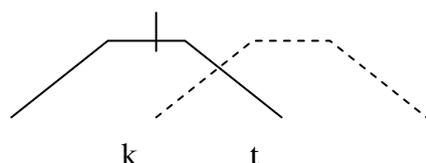
It is important to realize that there is a step between the gestural score and the actual, physical articulatory trajectories. Gestural scores provide input to the “task dynamic” module. Task dynamics is general model of skilled movement control, which can be applied to speech as well as other actions (Saltzman 1986, Saltzman & Munhall 1989). A gestural score may specify, for example, contradictory tract variable settings overlapping in time. The task dynamic model has to deal with such a situation by ‘blending’, which in at least some cases means averaging the parameter values for two gestures in the period where they conflict (Browman & Goldstein 1992a:30). A gestural score is a set of idealized instructions to articulators, which require some interpretation and modification to actually carry out. This interpretation is universal, not language-specific.

Gafos 2002 presents several results of GEST simulations that are useful in representing vowel intrusion. He reports the acoustic effects of different alignments among adjacent consonants. Aligning the c-center of one stop closure gesture with the onset of a heterorganic stop closure gesture results in an audible release between the two (at a certain speech rate). When the c-center of one stop is aligned with the target of a heterorganic stop, there is no audible release.

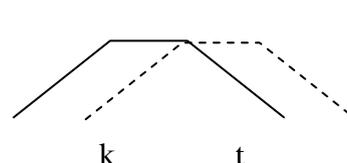
(11) Heterorganic stop clusters

Gafos 2002

a) CENTER (k) = ONSET (t)
(Audible release)



b) TARGET (k) = ONSET (t)
(No audible release)



Alignment a) above represents a French-like pronunciation of a [kt] sequence, the [k] having an audible release as in *acteur*. Alignment b) would produce a more English-like

pronunciation, where there is no release of the [k] before the [t] constriction is formed, as in *actor*. Vowel intrusion requires a period of release, consonants in a vowel intrusion structure may have a phasing relationship CENTER = ONSET, or a phasing relationship involving even less overlap.

1.2.4. Gestural representation and the vowel intrusion syndrome

Now that the basic apparatus of gestural phonology has been laid out, it is possible to show how specific properties of the vowel intrusion syndrome are predicted by this model. Vowel intrusion is frequently blocked in homorganic clusters and at fast speech rates. If intrusive vowels have the representation in (4), where vowel intrusion results from acoustic release in a consonant cluster, then both of these characteristics follow from general principles of task dynamics. These characteristics are explained more simply in the gestural approach than in other approaches, and this is the rationale for using a gestural model.

1.2.4.1. The heterorganicity requirement

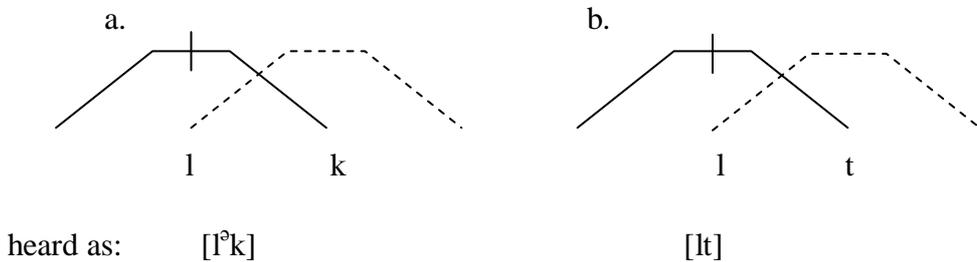
Intrusive vowels are cross-linguistically rare in homorganic RC clusters. Some examples illustrating this tendency are shown below; a fuller list of conditioning environments for vowel intrusion appears in the appendix.

| (12) Examples of: | Clusters w/ vowel intrusion | Clusters w/o vowel intrusion |
|---------------------------|-----------------------------|--|
| Scots Gaelic ⁴ | np lb lm Lg rf rx mn mr | Rd Rt r't' Rs Lt L't' mb mp Nd Nt N'd' N't' Ns |
| Finnish | lh lm lp rp rk rv rj rh rm | rt rs ns mp ls lt |
| Oscaan | lp rf lb rm nf nk rh lk rv | lt rt rn rs nt nd ns |

This property turns out to follow directly from task dynamics. Gafos 2002 shows that the alignment CENTER = ONSET produces a release in heterorganic clusters but not in homorganic clusters. The articulatory realization of a particular gestural coordination depends not only on which landmarks that are aligned, but on the types of gestures involved.

⁴ In the traditional transcription convention for Scots Gaelic, capital letters represent “tense” sonorants and apostrophes represent palatalization. Phonetic equivalents for one dialect are given in chapter 4, section 1.1.

(13) Acoustic effects of alignment CENTER = ONSET Gafos 2002



Intuitively, the reason for non-release in the homorganic cluster is that when the tongue receives instructions to begin moving away from the alveolar ridge, releasing the [l], it is also receiving instructions to begin moving towards the alveolar ridge, for the constriction of the [t]. When an articulator receives contradictory instructions, they must be reconciled through blending, which in this case causes the tongue to stay in place.

In at least the cases of slight, [ə]-like vowel intrusion, there is thus no need to posit any difference between the phasing of homorganic and heterorganic clusters. We can assume that in Finnish, for example, gives the same phasing to all RC clusters, and task dynamics explains why a release is heard in heterorganic [rk] but not homorganic [rt]. The description of output patterns is simplified, and there is no need to propose separate constraints or rules to deal with homorganic and heterorganic clusters.

1.2.4.2. Speech rate effects

Speech rate effects are another piece of the vowel intrusion syndrome that finds a natural explanation under the gestural account.

The duration and appearance of intrusive vowels is often described as inconsistent, often in a way that is dependent on speech rate. For example, Quilis 1981:298 notes that the duration of the intrusive vowel in Spanish Cr clusters is ‘very variable’. The examples in his study range from 8 ms. to 56 ms., with an average value of 29 ms. Jannedy 1994’s experimental work shows that German speakers produce intrusion more at slower speech rates, and that duration of the vowel ranges from 30-60 ms. According to Sanskrit grammarians, “between *r* and a prevocalic fricative, a *svarabhakti* is pronounced having the length of $\frac{1}{2}$ or $\frac{1}{4}$ of *a*; before other consonants (than fricatives) its length is $\frac{1}{4}$ or $\frac{1}{8}$ of *a*” (Allen 1953:73). In Dutch, vowel intrusion is optional for many speakers even when words are produced in isolation (Donselaar et al. 1999:60-61). For Saami, Bye 2001:139 indicates free variation between clusters like [lp] and [l:əp]. Holmer 1938:32 describes the intrusive vowel that appears in CR clusters in some Scots Gaelic dialects as ‘an obscure [ə] that may disappear’. For a Finnish dialect that has [ə]-like intrusive vowels, Harms 1976:77, who presents an informal gestural account, describes their appearance as depending on speech rate:

One final support for the view that schwa epenthesis is nonsegmental in nature is the great variation in the quality and duration of the intrusive vocoids. One-word

utterances—e.g., citation forms and exclamations (e.g. *helvetti* ‘hell’, *perkele* ‘devil’)—those with greatest sentence stress, are more likely to contain clearly perceptible schwa-type vowels... on the other hand, in fast speech and in words with weak sentence stress, these vocoids are very short; most frequently they are dropped altogether.

Most of the descriptions of variability concern intrusive vowels that are [ə]-like and short, rather than the longer intrusive vowels that are transcribed with copied qualities. Chamicuro, however, has intrusive vowels that have a distinct quality and yet appear only in emphatic speech.

| | | | |
|------|---------------|-----------------|-----------------|
| (14) | Chamicuro | | Parker 1994:266 |
| | Normal speech | Emphatic speech | |
| a. | túʔlu | túʔulu | ‘chest’ |
| b. | uɫáʔlo | uɫáʔalo | ‘my wife’ |
| c. | yapléʔti | yapléʔeti | ‘lightning’ |
| d. | piʔtótʃi | piʔitótʃi | ‘canoe’ |
| e. | maʔnáli | maʔanáli | ‘dog’ |

This variability and optional disappearance is expected in a gestural approach. Gafos 2002 reports from simulations with GEST that the presence of a release between two consonants depends not only on their phasing relation, but also on the rate of speech.

In the dynamic model of gestures, the parameter which determines how fast gestures reach their targets is called stiffness. The higher the value of the stiffness, the faster the gesture. Changing stiffness thus can be used to study the acoustic consequences of fast speech... Maintaining the relational invariance between two consonant gestures—c-center of first to onset of second gesture— I varied the dynamic parameter of gestural stiffness. It was observed... that below a critical value of stiffness an acoustic release is present in the transition between the two consonant gestures; beyond that critical value of stiffness, however, the acoustic release disappears. (286)

The tendency of intrusive vowels to disappear in fast speech and lengthen in emphatic speech is thus a direct prediction of the gestural analysis. This approach dispenses with the need for optional rules of syncope or other devices to explain the vowels’ inconsistent presence.

1.3. Timing-Augmented Surface Phonology (TASP)

Gestural representations are clearly useful for describing some sound patterns. But there is controversy over what role they should play in the grammar: whether they should supplant segments and / or features as phonological primitives; whether they are present in underlying representations; and whether gestural phasing is determined in the same level of the grammar where phonological operations like deletion occur or in a separate “phonetic implementation” level. The typology of vowel intrusion bears on many of these questions.

I argue for a model which I call Timing Augmented Surface Phonology (TASP), in which gestural phasing is determined by ranked, violable constraints. Constraints referring to gestural and non-gestural phenomena are present in the same level of the grammar. Gestures supplant features but the notion of the segment remains. Intersegmental gestural timing is hypothesized to be universally non-contrastive. Gestures are underlyingly present, but their timing is not. This greatly limits the possibility of gestural contrasts, in a way that is consistent with the typology of vowel intrusion.

1.3.1. Gestures and segments

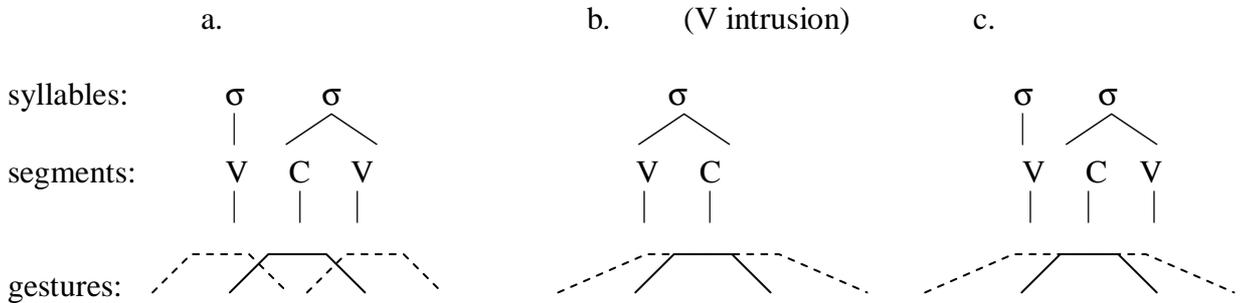
There is controversy about the relation between segments and gestures. In Browman & Goldstein's approach, the concept of the segment as an abstract unit visible to the phonology is abandoned. Gestures are the phonological primes, and segments are viewed at best as epiphenomenal. Byrd 1996:150-160, as well as Nittrouer et al. 1988, Saltzman & Munhall 1989:365 and Lofqvist 1991:346, suggest that the groups of gestures that constitute what are traditionally considered segments bear a more stable timing relationship to one another than do gestures that are parts of different segments: for example, that there is less variability in the alignment of the [k] and [p] gestures in a doubly articulated stop [kp̄] than in a [kp] sequence. The question is whether these groups of gestures have a stable timing relationship because they are associated with a single segmental unit, or whether segmenthood is a percept that results from a stable timing relationship. Byrd assumes the latter. She proposes that some gestures have lexically specified timing relationships, which causes them to have a more stable output timing than other gestures, and that "the percept and functionality of the segmental unit, to whatever extent it exists, results from its characteristic pattern of coordination... it is not the case that the quality of being a segment causes stable timing, but rather than stable timing causes the quality of being a segment." (159–60)

However, the 'segmenthood' of a group of gestures is not only a matter of consistent timing relations. Groups of gestures that are considered segmental act indivisible in certain ways in the phonology. For example, reduplication splits words and syllables but never segments. Language games are similar: they may separate a segment from its tone, but do not split up a segment. Speech errors also tend to work on whole segments.

The study of vowel intrusion can also contribute something to this debate. For example, vowel intrusion shows that gestures are not the units organized by syllables. As shown in chapters 2–5, intrusive vowels are non-syllabic: the vowel gesture corresponds to only one syllable despite the fact that it is heard in two pieces. However, there are other phenomena that plausibly involve a similar gestural score— a vowel completely surrounding a consonant— that are disyllabic. As discussed in chapter 3, there are languages where V.hV or V.?V sequences appear to involve a single vocalic gesture, yet clearly act like two syllables. In this way, syllabic structure is not predictable from the gestural score. Syllables do not organize gestures directly, but rather organize some other unit. This unit is the segment.

In TASP, an output representation contains both segments and gestures. Syllables organize segments rather than organizing gestures directly.

(15) Three possible timing-augmented segmental representations of [V_iCV_i].



In this my approach is close to that of Gafos 2002, who also incorporates segments into articulatory phonology and presents a formal theory of the relation between segments and gestures. He treats each segment as a set of gestures, which are organized with respect to one another in a way characteristic of that segment. Each segment has a ‘head gesture’, which is referred to by constraints on intersegmental coordination and serves as an anchor point for the other gestures associated with the segment. For consonants, the head gesture is the oral articulation. Segments are phased with respect to one another via their head gestures, as stated in (16), and the non-head gestures associated with each segment are in turn phased with respect to the head gesture.

(16) Definition: Inter-segmental coordination

Two segments S^1, S^2 are coordinated with some coordination relation λ if the head gestures of these segments are coordinated as in λ . (Gafos 2002:284)

TASP will include the same assumption. Incidentally, Zsiga 1997 also argues for the existence of both segments and gestures, but treats them as belonging to different stages in a derivation: segments cease to be relevant after features are mapped to gestures. TASP assumes that segments and gestures are relevant at the same stage of evaluation.

1.3.2. Gestural coordination in Optimality Theory

The gestural representations defended here could be used in various phonological frameworks, both rule- and constraint-based, but the present analysis will be shown in Optimality Theoretic terms.

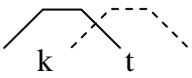
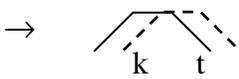
Gafos 2002 proposes that markedness constraints specify various alignments of gestural landmarks. Alignment constraints (McCarthy & Prince 1994) generally align edges of constituents with edges of other constituents. Gestural alignment constraints refer not only to edges of gestures, but to landmarks within gestures. The general form of such constraints is as follows:

(17) ALIGN (G^1 , LANDMARK¹, G^2 , LANDMARK²) Gafos 2002:278, 292
Align landmark¹ of gesture¹ to landmark² of gesture².

Landmark¹ takes values from the set {onset, target, c-center, release, offset}

The tableau below shows how the ranking of two such constraints would choose between two ways of coordinating the velar and alveolar closures in a [kt] sequence. In tableaus, I will use certain conventions for representing candidates. A candidate consists of a segmental representation, its associated gestures, and timing relations between these gestures. Only one curve, representing the head gesture, is shown for each segment (unless intrasegmental timing is relevant). In the case of this [kt] sequence, the head gestures are the velar closure and the alveolar closure. The symbol under each gestural curve indicates the segment that it is associated with. Below this is a phonetic transcription in brackets that tells how the sequence would sound. The bracketed transcription is *not* part of the representation being evaluated by the constraints; it is parenthetical, to remind the reader how that gestural score would be heard. In this case, one acoustic difference predicted by GEST is that only candidate a) would have an audible release, represented as a superscript [ə] (see section 2).

(18) C₁C₂ coordination

| /kt/ | ALIGN (C ₁ , RELEASE, C ₂ , TARGET) | ALIGN (C ₁ , CENTER, C ₂ , ONSET) |
|---|---|---|
| a.  [k ^ə t] | *! | |
| b.  [kt] | | * |

The ranking of ALIGN (C₁, RELEASE, C₂, TARGET) and ALIGN (C₁, CENTER, C₂, ONSET) determines whether there will be acoustic release, which is part of what produces vowel intrusion.

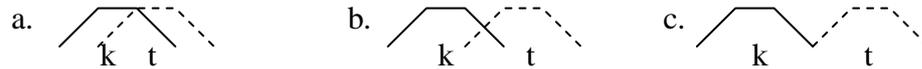
1.3.3. Gestures, underlying representations, and faithfulness

In TASP, only markedness constraints govern inter-segmental gestural coordination, not faithfulness constraints. This is necessary in order to avoid overpredicting the types of structures that can potentially contrast. If faithfulness constraints preserved underlying timing relations between segments, it would be predicted that these timing relations would contrast.

In Optimality Theory, positing faithfulness constraints to underlying distinctions expands the range of possible grammars. According to the principle of ‘richness of the base’, the grammar of a language must be able to take any structure as an input and transform it to an output that is a possible utterance of that language. There are no language-particular restrictions on possible inputs. If timing relations are part of the

structure allowed in inputs, then an input in any language could contain any of the following structures.

(19) Possible inputs



Markedness constraints want to change inputs so that they all have the same gestural coordination in the output. Faithfulness constraints want there to be no change, so that the surface timing is identical to the underlying timing.

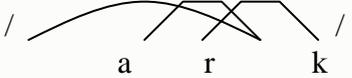
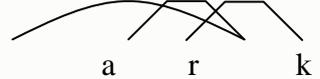
Another basic premise of Optimality Theory is that constraints can have any ranking, and that each ranking must produce a possible grammar. If there are faithfulness constraints on gestural coordination, we must assume that in some languages they are ranked above the markedness constraints on gestural coordination. Therefore, gestural coordination will be contrastive in some languages.

The tableaux below show what happens in a grammar that ranks IDENT-TIMING (“preserve underlying gestural timing relations”) above ALIGN (C_1 , center, C_2 , onset). Such a grammar will preserve the underlying timing of any input. If a CC cluster has the timing OFFSET = ONSET in the input, as in (20), then the output will also have the timing OFFSET = ONSET; if a CC cluster has the timing CENTER = ONSET, as in (21), then the output will have the timing CENTER = ONSET. The markedness constraint ALIGN (C_1 , CENTER, C_2 , ONSET) would prefer all outputs to have the timing CENTER = ONSET, but because this constraint is ranked below faithfulness, it is overruled.

(20) Language with contrastive gestural phasing

| input: | IDENT-TIMING | ALIGN (C_1 , CENTER, C_2 , ONSET) |
|-------------------|--------------|--|
| | | |
| a. → [arək] | | * |
| b. [ark] | *! | |

(21) Language with contrastive gestural phasing

| | | |
|--|--------------|---|
| input:  | IDENT-TIMING | ALIGN (C ₁ , CENTER, C ₂ , ONSET) |
| a.  [arək] | *! | * |
| b. →  [ark] | | |

In such a language, degrees of gestural overlap will be contrastive. The timing of an [r] and [k] might be all that distinguishes two morphemes. Hence, phenomena related to gestural timing, such as release and vowel intrusion, should be contrastive as well.

Vowel intrusion seems to be universally non-contrastive. In each language, it either always happens or never happens in a given environment. This strongly argues that if the gestural overlap analysis of vowel intrusion is to be maintained, there cannot be faithfulness to underlying gestural phasing between segments.

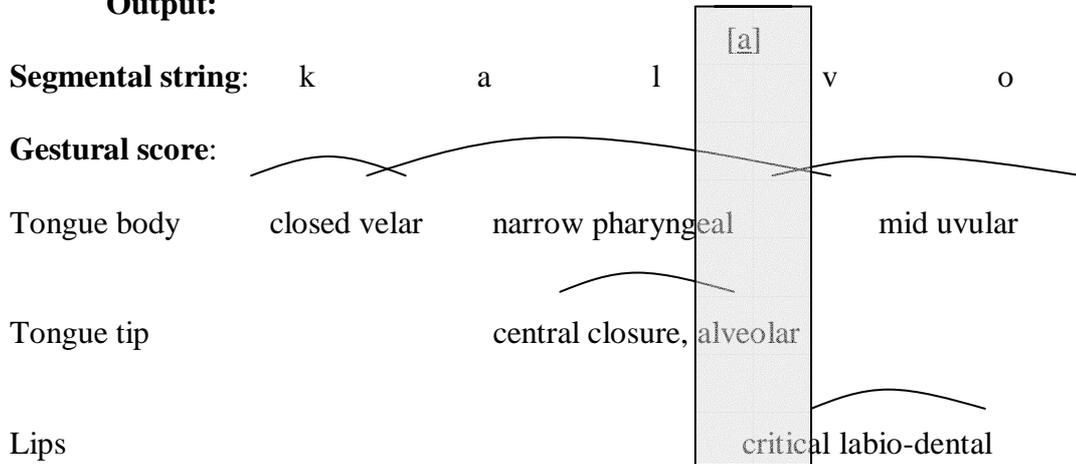
1.3.4. A TASP representation of vowel intrusion

A sample input – output pairing in TASP for a word like Finnish [kalavo] ‘transparency’, looks as in (22). The input consists only of a string of segments. (I argue below that a segment actually consists of a bundle of gestures associated with a root node, so the representation below will need to be expanded slightly). The output consists of a string of segments, syllabified, and their associated gestures, with the timing relations specified between the gestures.

The shaded area in the diagram below indicates the period when the intrusive vowel is perceived, namely the interval after the release of the [l]’s alveolar constriction and before the labio-dental constriction of the [v]. During this period, only the [a]’s articulation is active, and this is what is heard.

(22) **Input:** /kalvo/

Output:



The shaded area and the bracketed [a] are not formally part of the representation. The intrusive vowel, despite its acoustic prominence, does not correspond to any independent segment, gesture or other entity in the score, and this is important for explaining its invisibility to some phonological patterns.

The distinctive characteristics of TASP are summarized below.

(23) Characteristics of TASP

1. The input contains segments, but no gestural phasing relations.
2. Only markedness constraints determine gestural alignment, not faithfulness constraints. Hence, gestural alignment cannot be contrastive.
3. Gestural phasing is present in output candidates.
4. Gestural and non-gestural constraints are in the same level of the grammar and can potentially interact.
5. Higher prosodic structures, such as syllables and feet, are composed of segments, not of gestures.

With these basic assumptions about the grammar in place, we can explore the particular constraints that produce vowel intrusion. Vowel intrusion must be shaped entirely by markedness constraints on gestural phasing. In the following section, I show which constraints are needed to capture the typical conditioning environments of intrusive vowels.

1.4. Gestural coordination constraints

1.4.1. C-C and V-C phasing constraints

For an intrusive vowel to be heard in a CCV or VCC sequence, at least two things must be true: the consonants must be phased so that there is a release between them, and the vowel articulation must overlap this period of release.

The phasing of the consonants can be produced by ALIGN (C₁, CENTER, C₂, ONSET).

(24) ALIGN (C₁, CENTER, C₂, ONSET)

In a C₁ C₂ sequence, the center of C₁ is aligned with the onset of C₂.

According to GEST simulations (Gafos 2002:271-272), a phasing relation of CENTER = ONSET produces a schwa-like vocalic element between heterorganic consonants. For an intrusive [ə] to be heard, then, it is necessary for the consonants to be phased at least this far apart. In languages where the intrusive vowel is described as having a clear and audible quality, the consonants are probably even more spread apart, perhaps at RELEASE = ONSET or OFFSET = ONSET. Not knowing exactly which phasing relationship is appropriate in each language, I will generally use CENTER = ONSET to produce vowel intrusion in tableaux.

ALIGN (C₁, CENTER, C₂, ONSET) competes with another CC phasing constraint, ALIGN (C₁, RELEASE, C₂, TARGET). This constraint favors a phasing that does not produce release.

(25) ALIGN (C₁, RELEASE, C₂, TARGET)

In a C₁ C₂ sequence, the release of C₁ is aligned with the target of C₂.

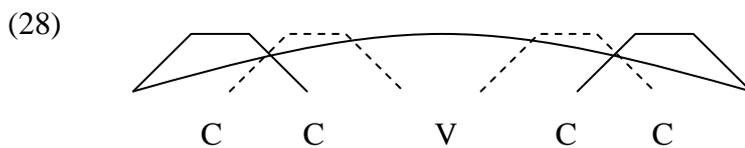
The ranking of these two determines whether there will be release or not in a consonant cluster.

Why should there be multiple constraints on the phasing of CC clusters? The competing C-C coordination constraints reflect the competing priorities of ease of articulation and ease of perception. Constraints favoring less overlap have a functional grounding in perceptibility: a consonant has clearer formant offsets when it is not heavily overlapped by another consonant. Donselaar et al. 1999 show that in Dutch, where vowel intrusion is optional, reaction times to lexical decision tasks and sonorant identification tasks are quicker when a word like *tulp* ‘tulip’ is pronounced with vowel intrusion ([tuləp]) than without ([tulp]). The alignment CENTER = ONSET helps listeners to recognize sounds more easily. The alignment RELEASE = TARGET, on the other hand, allows a faster and in that sense more efficient articulation.

A second type of constraint must ensure that the vowel overlaps the release period between the consonants. I propose that there are constraints demanding that a vowel articulation span its entire syllable. These can be instantiated as constraints aligning the onset and offset of a vowel to the left and right edges of the syllable, respectively.

- (26) ALIGN (V, OFFSET, SYLL, OFFSET)
The offset of every vowel is aligned with the offset of the rightmost segment that belongs to the same syllable as that vowel.
- (27) ALIGN (V, ONSET, SYLL, ONSET)
The onset of every vowel is aligned with the onset of the rightmost segment that belongs to the same syllable as that vowel.

These constraints prefer gestural alignments producing vowel intrusion, like the following:



Since vowel intrusion does not happen unilaterally, these constraints must be countered by opposing ones. I propose that there is a type of constraint that penalizes too much overlap of one gesture by another. Such constraints take the form below.

- (29) *GESTURE_x IN GESTURE_y
A gesture of type *x* does not fully surround a gesture of type *y* (extending on both sides of it).

An example of such a constraint is *C IN V.

- (30) *C IN V
A vowel articulation does not fully surround a consonant articulation.

This constraint will favor the vowel's articulation beginning no earlier than the last prevocalic consonant, and ending no later than the first postvocalic consonant, as below. This degree of overlap presumably is not sufficient to produce a vocalic-sounding release.



These four basic constraints determine whether there is release in a consonant cluster, and whether a vowel overlaps this period of release.

1.4.2. Typology of coordination effects

This section will demonstrate how different rankings of the constraints proposed above produce three different patterns of gestural organization within a /CCV/ or /VCC/ syllable: vowel intrusion, release without vowel intrusion, and no release. In this chapter, I discuss only phasing within the syllable. Vowel intrusion between syllables, and the interaction between syllable structure and gestural organization, are treated in chapter 2.

1.4.2.1. Vowel intrusion

Vowel intrusion occurs in a /CCV/ string when $\text{ALIGN}(\text{V}, \text{ONSET}, \text{SYLL}, \text{ONSET})$ is ranked above $*\text{C IN V}$, and $\text{ALIGN}(\text{C}_1, \text{CENTER}, \text{C}_2, \text{ONSET})$ is ranked above $\text{ALIGN}(\text{C}_1, \text{RELEASE}, \text{C}_2, \text{TARGET})$. These two rankings ensure that the vowel will fully overlap the consonant cluster, and that there will be a period of release during which the vowel can be audible.

In tableau (32), candidate a) has the phasing $\text{CENTER} = \text{ONSET}$ in the [kl] cluster, producing a release. But the vowel gesture does not fully overlap the cluster, so the release is not heard as vocalic. The vowel's phasing violates $\text{ALIGN}(\text{V}, \text{ONSET}, \text{SYLL}, \text{ONSET})$, so a) is eliminated. Candidate b) also has the $\text{CENTER} = \text{ONSET}$ phasing for [kl], and the vowel does overlap the whole cluster. Candidate c) has the phasing $\text{RELEASE} = \text{TARGET}$, which produces no release in [kl]. Since $\text{ALIGN}(\text{C}_1, \text{CENTER}, \text{C}_2, \text{ONSET})$ is high-ranked, c) is eliminated and b) wins.

(32) Vowel intrusion: Oscan *pukēle* 'son'

| /pukle/ | $\text{ALIGN}(\text{C}_1, \text{CENTER}, \text{C}_2, \text{ONSET})$ | $\text{ALIGN}(\text{V}, \text{ONSET}, \text{SYLL}, \text{ONSET})$ | $*\text{C IN V}$ | $\text{ALIGN}(\text{C}_1, \text{RELEASE}, \text{C}_2, \text{TARGET})$ |
|---|---|---|------------------|---|
| a.  [pukəle] | | *! | | * |
| b. →  [pukēle] | | | * | * |
| c.  [pukle] | *! | * | | |

For vowel intrusion in a /VCC/ string, the analysis is the same except that $\text{ALIGN}(\text{V}, \text{ONSET}, \text{SYLL}, \text{ONSET})$ must be ranked above $*\text{C IN V}$.

1.4.2.2. Release without vowel intrusion

If a language ranks ALIGN (C₁, CENTER, C₂, ONSET) above ALIGN (C₁, RELEASE, C₂, TARGET), but ALIGN (V, OFFSET, SYLL, OFFSET) below *C IN V, it has releases between all consonants, but no intrusive vowels. In French, for example, the word *acte* is generally pronounced with a release between the [k] and [t]. Candidates a)–c) and their violations are the same as in tableau (32), but since the constraint ranking is different, candidate a) wins.

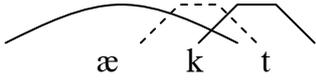
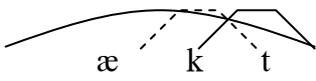
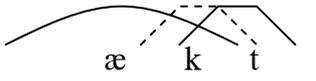
(33) French: release without vowel intrusion

| /akt/ | ALIGN (C ₁ , CENTER, C ₂ , ONSET) | *C IN V | ALIGN (V, OFFSET, SYLL, OFFSET) | ALIGN (C ₁ , RELEASE, C ₂ , TARGET) |
|---|---|---------|---------------------------------|---|
| a. →  a k t [ak ^a t] | | | * | * |
| b.  a k t [ak ^a t] | | *! | | * |
| c.  a k t [akt] | | *! | * | |

1.4.2.3. No release

In English, consonants generally are not released in a cluster. This pattern results from ranking ALIGN (C₁, RELEASE, C₂, TARGET) above (C₁, CENTER, C₂, ONSET). The candidates have the same violation marks as in (32) and (33), but under this ranking, c) wins.

(34) English: no release

| /ækt/ | ALIGN (C ₁ , RELEASE, C ₂ , TARGET) | *C IN V | ALIGN (V, OFFSET, SYLL, OFFSET) | ALIGN (C ₁ , CENTER, C ₂ , ONSET) |
|--|--|---------|--|---|
| a.  [æk ^ʰ t] | *! | | * | |
| b.  [æk ^æ t] | *! | * | | |
| c. →  [ækt] | | | * | * |

In clusters without release, it is hard to tell from transcriptions whether the vowel fully overlaps the cluster or not. This probably can be determined only instrumentally, although perhaps the degree of C-V coarticulation might provide a rough diagnostic.

1.4.3. The special behavior of sonorants

Vowel intrusion happens mostly, and perhaps only, with sonorants. Languages that have intrusion vowels next to some or all sonorants have either plain, non-vocalic sounding releases or no release at all next to other consonant types. This suggests that special phasing constraints apply to sonorants.

There is evidence from other phenomena that sonorants have special phasing relations both with vowels and with other consonants. In some languages, like Upper Chehalis, there is always a release before sonorants without regard to vowel overlap, which shows there is a special C-C coordination constraint referring to these sound classes.

Also, vowels seem to overlap better with sonorants than with other consonants. In Hua, all consonants clusters have release, but a vocalic quality is heard in the release only if a sonorant is involved.

1.4.3.1. Vowel intrusion by sonorants; release elsewhere

Hua has releases, transcribed as [ə], between all consonants in careful speech. The release has the quality of the following vowel only in a C[r] or C[ɣ] cluster. I show the vowels in superscript following Haiman's transcription.

(35) Plain release in Hua

Haiman 1980:26-7

- | | | |
|----|--|--|
| a. | f ^a tú | ‘smell’ |
| b. | k ^a t ^a r ^a gúʔ | ‘kind of mushroom’ |
| c. | t ^a v ^a r ^a gíe | ‘he sharpened it’ |
| d. | m ^a ni | ‘water, river, beverage other than milk or beer’ |
| e. | r ^a m ^a zoe | ‘I laid an offering (at a girl’s door)’ |
| f. | k ^a s ^a sípaie | ‘he wrapped it in leaves with a vine string’ |

Vowel intrusion

- | | | |
|----|--|-------------------------------|
| g. | pot ^a yaie | ‘it glanced off (the target)’ |
| h. | ok ^u rumaʔ | ‘sky’ |
| i. | k ^a ra | ‘dog’ |
| j. | f ⁱ rie | ‘he died’ |
| k. | t ^e re t ^e refie | ‘it flowed’ |
| l. | d ^a yai | ‘I’ |
| m. | b ^o ʔot ^a va | ‘one’ |

The consistent presence of release shows that all CC clusters have a wide phasing. It may be as wide as OFFSET = ONSET, since release happens even in homorganic clusters. But evidently, the vowel gesture overlaps this release period only if the intervening consonant is [r] or [ʎ].⁵ To capture this, we need a more specific version of *C IN V, which refers to particular classes of consonants.

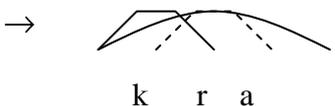
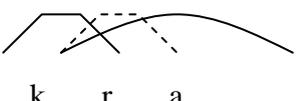
(36) *OBSTRUENT IN V

A vowel gesture does not completely surround the gesture of an obstruent consonant.

Under the ranking *OBSTRUENT IN V >> ALIGN (V, ONSET, SYLL, ONSET) >> *C IN V, a vowel will fully overlap a consonant cluster only if the closest consonant is a non-obstruent. This allows vowel intrusion to occur in a C₁C₂V input where C₂ is non-obstruent. In the tableau below, both candidates have a CR cluster with a release. In candidate a), the vowel overlaps this release and produces an intrusive vowel.

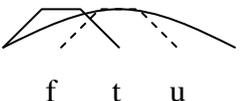
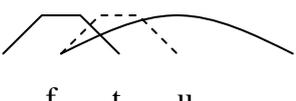
⁵ [ʎ] patterns with the gutturals in other cases of vowel intrusion as well, such as Negev Bedouin Arabic (see (51)). It is possible that the sound is often more uvular, even when transcribed as a velar.

(37) Hua vowel intrusion

| /kra/ | *OBSTRUENT IN V | ALIGN (V, ONSET, SYLL, ONSET) | *C IN V |
|--|--------------------|-------------------------------------|---------|
| a. →  k r a [k ^a ra] | | | * |
| b.  k r a [k ^a ra] | | *! | |

In a C₁C₂V input where C₂ is an obstruent, however, the high ranked *OBSTRUENT IN V prevents vowel intrusion. Only plain release can occur, as in candidate b) below.

(38) Hua release

| /ftu/ | *OBSTRUENT IN V | ALIGN (SYLL, ONS, V, ONS) | *C IN V |
|--|--------------------|------------------------------|---------|
| a.  f t u [f ^u tu] | *! | | * |
| b. →  f t u [f ^ə tu] | | * | |

Hua shows that sonorants are more conducive to being overlapped by vowel articulations. This is part of the reason that they are especially conducive to vowel intrusion.

1.4.3.2. Release by sonorants, no release elsewhere

There is also evidence that there are special C-C phasing constraints for clusters that include a sonorant. Some languages have releases only next to sonorants.

Upper Chehalis (Q^way'áyíłq') (Kinkade 1963 et seq.) has excrescent schwas (which are presumably an uncolored release) between a consonant and any one of [m n j l w ?]. Kinkade argues that these schwas are purely transitional, which is equivalent to saying that they result from C-C phasing. In their phonological behavior, they contrast with phonetically similar epenthetic [ə]s that appear in a different set of environments.

- (39) Upper Chehalis excrescent schwas Kinkade 1963:192-3
- | | | |
|----|------------------|------------------------|
| a. | ǰə́ləlp | ‘open-weave basket’ |
| b. | č’óp’waxə́nstwən | ‘squeeze with the arm’ |
| c. | q’wó tə́weʔ | ‘maple’ |
| d. | sqə́ʔúq’ə́ls | ‘skull’ |

The Upper Chehalis schwas differ from intrusive vowel in two ways. First, there is no indication that these schwas have any quality that varies depending on the neighboring vowel. Second, in vowel intrusion, the sonorant is always adjacent to a vowel. The Upper Chehalis schwa does not need to be near a vowel at all: many consonants may intervene between the schwa and the nearest full vowel, as in [č’óp’waxə́nstwən], and those intervening consonants can be of any type.

These two facts together suggest that these schwas are a result only of distance between consonants, without any overlapping vowel articulation. There must therefore be special coordination constraints on CC clusters that include sonorants.

- (40) ALIGN (R, CENTER, C, ONSET)
 In a C₁ C₂ string, C₁ a sonorant, the center of C₁ is aligned with the onset of C₂.
- (41) ALIGN (C, CENTER, R, ONSET)
 In a C₁ C₂ string, C₂ a sonorant, the center of C₁ is aligned with the onset of C₂.

These constraints produce release next to sonorants, without vowel intrusion, as shown below. Candidates a) and b) have a CENTER=ONSET phasing for the [qʔ] cluster, as demanded by ALIGN (C, CENTER, R/H, ONSET). Candidate c) has a RELEASE = TARGET alignment for [qʔ], so it is eliminated. Whether a) or b) wins is determined by the relative ranking of *C in V and ALIGN (V, ONSET, SYLL, ONSET). When the former is higher-ranked, as below, the vowel gesture is not permitted to extend fully over a consonant in order to span the syllable. Candidate b) wins.

(42) Upper Chehalis [sqəʔúq^wəls] ‘skull’

| /sqʔuq ^w ls/ | ALIGN (C, CENTER, R/H, ONSET) | *C in V | ALIGN (C ₁ , RELEASE, C ₂ , TARGET) | ALIGN (V, ONSET, SYLL, ONSET) |
|--|-------------------------------|---------|---|-------------------------------|
| <p>a.</p> <p>s q ʔ u</p> <p>[sq<u>u</u>ʔúq^wəls]</p> | | **! | * | |
| <p>b. →</p> <p>s q ʔ u</p> <p>[sqəʔúq^wəls]</p> | | | * | * |
| <p>c.</p> <p>s q ʔ u</p> <p>[sqʔúq^wəls]</p> | | *! | | * |

Diamandis Gafos (p.c.) reports similar facts for Moroccan Arabic: there are audible releases after gutturals in clusters.

Thus, there are special constraints both on the phasing of sonorants with respect to other consonants, and on vowels overlapping sonorants. Both of these contribute to restrict vowel intrusion to clusters with sonorants.

1.4.4. Hierarchy of sonorant / vowel overlap

Besides being restricted to sonorants generally, vowel intrusion happens only with a subset of the inventory of sonorants in most languages. Cross-linguistically, vowel intrusion happens more with liquids than with other sonorants, and more with rhotics than laterals. This indicates a need for more specific constraints specific consonant classes, in addition to those in (36), (40), and (41).

The chart below contains the inventory of sonorants in several languages, divided into those that are and aren't found with intrusive vowels. In some cases, a certain segment is never found in a position where it could trigger vowel intrusion and hence is irrelevant to determining whether there is a hierarchy of segments allowing vowel intrusion. Such segments, where known to me, are in boldface. For example, Dutch has vowel intrusion only in codas, and [h] does not appear in codas, so we cannot tell whether in principle [h] would allow vowel intrusion or not.

(43) Sonorant inventories

| | Triggering V intrusion | Not triggering V intrusion |
|-----------------|---|----------------------------|
| Kekchi | ʔ | r l n m w j h |
| Mamaindé | h | n m l j w |
| Tiberian Hebrew | ʔ ʕ h h | r l n m w j |
| Spanish | r | r l m n ñ ʎ |
| German | ʁ | l m n j v ŋ |
| Sanskrit | r (l) | m ŋ n ɟ ŋ y v h |
| Dutch | r/ʁ l | m n ŋ h |
| Hausa | r l | r n m w j ʔ |
| Finnish | (r?) ⁶ l n h | (r?) m ŋ j |
| Oscan | r l n | m h |
| Saami | r l j β ð ⁷ | m n ɟ h |
| Hocank | r n w | h j m ʔ |
| Scots Gaelic | r ^v r r ^j l ^v l ^{vj} l n ^v n ^{vj} n m | w j h |

This list reveals a partial implicational hierarchy as to which sonorants allow vowel intrusion. First, there are clear-cut cases where gutturals do have vowel intrusion and other sonorants don't, such as Kekchi and Tiberian Hebrew. This suggests the following implication:

(44) Vowel intrusion triggers
non-guttural sonorants → gutturals

A number of languages have vowel intrusion only over non-guttural sonorants and not over gutturals, but in most or all of these cases, whatever gutturals the language has never appear in positions where vowel intrusion would be expected (as with Dutch [h]). Thus, the lack of vowel intrusion with gutturals can be attributed to other factors that prohibit gutturals appearing in clusters, and does not form a counterexample to the generalization.

A potential counterexample to (44) comes from Saami. Saami transcriptions often appear to contain clusters of [h] and a voiceless stop, in words like [toh:pa] 'sheath', without vowel intrusion (Bye 2001:138). Bye analyzes these as single preaspirated consonants, not as clusters, but if the cluster interpretation were favored, it would be a problem for the proposed hierarchy. Also, Hocank is a counter-example, because it has vowel intrusion in CR but not Cʔ clusters. I will argue in chapter 5, however, that Hocank vowel intrusion happens for different reasons than the other cases here, and there is a different type of constraint that rules out vowel intrusion with [ʔ].

⁶ There is a disagreement about this data, as discussed in chapter 2; apparently [r] does not trigger vowel intrusion in modern Finnish although it was reported to do so in the 1920's.

⁷ According to Bye, β and ð are approximants.

In languages that have vowel intrusion with gutturals, there are no cases where only a subset of the gutturals trigger it (unless one of the gutturals does not occur in the correct position, like Kekchi [h]). No implicational hierarchy within the guttural class can be established at present.

Within the class of non-guttural sonorants, there is a clear preference for vowel intrusion with liquids, especially rhotics. Intrusion with laterals implies intrusion with rhotics, except the alveolar trill. For example, an experiment by Jannedy 1994 produces intrusion in German [bʁ] but not [gl]. In Sanskrit, some authorities report intrusion after both [r] and [l], but others only after [r]. For Irish Gaelic, which has had vowel intrusion after many sonorants, Greene 1952:217 mentions that there is evidence that the intrusive vowels historically arose first after [r]. The preference for intrusion with rhotics is even revealed in variation. For Dutch, where vowel intrusion is optional, a production experiment by Kiuipers & Donselaar 1997 found that speakers had vowel intrusion 60% of the time after /r/ (which can be alveolar or uvular) and only 40% of the time after [l].

The alveolar trill is the only rhotic that produces vowel intrusion less than [l] does. Hausa and Finnish (according to most descriptions) have vowel intrusion with [l] but not [r]. Intrusion is common with [n] than [m], suggesting a preference for overlap with coronals.

These facts support the following hierarchy:

- (45) Vowel intrusion triggers
obstruents, if ever → other approximants, nasals → r → l → r , ʁ → gutturals

Among nasals: m → n

Beyond this the pattern becomes less clear, and no implicational hierarchy can be established yet. Saami has vowel intrusion after glides but not nasals; Finnish and Scots Gaelic have it after some nasals but no glides.

1.4.4.1. Constraints on V / C overlap

As argued above, there are two overlapping reasons that sonorants are particularly conducive to vowel intrusion: they are subject to special constraints favoring release; and they are *not* subject to the special constraints that disfavor other types of segments being fully overlapped by a vowel. The implicational hierarchy as to which segments within the sonorant class allow vowel intrusion could be due to either of these factors or both of them. Hua, which has release before all consonants but vowel intrusion only before [r] and [ɣ] (and not other sonorants like [n]), is evidence that vowels overlap some sonorants better than others. I know of no Upper Chehalis-like language that has release only by certain sonorants.

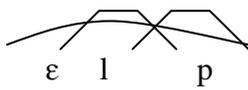
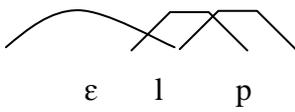
Therefore, I propose that the *V IN C constraints are relativized to particular classes of sounds within the sonorant group, and that this family of constraints has a universally fixed ranking that correlates with the hierarchy of vowel intrusion triggers. This yields the following set of constraints.

- (46) *OBSTRUENT IN V >> *NASAL IN V; *GLIDE IN V >> *[r] IN V >> *[l] IN V >> *[r] IN V, *[ɾ] IN V >> *GUTTURAL IN V

The ranking of ALIGN (V, OFFSET, SYLL, OFFSET) with respect to this scale will determine which sonorants are eligible to trigger vowel intrusion.

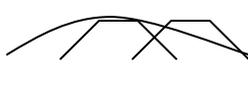
Dutch, for example, has ALIGN (V, OFFSET, SYLL, OFFSET) ranked below *NASAL IN V but above *[l] IN V. The tableaux below show how this ranking produces vowel intrusion into clusters like [lp] but not into clusters like [mt]. Both cluster types have a release, but only in the case of [lp] can the vowel fully overlap this period of release, as in candidate a).

- (47) Dutch vowel intrusion

| /hɛlp/ | *NASAL IN V | ALIGN (V, OFFSET, SYLL, OFFSET) | *[l] IN V |
|--|-------------|---------------------------------|-----------|
| a. →  ε l p [hɛlɔp] | | | * |
| b.  ε l p [hɛlp] | | *! | |

In tableau (48), the intrusive vowel candidate a) is eliminated because it involves total overlap of a vowel and [m].

- (48) Dutch blocking of vowel intrusion

| /kamt/ | *NASAL IN V | ALIGN (V, OFFSET, SYLL, OFFSET) | *[l] IN V |
|--|-------------|---------------------------------|-----------|
| a.  ɑ m t [kamɔt] | *! | | |
| b. →  ɑ m t [kamt] | | * | |

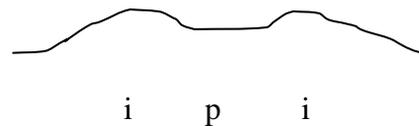
Dutch has, in fact, intrusive *stops* between nasals and heterorganic consonants, so that /kamt/ is pronounced [kampt]. Stop intrusion is another phenomenon that is likely a percept caused by a gestural timing pattern rather than epenthesis of a stop segment: it is a release of the [m] after the raising of the velum and cessation of voicing.

1.4.4.2. Additional evidence for *C in V: articulatory trough data

The phenomenon of articulatory “troughs” provides an additional source of evidence that some types of consonants are more easily overlapped by vowels than others.

An articulatory trough occurs when articulations associated with the identical vowels in a V_iCV_i sequence are relaxed during the C (Bell-Berti & Harris 1974, Gay 1975). The trough phenomenon suggests that the two vowels have separate gestures, and that the trough represents the juncture where the first vowel gesture is leaving its target and the second has not yet reached its target.

(49) Tongue movement: (approximated from Harris & Bell-Berti 1984)

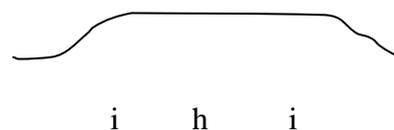


Hypothesized gestures:



Articulatory troughs may be absent for some consonants, however. Harris & Bell-Berti 1984 find that, in nonsense words produced by an English speaker, there is a decrease in lip rounding during the medial consonant in [ɔʔɔ] sequences but not [ɔʔɔ], and a relaxing of the tongue position during the medial consonant in [ipi] but not [ihi] or [iʔi]. This suggests that the sequences involving laryngeals have a single vocalic gesture spanning the two syllables, as below, and that this vowel gesture fully surrounds the consonant gesture.

(50) Tongue movement: (approximated from Harris & Bell-Berti 1984)



Hypothesized V gestures:



The fact that troughs are lacking only with gutturals supports the idea that these are most amenable to vowel overlap.

1.4.4.3. VC homorganicity

Besides the widespread restrictions on consonant types triggering vowel intrusion, there is one example of vowel intrusion happening only with a particular vowel. In some dialects of Bedouin Arabic, copy vowels appear [a]HC clusters only (H = guttural). These arose through a historical process known as the *gahawa* syndrome, after the word for ‘coffee’, which is [qahwa] in Classical Arabic ([qahawa] shows the result of the process.) In other Bedouin and Gulf dialects, the gutturals have completely metathesized with the [a], in a process known as the *ghawa* syndrome. As Steriade 1990 points out, metathesis of this type can be seen as the movement of a consonant articulation all the way across a vowel.

(51) Negev Bedouin Arabic reflexes of Classical Arabic words
(NBA- Blanc 1970:124-5, CA- Wehr 1971)

| | | | | |
|----|-------|---|----------|----------|
| a. | ʃahr | > | ʃa'har | ‘month’ |
| b. | ʃaʕr | > | ʃa'ʕar | ‘hair’ |
| d. | qahwa | > | ga'hawah | ‘coffee’ |
| e. | bayl | > | ba'yal | ‘mule’ |
| f. | wahʃ | > | wa'haʃ | ‘beast’ |
| g. | baxt | > | ba'xat | ‘luck’ |

These vowels may not be synchronically represented as intrusive vowels. They seem to have been historically reanalyzed as regular segments for at least some speakers. What indicates this is that [ʃahar] has an alternate pronunciation [ʃihar], reflecting the open syllable raising process of Arabic. Such a process would not affect a vowel without affecting the following intrusive vowel. But given the similarity of the conditioning environment to examples of current vowel intrusion, it is reasonable to hypothesize that the *gahawa* and *ghawa* syndromes are relics of a vowel intrusion process that was productive at some point in the past.

The most likely reason that gutturals in this language overlap heavily only with [a] is that [a] is articulatorily most similar to the guttural consonants, involving a narrow pharyngeal constriction. There are several other cases of historical metathesis that support this conclusion. Grammont 1933 notes that in various French dialects such as Pléchéâtel and Havre, [r] has metathesized with [e] but not with other vowels.

| | | | |
|------|-----------|------------------|-------------------|
| (52) | Pléchâtel | Standard French | Grammont 1933:245 |
| a. | kerve | <i>crever</i> | |
| b. | gerlô | <i>grelot</i> | |
| | Havre | | |
| c. | bertô | <i>breton</i> | |
| d. | kersô | <i>cresson</i> | |
| e. | gerloté | <i>grelotter</i> | |

Grammont analyzes this metathesis as ‘inversion by penetration’, which means, essentially, metathesis by way of vowel intrusion. He points out that [r] is articulated in the same general region as [e], and proposes that this is what allows the ‘penetration’ to occur. He gives the same reason for why in unaccented syllables in Latin, there was historical metathesis of [i] with [r] and [u] with [l], but not the same liquids with other vowels.

These cases are evidence that vowel type as well as sonorant type can affect the potential for VC overlap. Vowels prefer to overlap with consonants that are articulatorily similar to them.

1.4.4.4. The relevance of vowel intrusion

Vowel intrusion is only one case within wider patterns of release and VC overlap, and its importance ultimately is in the light it sheds on more general constraints on gestural phasing. This typological survey provides evidence for constraints favoring a low degree of overlap between sonorants and adjacent consonants, a high degree of overlap between sonorants and adjacent vowels, and better overlap between homorganic vowels and consonants.

Among types of gestural coordination, vowel intrusion is ideally suited for a typological survey. Because it is clearly audible, it is often mentioned in descriptive works, unlike, for example, release. Furthermore, intrusive vowels are distinguishable from epenthetic vowels by their phonological behavior. Since vowel segments form the nuclei of syllables, they influence a large range of syllable-conditioned phonological processes. Intrusive vowels are conspicuous in their failure to do so. By contrast, intrusive stops, while also audible and often transcribed, offer few clear diagnostics to tell whether speakers treat them as normal segments or not. For example, a [t] is often heard in *Nancy* [næntʃi]. But since an extra consonant in that position would not be expected to affect the stress pattern or anything else easily detectable, there is little way to tell from a description whether the [t] is epenthetic or intrusive.

1.5. Gestures and features

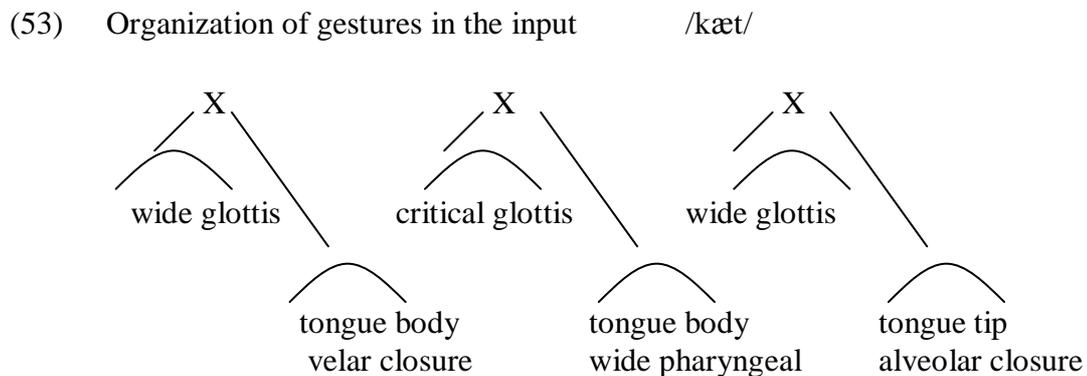
The above analysis has focused on the role of segment type and order in triggering the gestural phasing pattern that is heard as vowel intrusion. But some patterns can only be explained by reference to other types of structure. In particular, phenomena often analyzed as involving feature-sharing, such as geminates and assimilation

structures, affect the distribution of release. I will suggest that for two segments to share a feature is equivalent to sharing a gesture. To extend the theory to account for these cases, it is first necessary to clarify the relation between features and gestures.

Zsiga (1995, 1997) proposes that phonological representations include both features and gestures. She divides phonological processes into those that change features, and those that do not change features but involve gestural overlap. Zsiga 1995 examines cases of [s] → [ʃ] palatalization in English, and concludes that these are of two kinds: a feature-changing assimilation, as in [kənfeʃən] *confession*, and assimilation through gestural overlap as in [preʃju] *press you*. The gestural assimilation is revealed instrumentally to be more variable and incomplete.

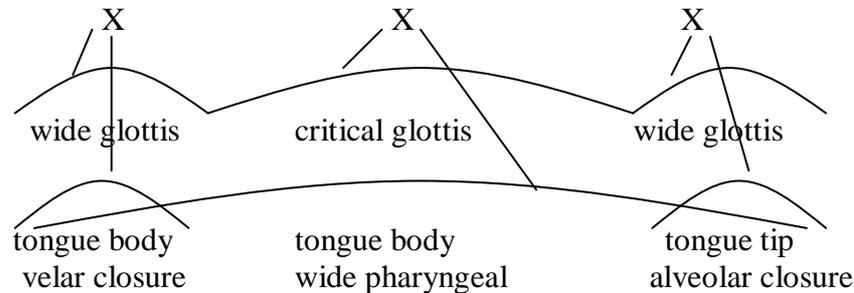
My view is similar in recognizing the need for distinguishing between categorical (“featural”) and gradient (“gestural”) effects. However, it is not necessary to have both a featural and a gestural representation, and a mapping between the two, in order to achieve this. Rather, gestures themselves can be associated with root nodes, in addition to having phasing relations with other gestures. I will assume that gestures are, in a sense, features enhanced with duration.

In TASP, there is an underlyingly association between root nodes and gestures. For example, the underlying representation of *cat* contains three root nodes, each associated with several gestures, shown below. These gestures do not have phasing relationships with one another specified, and their strength or stiffness is not specified either. (To be more precise, there are no faithfulness constraints preserving any underlying phasing, stiffness, etc., so its presence in the underlying representation, while not impossible, would be irrelevant.)



In the output candidates, gestures still are associated with root nodes, and in addition, phasing relationships and other characteristics such as stiffness of gestures are specified. Also, gestures that were present underlyingly may be absent (violating MAX), non-underlying gestures may be added (violating DEP) or gestures may be associated to root nodes they were not underlyingly associated with. The same gesture may be associated with two root nodes, or a single root node may be associated with multiple gestures for a single articulator.

(54) Organization of gestures in the output [kæt]



In the representation above, the gestures are shown in a tier-like organization, mostly for graphical convenience. However, as Browman & Goldstein 1990 point out, gestures do seem to interact in a somewhat tier-like fashion: consonant gestures are overlaid on a sequence of more or less continuous vowel articulations that minimally overlap with one another. I assume that this is because gestures must, for simple physical reasons, interact differently with one another depending on whether they use the same articulators. If two gestures make demands on the same organ, especially as a primary articulator, then there are probably more constraints against them heavily overlapping than if they used different articulators. For this reason it may make sense to think of, for example, a “tongue-body tier”, comprising a sequence of tongue-body articulations whose mutual phasing relations are subject to different considerations than the phasing relationships between tongue-body gestures and other gestures. It is not necessary to include tiers in the formal representation to capture this (special constraints on the phasing of same-articulator gestures will be enough), but the informal separation into tiers is intuitively helpful.

Thus far, TASP simply transfers the role of features to gestures. But there are important differences between the two approaches. Feature theory does not in itself make predictions about the relationship between featural structure and non-contrastive phonetic characteristics like release. But in TASP, predictions about the relation between, for example, categorical assimilation and release, fall out of the representation.

1.5.1. Gesture sharing

I assume that many kinds of assimilation result from two segments sharing a single gesture, such as [constricted glottis] or [tongue tip alveolar closure]. If two segments share a constriction gesture, it is not possible to have a release of that constriction within the cluster, so place assimilation should preclude release.

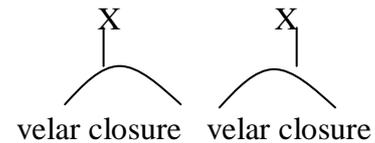
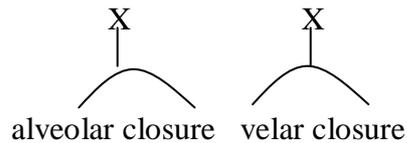
There is evidence that this is true. Dell & Elmedlaoui 1996:386 find that in Imdlawn Tashlhiyt Berber, release cannot happen between stops that are homorganic as a result of assimilation, although it can occur between stops that are underlyingly homorganic. Assimilation is the linking of a segment to a feature of an adjacent segment; so under the theory that features license gestures, assimilation necessarily involves a single gesture, which of course cannot contain a release and reconstriction.

(55) Imdlawn Tashlhiyt Berber

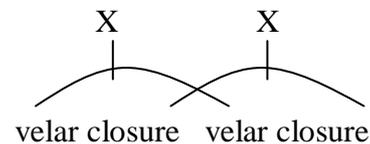
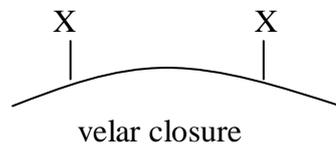
a. Assimilation structure:
release impossible

b. Non-assimilation structure:
release possible

Input:



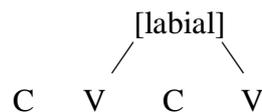
Output:



In general, release and assimilation do not occur in the same clusters in this language. If, in a sequence of stops such as /td/ or /kk^w/, the first is released, there cannot be assimilation to the second in voicing or in secondary labiality.

Another type of evidence that feature-sharing is equivalent to gesture-sharing comes from Turkish vowel harmony. This is usually analyzed as the sharing of a single feature— such as [labial] for round vowels— by multiple segments.

(56) Autosegmental representation of vowel harmony



In Turkish, there is evidence (Boyce 1990) that a single lip-rounding gesture spans the word. In a word with multiple round vowels, the intervening consonants have some lip rounding as well. In English, where each round vowel bears its own separate [labial] feature, lip-rounding does not continue between two round vowels in a word. This is additional evidence that feature-sharing has phonetic as well as phonological implications.

The idea that adjacent segments can share a gesture helps to explain one of the cross-linguistically recurrent characteristics of vowel intrusion: its failure to occur in homorganic clusters.

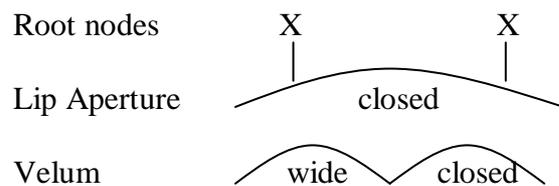
A partial explanation for this fact was already offered: we have seen that an alignment of CENTER = ONSET produces vowel intrusion in heterorganic but not homorganic RC clusters, and this can explain the heterorganicity condition on vowel intrusion in any language that uses this phasing. But this explanation cannot work for all cases, because not all clusters with vowel intrusion have the CENTER = ONSET phasing. In

some languages, intrusive vowels grow historically grow longer until they are as long as ordinary vowels. Sometimes they are eventually reanalyzed as regular vowels, as in Negev Bedouin Arabic, discussed under (51). In other languages, the sonorant apparently moves all the way across the vowel, resulting in metathesis. In either case, we would expect that as the overlap between consonants decreases, intrusive vowels would eventually develop in homorganic clusters as well. According to Gafos 2002, this will happen by the time the alignment $OFFSET = ONSET$ is reached.

Yet in Scots Gaelic, for example, this has not happened. In Scots Gaelic $VRVC$, the intrusive vowel is now as long as or longer than the preceding vowel portion, as shown in Bosch & de Jong's 1997 phonetic study⁸. The sonorant is now around the center of the vowel gesture. Yet vowel intrusion is still triggered only by heterorganic clusters: it doesn't occur in $[Lt]$, $[mb]$, etc. This suggests there is another reason that homorganic clusters don't have release.

I suggest that it is because they share a single oral constriction gesture. An $[mb]$ sequence has just one labial closure gesture. Therefore, C-C phasing constraints cannot possibly cause a release within $[mb]$.

(57) Homorganic cluster



There is no reason to believe that the $/m/$ in Scots Gaelic $/mp/$ clusters has undergone assimilation ($[np]$ clusters occur as well, but with vowel intrusion), so there must be a constraint forcing gesture-sharing in clusters that are underlyingly homorganic. This can be accomplished with a gestural version of the Obligatory Contour Principle, similar to that proposed by Gafos 2002:295: identical gestures cannot overlap.

(58) OCP-GESTURE

Overlapping identical oral gestures are prohibited.

When two segments with identical oral gestures are adjacent, one way of eliminating this overlap is for the segments to share a single long oral gesture.

Since gesture-sharing structures do not seem to be chosen universally, OCP-GESTURE must compete with another constraint. I propose that there is a general preference for a one-to-one mapping between features and gestures.

⁸ I argue in chapter 4 that Scots Gaelic vowel intrusion synchronically involves a different type of structure than the other languages discussed here: the vowel and sonorant now seem to form a complex nucleus. The following discussion, therefore, may be accurate only for an earlier stage of the development of Scots Gaelic.

(59) *MULTIPLE LINKING

A single gesture is not associated with more than one segment.

The ranking between these two constraints determine whether a language chooses gesture-sharing structures or sequences of identical gestures. In any language where OCP- GESTURE is ranked above *MULTIPLE LINKING, homorganic clusters will involve gesture sharing, and release will be impossible. In a language that has the opposite ranking, sequences of identical gestures will be permitted, and homorganic clusters will potentially have releases, if the phasing constraints permit.

At this point we have two overlapping explanations of the lack of vowel intrusion in homorganic RC clusters: task dynamics and gesture sharing. Both seem needed. There are some languages where the gesture-sharing account is the only possible one: task dynamics cannot explain the lack of release in homorganic clusters in languages that ordinarily phase clusters to have little overlap. But there are other languages that demonstrate only a tendency not to have vowel intrusion in homorganic clusters, without the ban being absolute. This is the case in Saami, where [l:s] and [l:n] clusters can have vowel intrusion but not [l:t].

For Finnish, (Harms 1976) reports that homorganic clusters don't have a release but do have some kind of decrease of "energy" between the consonants. This is consistent with the idea that homorganic Finnish clusters involve two separate gestures with a low degree of overlap, and that the nonrelease is due only to task dynamics, not gesture sharing.

1.5.2. Homorganic CR clusters

The examples of vowel intrusion being blocked in homorganic clusters above all involve RC clusters; the list yields no clear-cut examples where vowel intrusion in CR clusters is subject to the same restriction. Hocank, for example, breaks up the homorganic CR clusters [sr] and [sn].

A striking illustration of the difference between RC and CR with respect to homorganicity restrictions comes from ancient Oscan, which developed copy vowels in both cluster types. Intrusion does not occur into the homorganic RC clusters [rt], [rn], [rs], and [lt], but it does occur in the homorganic CR clusters [tr] and [dr]. The heterorganicity requirement depends on the direction of consonant contact in Oscan. In Scots Gaelic, also, a few dialects have also developed vowel intrusion in [dl] and [dr] clusters but none in [ld] or [rd] clusters (Borgström 1941:90).

The vowel intrusion in homorganic CR onsets shows that these sequences do not involve gesture-sharing. This is reminiscent of the fact that place assimilation happens more in RC than CR clusters.

There is a functional reason that gesture sharing should be more marked in [tr] cluster than in an [rt] cluster. The perceptibility of [t] depends heavily upon its release burst, since the period of constriction itself is silent. An [r], on the other hand, is audible during its constriction period. Since gesture-sharing eliminates release in a cluster, it damages the perceptibility of [tr] far more than of [rt]. (In a [tr] cluster, it is not strictly correct to say that there is no release: the constriction degree must be relaxed slightly for the [r]. Clusters that involve the same constriction location but different degrees must

have a more complex type of shared gesture than that of an [nt] cluster. But such a slight opening of the constriction will produce less burst than the normal, controlled movement away from the constriction.)

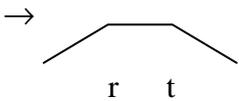
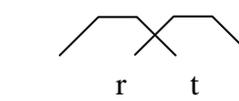
This can be captured with the following constraint:

(60) *MULTIPLE LINKING: STOP-C

A single head gesture is not associated with a stop and a following consonant.

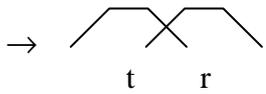
When high-ranked, this constraint will prevent a language such as Oscan from creating a gesture-sharing structure for [tr], as shown below. When an input contains an RC cluster, gesture-sharing is preferred, as in candidate a) below. Candidate b) is eliminated because it involves two alveolar constrictions overlapping.

(61) RC clusters

| /rt/ | *MULTIPLE LINKING: STOP-C | OCP-GESTURE | *MULTIPLE LINKING |
|---|---------------------------|-------------|-------------------|
| a.  (no release possible) | | | * |
| b.  (release possible) | | *! | |

When the input contains a CR cluster, however, the higher ranked * MULTIPLE LINKING: STOP-C eliminates candidate a), and candidate b), with overlapping gestures, is permitted to surface, as shown below.

(62) CR clusters

| /tr/ | * MULTIPLE LINKING: STOP-C | OCP-GESTURE | *MULTIPLE LINKING |
|---|----------------------------|-------------|-------------------|
| <p>a.</p>  <p>(no release possible)</p> | *! | | * |
| <p>b.</p>  <p>(release possible, depending on phasing)</p> | | * | |

In this way, * MULTIPLE LINKING: STOP-C can produce languages where the heterorganicity restriction holds for RC clusters but not CR.

1.5.3. Gestures and levels of grammar

A further question about the phonological role of gestures is whether they belong to a separate “phonetic implementation” level of the grammar. It is often assumed that one level of the grammar determines the arrangement of segments, features, syllables, etc., and then passes this output to a separate module that determines the phonetic realization of the structure. Zsiga 1997:270, for example, proposes that “segments (root nodes) are relevant for phonological alternations, but cease to be relevant when features are mapped into gestures.”

In TASP, there are no separate levels of the grammar for constraints on the associations of gestures to root nodes (the equivalent of Zsiga’s “phonological alternations”) and constraints on gestural phasing. This unity allows a more straightforward modeling of the ways in which phonological alternations are guided by a desire to create a good gestural alignment in the output.

For example, the asymmetry between release in RC and CR clusters above could be analyzed as caused by a constraint against gesture-sharing in CR clusters (as argued above), or by a constraint against feature-sharing in CR clusters. The non-shared features would be mapped to separate gestures by the phonetic component, and the end result would be the same.

However, the split-level approach relies on a featural constraint whose functional purpose is precisely to block an undesirable gestural alignment. The set of featural constraints is grounded in a knowledge of what the gestural results of each featural structure will be. This seems like an unnecessary complication: it is simpler to have gestural constraints refer to gestural alignment, and constraints on other structures, such as the branching of association lines, refer strictly to those structures.

1.5.4. Geminates

Another case in which gesture-sharing structures influence vowel intrusion is the special behavior of geminates, which I assume also involve a single gesture associated with two root nodes. Geminates trigger vowel intrusion more than singletons: Saami has vowel intrusion in R:C but not RC clusters, and some dialects of Finnish have vowel intrusion in RC: clusters but not RC or RCC clusters.

There is a general pattern of languages preferring releases before and after geminates. Imdlawn Tashlhiyt Berber allows releases in C_iC_i or C_iC_i clusters but not in most C_iC_i clusters (Dell & Elmedlaoui 1996). Word-final geminate stops in Amharic are always obligatorily released, while in singletons release is optional in some environments (Hudson 1995:664). Stefania Marin reports similar facts for final geminates and singletons in Wolof (p.c.). Wolof is also described as inserting a [ə], which may be simply a release, between a geminate and a consonant-initial suffix (Ka 1994:105). It is obvious why release is especially important perceptually for geminates: without an audible release it would be difficult to perceive the length of closure, and hence to tell the difference between geminates and singletons.

I propose that there are specific phasing constraints for clusters that include geminates, such as that below.

(63) ALIGN (C:, CENTER, C, ONSET)

In a $C_1 C_2$ sequence, where C_1 is a geminate, the center of C_1 is aligned with the onset of C_2 .

(64) ALIGN (C, CENTER, C:, ONSET)

In a $C_1 C_2$ sequence, where C_2 is a geminate, the center of C_1 is aligned with the onset of C_2 .

The existence of a specific constraint on geminate phasing in addition to the general constraints on CC phasing predicts that in some languages geminates will show a greater tendency to allow vowel intrusion.

1.6. Conclusion

This chapter highlights some of the cross-linguistically common properties of intrusive vowels. I have defended Steriade 1990's proposal that vowel intrusion involves gestural overlap, but claimed furthermore that it is unlike epenthesis in that it does not add a segment or syllable to the word. I have also discussed the implications that this phenomenon has for our understanding of gestural overlap.

1. It supports the idea that gestural coordination constraints on onsets and codas are not symmetrical, since intrusive vowels can appear in one without appearing in the other.
2. It shows that, in a language that has vowel intrusion in a VC_1C_2 sequence, there must be phasing relationships between V and C_2 , unlike in Browman & Goldstein's

model of English. This suggests that the organization of gestures within a syllable is not uniform cross-linguistically.

3. It shows that some consonants are more likely to allow or give rise to this configuration than others, and that there is an implicational hierarchy cross-linguistically as to which consonants trigger it.

4. It suggests that V / C overlap is less marked if V and C are homorganic.

5. It provides evidence against underlying gestural phasing relationships, since intrusive vowels, the result of a particular gestural coordination, are non-contrastive.

Chapter 2 contains more detailed case studies of languages with vowel intrusion, concentrating on ways syllable structure affects vowel intrusion and ways in which intrusive vowels act non-syllabic.

APPENDIX

Examples of vowel intrusion conditioning environments

| | clusters with intrusive vowels | RC or CR clusters surfacing without intrusive vowels | examples of other clusters |
|-----------------------------|--|--|--|
| Dakota | bl, gl, gn, gm | sl, fl, xl, sn, fn, xn, sm, fm, xm | kp, pt, sk, kf, pc, xt |
| Dutch | lm rm lp rp rf lf lk rk lg rg rn | rt rs lt nt ls ns | kt |
| Finnish | r / l + C; h + voiced C hv hj hm hn hl hr lk lv lj lh lm lp rp rk rv rj rh rm nh | hk ht lt ls ll mm mp nn ns nt nk nj rn rr rt rs | kl kr ks ps pl pr tk tr tj sk sl sm sp sv tt ts |
| Hausa | r / l + C. examples given: rh lb lk rk rm lm | rC mC nC wC yC ?C (many examples of each) | sk pt kw bd fs br y? |
| Hocank | pn pr kn kr kw sn sr sw fn fr fw tw xn xr xw | C? | st ps kdʒ kf tʃg xg t? |
| Irish Gaelic I (diachronic) | l / r / n + fricative or voiced stop lb nb r'b' l'v' n'v' r'v' nf g'm' n'm' rm nx rx lg rg lf rf rn | rk lk rp lp mb nd ng nr lr | |
| Irish Gaelic II | plosive / m / f / s / h + nasal / liquid gl g'n' dr bn m'n' mr f'r' hn' sr (not nec. complete) | | |
| Lakhota | bl gl gm gn mn | | |
| Oscan | RC: lp rf lf rv lv rm rg rk lk nf ng nk rh | lt rt rn rs nd nt ns | |

| | | | |
|-----------------|--|--|--------------------------------|
| | CR: kr kl tr dr fr tn kn fn mn | | |
| Saami | r:k r:j r:m r:n r:n β:n l:j l:f l:p l:m l:n l:n l:s l:f l:v | lf lk lp rf rk rp l:t l:ts̄ l:tʃ̄ h:p h:t h:ts̄ h:tʃ̄ h:k ⁹ | s:k s:t s:m s:p ʃ:m ʃ:t |
| Sanskrit | r + fricative (some authorities) r + any C (some authorities) l / r + fricative (some authorities) | | |
| Scots Gaelic | mr mn mʃ mç Nk Nç Nx np nv nç nx nm Lb Lp Lg Lv Lx Lm lg' lv lm lj L'x Rg' Rk rb rg rv rf rγ rx rm r'g' r'v r'ç r'x r'm r'j | <u>RR</u> : jh Rh rh r'h Lh lh mr nr Rn Rl <u>RC</u> : jp rb rp Rd Rt r't' r'k' Lp Lt L't' lk' Lk mb mp Nd Nt N'd' N't' N'g' Ng Nk rf Rs rx lf Ns N'ʃ | see full chart in chapter 3 |
| Spanish | all rC Cr some possibly historical examples with [l] | CR: pl bl fl kl gl gn RC: mp ns nt lm lv lt | st sp bs kt |

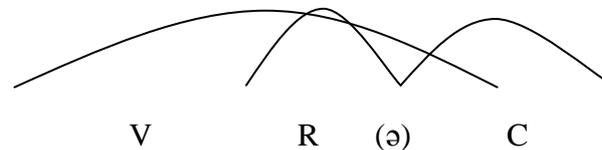
⁹ These are analyzed by Bye 2001 as superheavy preaspirated stops rather than clusters.

CHAPTER 2. GESTURAL PHASING AND THE SYLLABLE

2.1. Syllabicity and segmenthood

In chapter 1, the thesis was defended that intrusive vowels are the result of an overlapping vowel articulation being heard in the period of acoustic release between two consonants. This structure accounts for the typological characteristics of vowel intrusion, such as the types of clusters that intrusive vowels occur in and the ‘copied’ quality of the vowels.

(65) Gestural score of vowel intrusion



This chapter focuses on how this gestural timing relates to syllable structure. I claim that vowel intrusion does not create a new syllable, and also that gestural timing constraints make crucial reference to boundaries.

2.1.1. The non-syllabicity hypothesis

Steriade 1990, who first proposed the gestural structure above, assumes that gestural retiming automatically causes adjustments to syllable structure.

To complete the account, we must add the following assumption about the syllabic interpretation of overlapping vocalic and consonantal gestures: a vowel gesture is interpreted as a monosyllable only if all the superimposed consonantal gestures are peripheral, that is only if the beginning of a *contiguous* cluster of consonantal articulations coincides with or precedes the beginning of the vocalic gesture (or, in the case of a postvocalic gesture, only if the end of the cluster coincides with or follows the end of the vowel). Since Dorsey’s Law [vowel intrusion in Hocank- NH] creates a sequence in which a consonant gesture has come to be nonperipherally superimposed on a vowel gesture, it automatically turns a monosyllable into a disyllable. (391)

The phonological behavior of intrusive vowels does not support this claim. While there probably are disyllable structures that involve vowels fully overlapping consonants, such overlap does not in itself create a new syllable. Rather, intrusive vowels are a percept resulting from a certain type of gestural organization *within* the syllable or at syllable boundaries.

The first suggestion that gestural overlap doesn’t necessarily create a new syllable comes from Bosch 1995, who extends Steriade’s gestural timing analysis to intrusive vowels in Scots Gaelic. Bosch points out the extensive evidence from both phonology

and speaker intuitions (discussed in chapter 4) that Scots Gaelic intrusive vowels do not form full-fledged syllables:

[E]penthesis in Scots Gaelic, though typically considered a phonological process... must be analyzed in gradient rather than discrete terms. In particular, the syllable formed by the epenthetic vowel is properly understood to be an extension of the original syllable, as opposed to a second, new syllable position, thus pointing to the need for a gradient rather than discrete understanding of the syllable as constituent. (2)

She adds that Scots Gaelic intrusive vowels do not add a vowel slot on the timing tier, or a new moraic position to the word (Bosch 1995:11). This claim is particularly striking for Scots Gaelic because the intrusive vowels are quite long- as long as the non-intrusive portion of the vowel.

The proposal here differs significantly from Bosch's in that the intrusive vowel is not analyzed as syllabic in any sense. (Bosch does refer to "the syllable formed by the epenthetic vowel.") Nor is the syllable seen as a gradient constituent; it is fully discrete. A Scots Gaelic word like [ʃalək] is no more than a CVCC syllable; the timing of the gestures creates only the percept (for non-native speakers) of a second syllable.

On the basis of the languages studied here, I will argue that cross-linguistically, intrusive vowels *never* form syllables, regardless of their length. They act non-syllabic for a great variety of phonological diagnostics in different languages, such as language games (Kekchi), syncope (Scots Gaelic), allomorph conditioning (Finnish), stress (Spanish, Chamicuro), reduplication (Hocank), etc. Some of these patterns will be presented in detail in the individual case studies in this and following chapters. I am referring, of course, only to vowels that synchronically have the gestural representation in (65); there are also cases where once intrusive vowels have clearly been reanalyzed as segmental and syllabic. But there is often evidence in these cases that their gestural representation has changed as well, so that they are only historically related to the phenomenon at hand.

Why should intrusive vowels be non-syllabic? I propose that this follows from two facts: intrusive vowels are not associated with an independent segment, and syllables organize segments. Syllables do not organize sounds, nor subparts of gestures, no matter how perceptually prominent. The non-syllabicity of intrusive vowels also relates to the fact that they do not target marked clusters: they do not repair syllable structure because they do not create new syllables, and they do not create new syllables because their purpose is not to repair syllable structure.

This proposal runs counter to a pervasive (although usually unstated) assumption that a vocalic sound can be non-syllabic if it is very short and clearly 'transitional', but that a certain level of phonetic prominence entails syllabicity. The study of vowel intrusion makes it clear that there is no threshold of duration or quality that defines whether a vowel sound is syllabic: a non-syllabic vowel sound can be longer than a syllabic vowel sound even in the same language, as in Scots Gaelic. The notion of 'syllabicity' must be defined on grounds more categorical and abstract than the fieldworker's ear or intuition. To be syllabic, a vowel sound must correspond to an independent segment, with all the behavior that segmenthood implies, such as an ability

to have independent quality, and to be independently manipulated by phonological grammar.

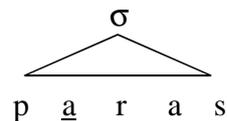
In the theory assumed here, a word's output representation consists of a string of segments organized into syllables, a set of gestures associated with the segments, and a set of phasing relationships among the gestures that organize them into a gestural score. In the representation, the intrusive vowel is not an entity with any formal status. It can be defined as the section of the vowel gesture that is heard in the interval between the release of one consonant and the closure of the next. But that subpart of a gesture, defined on basically auditory terms, is not something that any rule or constraint can refer to. In particular, the syllable structure cannot refer to it because it is not an independent segment.

2.1.2. Alternative accounts of monosyllabicity

The monosyllabic behavior of intrusive vowel sequences has been noted before (particularly for Scots Gaelic and Hocank), and linguists have proposed several structures for these sequences. All of the non-gesturalist proposals require expanding the type of structure that can constitute a syllable, and fail to predict many of the properties of intrusive vowels.

Alderete 1995 analyzes Hocank intrusive vowel sequences like [paras] 'flat' as single syllables with a CVCV(C) segmental content. He posits no further syllable-internal structure.

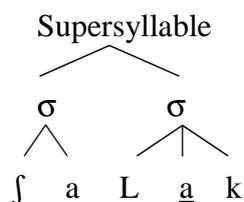
(66) CVCVC syllables



This syllabification is forced by a constraint, SYLL-PLACE, demanding that segments sharing a place feature (in this case, the two vowels) belong to the same syllable.

Bosch & de Jong 1998 propose that Scots Gaelic intrusive vowel sequences like [ʃalak] 'hunting' are "supersyllables". A supersyllable consists of two ordinary syllables. Some syllable-based phenomena refer to the regular syllables, and some refer to the supersyllables.

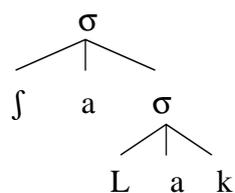
(67) Supersyllables



A disadvantage of this approach, as the authors note, is that it is not clear how a supersyllable differs from a foot.

Smith 1999, working within the X-bar theory of phonology, proposes that Scots Gaelic intrusive vowel sequences are recursive syllables. One syllable forms the coda of another syllable.

(68) Recursive syllables



These three proposals can be grouped as “expanded syllable” approaches. All of them treat the intrusive vowel as a true segment, which forces them to expand the set of possible syllable structures to allow non-adjacent vowels or new types of hierarchical structure. There is no alternative to such expansion if one is to keep the view that the intrusive vowel is segmental and yet the whole CVCVC sequence is one syllable.

The main problem with these approaches is that they do not straightforwardly predict the other characteristics of the vowel intrusion syndrome. As shown in chapter 1, these monosyllabic “CVCVC” structures tend to have identical vowels, and their middle consonant is a sonorant that’s heterorganic to the consonant to which it is underlyingly adjacent. Under the gesturalist view, independently motivated principles of gestural organization and physics predict that the structure in (65) would have these properties: there is more audible release between heterorganic consonants due to the task dynamics of producing consonant clusters, the vowels are identical because they are a single gesture, and the dispreference for vowel overlap with certain consonant types, while not yet well understood from a physical perspective, is at least supported by other phenomena such as vowel copy. But there is no obvious reason why CVCVC syllables, supersyllables, or recursive syllables would be subject to any of these restrictions. If we allow a syllable to form the coda of another syllable, for example, it does not fall directly out of the structure that the internal syllable should have to have a sonorant onset, or have the same vowel quality as the upper syllable, or have a heterorganic onset and coda. New principles can be added, of course, such as Alderete’s constraint SYLL-PLACE, but the necessity of these makes the expanded syllable approaches less explanatory.

It is better to keep a simple, standard view of the segmental content of syllables, while acknowledging that the phasing of the gestures associated with those segments can cause syllable-like percepts. In fact, far from creating their own syllables, intrusive vowels are crucially sensitive to the presence of syllable boundaries. This will be demonstrated by case studies of Dutch and Finnish.

2.2. Dutch

Dutch has an optional intrusive [ə] in tautosyllabic RC clusters. The difference between tauto- and hetero-syllabic clusters supports the existence of additional gestural alignment constraints. Dutch also provides evidence, from phonological patterning and speaker intuitions, of the intrusive vowel's non-segmental and non-syllabic status. Dutch may be the only language where there have been psycholinguistic studies on the processing and production of intrusive vowels, and these provide a unique type of evidence for the intrusive vowel's function.

2.2.1. Conditioning environment

Vowel intrusion occurs after an [l] or [r] that is followed by a labial or velar, i.e. [m], [p], [f], [k], or [x], and also in the cluster [rn]. According to Booij 1995:8, the Dutch /r/'s articulation varies: "The /r/ may be realized as an alveolar roll [r] (in particular in utterance-initial position), as an alveolar flap [r̥], as a uvular roll [R], as a uvular fricative [χ], or as a uvular approximant [ʁ]. In postvocalic position /r/ may also be realized as a palatal approximant similar to [j]. This is a matter of individual and regional variation." The symbol [r] is used below, but it should be borne in mind that the realization may differ.

A chart of final CC clusters in Dutch, based on Booij 1995:40-1, is given below. Clusters with vowel intrusion are shaded. This chart shows the surface forms of final clusters; underlyingly, final obstruents might be voiced. Some clusters with "appendix" consonants (explained below) are omitted.

(69) Dutch final clusters (some appendix Cs omitted)

| | p | b | t | d | k | f | v | s | z | x | ɣ | m | n | ŋ | l | r |
|---|----|---|----|---|----|----|---|----|---|----|---|----|----|---|---|---|
| m | mp | | | | | | | | | | | | | | | |
| n | | | nt | | | | | ns | | | | | | | | |
| ŋ | | | | | ŋk | | | | | | | | | | | |
| l | lp | | lt | | lk | lf | | | | lx | | lm | | | | |
| r | rp | | rt | | rk | rf | | | | rx | | rm | rn | | | |
| s | sp | | st | | sk | | | | | | | | | | | |

Basically, Dutch has vowel intrusion in all heterorganic sonorant-initial clusters. In effect, this means that intrusion occurs only after [l] and [r], since nasals are always homorganic to the following sound. The cluster [rn] is the only one that may contradict the heterorganicity generalization: it should be homorganic for those speakers who have an alveolar [r]. I do not have an explanation for this exception, although it's interesting to note that Irish Gaelic also allows vowel intrusion in [rn] sequences (although not in [nr] sequences). This suggests that there may be some factor particular to the transition between [r] and [n] that increases the likelihood of vowel intrusion.

Below are examples of each cluster that triggers vowel intrusion. The intrusive vowel is always transcribed as [ə], and is not present in spelling.

| | | | |
|------|---|---------------|----------------|
| (70) | Dutch RC clusters with intrusive vowels | | Booij 1995:127 |
| a. | kɑl <u>ə</u> m | <i>kalm</i> | ‘quiet’ |
| b. | ɑr <u>ə</u> m | <i>arm</i> | ‘arm’ |
| c. | hɛl <u>ə</u> p | <i>help</i> | ‘help’ |
| d. | hɑr <u>ə</u> p | <i>harp</i> | ‘harp’ |
| e. | hɛr <u>ə</u> fst | <i>herfst</i> | ‘autumn’ |
| f. | ɛl <u>ə</u> f | <i>elf</i> | ‘eleven’ |
| g. | mɛl <u>ə</u> k | <i>melk</i> | ‘milk’ |
| h. | ʋɛr <u>ə</u> k | <i>werk</i> | ‘work’ |
| i. | ɑl <u>ə</u> x | <i>alg</i> | ‘alga’ |
| j. | ɛr <u>ə</u> x | <i>erg</i> | ‘very’ |
| k. | ʏr <u>ə</u> n | <i>urn</i> | ‘urn’ |
| l. | hɔr <u>ə</u> n | <i>hoorn</i> | ‘horn’ |

Dutch also has an underlying, segmental [ə], which contrasts with intrusive [ə] in minimal pairs like the following:

| | | | |
|------|------------------------------|---------------|-----------|
| (71) | Underlying vs. intrusive [ə] | | |
| a. | ʋɪl <u>ə</u> x | <i>wilg</i> | ‘willow’ |
| b. | ʋɪl <u>ə</u> x | <i>willig</i> | ‘willing’ |
| a. | hɔr <u>ə</u> n | <i>hoorn</i> | ‘horn’ |
| b. | hɔr <u>ə</u> n | <i>horen</i> | ‘to hear’ |
| a. | bəl <u>ə</u> x | <i>balg</i> | ‘bellows’ |
| b. | bəl <u>ə</u> x | <i>ballig</i> | ‘snooty’ |
| a. | tɔr <u>ə</u> n | <i>toorn</i> | ‘anger’ |
| b. | tɔr <u>ə</u> n | <i>toren</i> | ‘tower’ |

These words do not (necessarily) sound the same. In the speech of my consultant, the intrusive [ə] seemed shorter and less distinct than underlying [ə], and it was usually possible to tell the words above apart when they were spoken in isolation.

Some Dutch speakers also have a slight intrusive vowel in CR onsets (as pointed out to me by Fred Landman), but this phenomenon has received little attention and the precise conditioning environment is not known.

Intrusive [ə] is optional. Donselaar et al. 1999:60 report that for most speakers, there is no difference in prestige between the two pronunciations, but for those who do perceive a difference in prestige, the forms without vowel intrusion are more prestigious and standard. Wijnen, Krikhaar, & Den Os 1994 report that vowel intrusion is “practically standard” in child Dutch.

2.2.2. The role of syllable structure

Vowel intrusion in most dialects of Dutch happens only within syllables. There are two circumstances under which a heterorganic RC cluster may fail to show vowel intrusion: when C is the onset of a following syllable, and when C is an unsyllabified “appendix”.

2.2.2.1. Heterosyllabic clusters

For most speakers, intrusive vowels appear only between two consonants that are in the same coda, not between two heterosyllabic consonants, as in the following words:

| | | | |
|------|-------------------|--------------|-----------------------------|
| (72) | Heterosyllabic RC | | |
| a. | ʋer.kən | ‘to work’ | Booij 1995:128 |
| b. | tʏl.pən | ‘tulips’ | |
| c. | er.kər | ‘bay window’ | |
| d. | pəl.ka | ‘polka’ | |
| e. | kər.ma | ‘karma’ | Kuijpers & Donselaar 1997:7 |

Vowel intrusion does happen sporadically in such clusters, and may be regular in some dialects. According to Gussenhoven 1993:51, Amsterdam Dutch has intrusion in medial clusters only if the following syllable is weak: it could happen in the words above, but not in [bəl'kən] ‘balcony’, [hər'pun] ‘harpoon’, etc. He suggests that a stressed syllable adds the initial consonant of the following weak syllable to its coda. Under this analysis, intrusion happens only within syllables in all dialects; it is the syllabification of medial RC clusters that differs.

The dependence of vowel intrusion on syllable structure is very common cross-linguistically. Some languages, like Dutch, have intrusive vowels only within syllables; some, like Finnish, have them only between syllables; and some, like Scots Gaelic, have them in both situations.

| | | | |
|------|----------------------------|-------------------|------------------|
| (73) | Vowel intrusion locations: | between syllables | within syllables |
| | Scots Gaelic | Yes | Yes |
| | Dutch | No | Yes |
| | Finnish | Yes | No |
| | English (most dialects) | No | No |

Hocank has a fifth pattern: it has intrusive vowels in both tautosyllabic and heterosyllabic clusters, but those within syllables are long, full vowels while those between syllables are

very short. The variety of patterns attested show that the grammar must contain different phasing constraints for tauto- and hetero-syllabic clusters.

There are several types of constraint arrays that could account for this typology. There could be a) general C-C phasing constraints that do not refer to syllable structure, b) C-C phasing constraints that refer only to tautosyllabic clusters, and c) C-C phasing constraints that refer only to heterosyllabic clusters. Any two of these constraint types are sufficient to produce the typology above; the third is redundant. Since gestural coordination is known to be most stable within the syllable, I will assume that constraints of type b) exist; for the second type I will, somewhat arbitrarily, choose a). One reason for preferring a) is that it allows a simple account of languages, like Dutch, where the same phasing holds between heterosyllabic CCs and CC sequences where one C is unsyllabified. It also allows a single (high-ranked) constraint to account for all the CC phasing patterns in languages like Scots Gaelic, where the same phasing holds within and between syllables.

In short, languages have general constraints on CC alignment, and constraints specifically on CC alignment within syllables. In languages where the general constraints are higher ranked, phasing will be the same for tautosyllabic and heterosyllabic CC clusters. In languages where a specific constraint is higher ranked, phasing within and between syllables may be different.

According to this analysis, the highest-ranked general constraint in Dutch is one that prefers the phasing $\text{RELEASE} = \text{TARGET}$ (a phasing that produces no audible release) in RC clusters.

(74) $\text{ALIGN}(\text{R}, \text{RELEASE}, \text{C}, \text{TARGET})$

In a $C_1 C_2$ string, C_1 a sonorant, the release of C_1 is aligned with the target of C_2 .

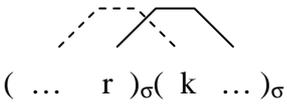
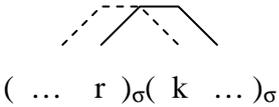
The highest-ranked constraint that refers specifically to tautosyllabic consonants is one that prefers a phasing of $\text{CENTER} = \text{ONSET}$, which will produce audible release.

(75) $\text{ALIGN}(\text{R}, \text{CENTER}; \text{C}, \text{ONSET}) \text{ IN } \sigma$

In a $C_1 C_2$ string, C_1 a sonorant, where C_1 and C_2 belong to the same syllable, the center of C_1 is aligned with the onset of C_2 .

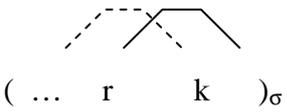
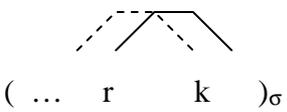
The syllable-specific constraint is ranked above the general constraint. Tableaus (76) and (77) show how this grammar treats heterosyllabic and tautosyllabic clusters differently. In [verkən] ‘to work’, the [r] and [k] are adjacent across a syllable boundary. Since $\text{ALIGN}(\text{R}, \text{CENTER}; \text{C}, \text{ONSET}) \text{ IN } \sigma$ does not apply, $\text{ALIGN}(\text{R}, \text{RELEASE}, \text{C}, \text{TARGET})$ is able to enforce a high degree of overlap and prevent vowel intrusion.

(76) Dutch heterosyllabic clusters (no vowel intrusion)

| /vɛrkən/ | ALIGN (R, CENTER; C, ONSET) IN σ | ALIGN (R, RELEASE; C, TARGET) |
|---|--|----------------------------------|
| a.  (... r) σ (k ...) σ [vɛrəkən] | | *! |
| a. →  (... r) σ (k ...) σ [vɛrkən] | | |

In [vɛrk] ‘work’, [r] and [k] are tautosyllabic, so the higher-ranked ALIGN (R, CENTER; C, ONSET) IN σ forces a low degree of overlap, producing vowel intrusion.

(77) Dutch vowel intrusion in tautosyllabic clusters

| /vɛrk/ | ALIGN (R, CENTER; C, ONSET) IN σ | ALIGN (R, RELEASE; C, TARGET) |
|---|--|----------------------------------|
| a. →  (... r k) σ [vɛrək] | | * |
| a.  (... r k) σ [vɛrk] | *! | |

For those Dutch speakers who do not have vowel intrusion at all, the constraint ALIGN (R, RELEASE; C, TARGET) must be ranked higher than ALIGN (R, CENTER; C, ONSET) IN σ .

2.2.2.2. Appendices

Vowel intrusion does not happen when [l] or [r] are followed by alveolar obstruents [t] or [s], as shown below.

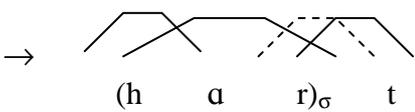
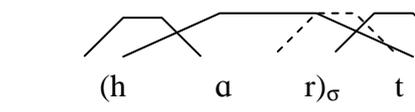
- (78) Dutch RC clusters without intrusive vowels Booij 1995:127
- | | | | |
|----|------|-------------|---------|
| a. | hart | <i>hart</i> | ‘heart’ |
| b. | hars | <i>hars</i> | ‘resin’ |
| c. | halt | <i>halt</i> | ‘stop’ |
| d. | hals | <i>hals</i> | ‘neck’ |

The lack of intrusion in [lt] and [ls] could be ascribed to the task dynamics of producing homorganic clusters, as discussed in chapter 1, but this explanation does not extend to the [r]C cases. Some Dutch speakers have a uvular /r/ ([ʀ], [χ], [ʁ]), which is not homorganic to [t] or [s]. If homorganicity were the only factor ruling out intrusion before [t] and [s], we would expect to find descriptions of dialects where [r] is uvular and [rt] and [rs] clusters have vowel intrusion. Such cases have not been reported.

Booij 1995 adopts a different explanation for the lack of vowel intrusion before [t] and [s]: these consonants are not part of the syllable. There is independent evidence for this claim (Booij 1995:26-7 and references therein). For example, long vowels like [a] can only be followed by one coda consonant in Dutch, making words like *[kamp] impossible. But long vowels do occur before clusters of up to four consonants provided that all but the first are coronal obstruents. Words like [bɛdarst] ‘calmest’ and [kars] ‘candle’ are well-formed. This can be explained if [kars] has a one-segment coda, [r], and the [s] is an “appendix” consonant that is not part of the syllable. Appendix groups also violate otherwise regular constraints on sonority profiles within Dutch syllables.

If the final [t] or [s] is not syllabified, the constraint system already proposed accounts for final [rs] and [rt] clusters, as shown in tableau (79).

(79) No vowel intrusion before appendix

| /hart/ | ALIGN (R, CENTER; C, ONSET) IN σ | ALIGN (R, RELEASE; C, TARGET) |
|--|--|----------------------------------|
| a.  [hart] | | |
| b.  [harət] | | *! |

The claim that vowel intrusion happens only within syllables implies, of course, that the intrusive vowel is not itself a syllable. The following section summarizes the evidence for this claim.

2.2.3. Monosyllabic behavior

In Dutch, evidence for the non-syllabicity of intrusive vowels comes primarily from speaker intuitions and phonological patterning. There is also indirect support from phonetic measurements.

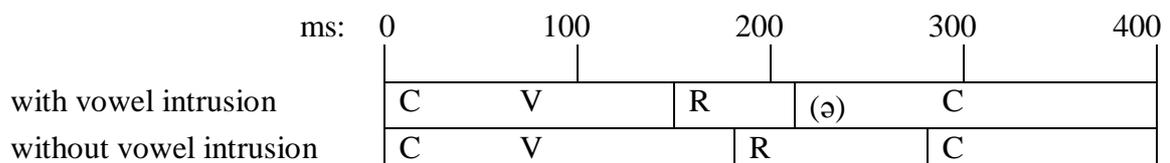
2.2.3.1. Syllable duration

Donselaar et al. 1999 describe the timing of segments in words with and without vowel intrusion. These measurements were taken as a control on the stimuli for a larger experiment. Experiments 3 and 4 of this study involved tokens of 36 words, each pronounced by an experimenter once with and once without vowel intrusion (recall that vowel intrusion is optional). Each word was measured at three points: the end of the CV portion, the end of the CVR portion, and the end of the word. While there was no significant difference in overall word duration, the CVR and CV portions were shorter in words with vowel intrusion, as shown below¹⁰.

| (80) Durations of CVRC words | CV | CVR | CVRC |
|------------------------------|-----|-----|------|
| with vowel intrusion | 156 | 208 | 400 |
| without vowel intrusion | 181 | 277 | 401 |

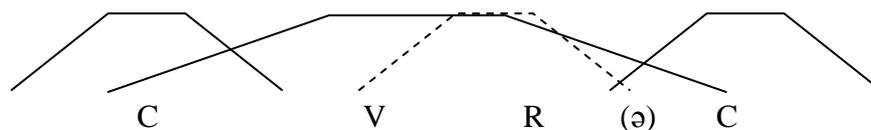
(81) shows these durations graphically.

(81) Timing patterns of CVRC words



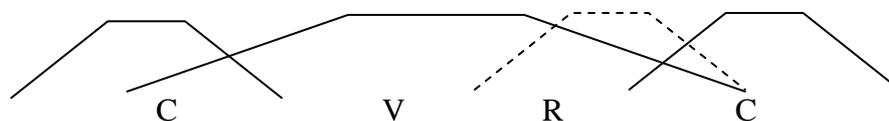
These data are strikingly consistent with the proposal that vowel intrusion is not addition of a syllable, but a special timing of segments within the syllable such that the sonorant heavily overlaps the vowel. An earlier onset and offset for the sonorant are precisely what the representations below predict.

(82) Syllable with vowel intrusion



¹⁰ Donselaar et al. measure the words in two groups; I have averaged the figures according to the number of words in each group.

(83) Syllable without vowel intrusion



Donselaar et al. do not compare the duration of CVR_əC words with vowel intrusion and CVR_əC words where the ə is underlying. I have not taken instrumental measurements, but I consulted a native speaker from the central part of Holland, and found that there is a clearly perceptible difference between his pronunciation of minimal pairs like those in (71). Impressionistically, words with intrusive [ə]'s sound shorter than words with underlying [ə]'s. The consultant's conscious intuition is that words with intrusive vowels are monosyllables but that "it's sometimes difficult to get these consonants together." He adds, though, that the spelling might bias one to think this.

2.2.3.2. Syllable count judgments

Donselaar, Kuijpers, and Cutler 1999 report a psycholinguistic experiment in which native speakers treated words with vowel intrusion like monosyllables.

In the experiment, subjects heard a series of spoken words, some of them real words and some nonsense, and were asked to orally respond with a "reversed" version of each word. They were told that if the word was one syllable, they should reverse the segments, so that for the stimulus [tap] the subject would be expected to produce [pat]. But if the word was a disyllable, they only had to reverse the syllables, so that for [hotel] the subject would be expected to produce [telho]. Indirectly, the task forced speakers to make syllable count judgments. The stimuli included both words with underlying [ə] in the second syllable and words with intrusive [ə]s.

Subjects treated real words with intrusive [ə], like [tʌl_əp] 'tulip', as monosyllables 94% of the time, producing [plut] rather than [ləptu] (or, significantly, [pəlut]). Nonsense words with intrusive [ə] were treated as monosyllables 58% of the time. This suggests that subjects had trouble telling from a single hearing whether the [ə]s in nonsense words were meant to be segmental or intrusive. Perhaps their knowledge of which [ə]s are intrusive derives partly from noticing the variability present in multiple productions of the vowel.

The experiment is consistent with the claim that speakers consider the intrusive [ə] to be non-syllabic, since when presented with [tul_əp] subjects followed the instructions they were given for monosyllables. Also, their failure to keep the [ə] in the segment-by-segment reversal—i.e. producing [plut] instead of [pəlut]¹¹—is consistent

¹¹ It is actually not made clear in Donselaar et al. 1999 that the "monosyllabic" responses were [plut], but this is stated in a summary of the experiment by Warner et al. 2001. The papers share a co-author, Anne Cutler. In addition, this is consistent with the results I have obtained in giving consultants the same task.

with the claim that the [ə] is not a segment, and hence unavailable for such manipulation. The experiment is open to the objection, however, that speakers may have consulted the orthography in order to complete the task.

Warner et al. 2001 report that Goetry et al. (unpublished) have data showing that preliterate Dutch children also judge forms like [tʏləp] as monosyllabic approximately half the time, in a way that differs from their treatment of true disyllables, but I have not had access to this manuscript.

2.2.3.3. [n]-deletion

The phonological behavior of intrusive [ə]s also differentiates them from regular, segmental [ə]s. The segment [ə] in a final syllable conditions two processes: deletion of a following [n] and selection of certain suffix allomorphs. Intrusive [ə] fails to condition either pattern. A regular CVCəC words also licenses a greater range of qualities for the first vowel than a CVCəC word where [ə] is intrusive, while CVCəC licenses lexical tones that CVCəC cannot. These patterns are highlighted in the next few sections.

An –[ən] coda that is followed by a morphological boundary can usually be pronounced without the [n], as in the examples below (exceptions are the indefinite article *een* and an /n/ at the end of a verbal stem). This deletion is optional for some speakers, including my consultant, and obligatory for others, according to Booij 1995. It happens in a variety of morphological contexts, both word-medially and word-finally.

| | | | |
|------|--------------------|--------------------|----------------------------|
| (84) | Dutch [n]-deletion | | Booij 1995:139 |
| a. | <i>regen</i> | reɣən / reɣə | ‘rain’ |
| b. | <i>gouden</i> | ɣɔudən / ɣɔudə | ‘golden’ |
| c. | <i>boven</i> | bovən / bovə | ‘above, upstairs’ |
| d. | <i>bloemen</i> | blumən / blumə | ‘flowers’ |
| e. | <i>lopen</i> | lopən / lopə | ‘to walk’ (pres. pl./inf.) |
| f. | <i>openlijk</i> | opənlək / opələk | ‘openly’ |
| g. | <i>regentje</i> | reɣəntjə / reɣətjə | ‘rain’ (diminutive) |
| h. | <i>open-baar</i> | opənbɑ:r / opəbɑ:r | ‘public’ |

This [n] deletion does not happen after an intrusive [ə], a fact that has not to my knowledge been noted in the literature. Consultants report that deleting the [n] of a word like *hoorn* ‘horn’, which is pronounced [horən], is completely unacceptable. [horə] has to mean *horen* ‘to hear’, whose alternate pronunciation is [horən].

The difference between these two phonetic [ən] sequences can be explained under the gestural approach if we assume that the constraint motivating [n]-deletion is one on well-formed syllable structure. [ə] is more restricted than other short nuclei in Dutch in what codas may follow it; for example, it cannot be followed by a cluster of two consonants in the same syllable (Booij 1995:19). Although [n] is not a branching coda, it

evidently falls in the group of codas that cannot follow [ə], for some speakers. The reason for this restriction is beyond the scope of discussion here; it will be simply be instantiated with the following constraint:

(85) *ən]_σ

A syllable with the nucleus [ə] may not have coda [n]

This constraint will not favor [n]-deletion after an intrusive [ə], because this [ə] is not a segment or the nucleus of a syllable. In the tableaux below, it should be remembered that the constraint *ən]_σ is evaluating only the segmental representation, given under the gestural curves. The phonetic transcription in brackets is parenthetical and not part of the output representation at all.

(86) [n]-deletion after underlying [ə]

| /horən/ | *ən] _σ | MAX |
|--|-------------------|-----|
| a. o) _σ (r ə n) _σ [horən] | *! | |
| b. → o) _σ (r ə) _σ [horə] | | * |

(87) No [n]-deletion after intrusive [ə]

| /horn/ | *ən] _σ | MAX |
|--|-------------------|-----|
| a. → o r n) _σ [horən] | | |
| b. o r) _σ [horə] | *! | |

This pattern demonstrates that an acoustic [ən]-like sequence resulting from vowel intrusion is not treated by the grammar in the same way as a segmental [ən] sequence.

2.2.3.4. Allomorph selection

Segmental [ə] and intrusive [ə] also trigger different allomorph selection. The suffix meaning ‘inhabitant of’ has three allomorphs. It is *-der* [dər] after an [r], as in a) below; *-aar* [ar] after a sequence of [ə] + coronal sonorant, as in b) and c) below; and *-er* [ər] elsewhere, as in d) and e).

(88) Suffix allomorphy

| | | | |
|----|-----------------------|---------------|-----------------------------|
| a. | <i>Bijlmermeerder</i> | bɛilmərmerdər | ‘inhabitant of Bijlmermeer’ |
| b. | <i>Diemenaar</i> | dimənar | ‘inhabitant of Diemen’ |
| c. | <i>Assenaar</i> | asənar | ‘inhabitant of Assen’ |
| d. | <i>Lochemer</i> | lɔxəmər | ‘inhabitant of Lochem’ |
| e. | <i>Amsterdammer</i> | amstərdəmər | ‘inhabitant of Amsterdam’ |

Words that end in a [ən] due to vowel intrusion take *-er*, not *-aar* as words ending in underlying *-[ən]* do. The consultant offered the following near-minimal pair:

| | | |
|---------|-----------------|---------------------------------|
| (89) a. | <i>Maarner</i> | ‘inhabitant of Maarn’ ([marən]) |
| b. | <i>Lorenaar</i> | ‘inhabitant of Loren’ |

Both terms were nonce words for him rather than learned forms. This shows that in new word formation, the [ən] sequence resulting from vowel intrusion is not phonologically equivalent to the [ən] resulting from an underlying /ən/.

This allomorphy choice can be explained if the restriction on [-ər] is motivated by a constraint prohibiting [ə] *segments* in adjacent syllables. Such a constraint is independently motivated, since Dutch normally deletes the first in a sequence of [ə]s: /kopərən/ → [koprən] ‘copper’.

2.2.3.5. Lexical tone

Words like [ɛrəm] ‘arm’ also pattern with monosyllables in their ability to host lexical tone. In some Limburghian dialects of Dutch, such as Venlo, stressed syllables with two sonorant moras can host a lexical H on the second mora (Gussenhoven & van der Vliet 1999:101). Monomoraic syllables cannot host this lexical tone.

If a word like [ɛrəm] were disyllabic, the first syllable, [ɛ], should be monomoraic and unable to host the lexical tone. But in fact, [ɛrəm] does host lexical tone in Venlo Dutch. Gussenhoven & van der Vliet, who assume [ɛrəm] to be disyllabic, analyze this as indicating that tone assignment precedes the division of /ɛrm/ into two syllables. But the data presented is equally compatible with the claim that [ɛrəm] is one heavy syllable on the surface.

2.2.3.6. Distribution of long vowels

Another argument that vowel intrusion does not create a new syllable comes from the patterning of long vowels and consonant clusters. A long vowel, meaning one of [i, y, u, e, ø, o, a] cannot be followed by two consonants in the same syllable. Thus, a word like *[kimp] or *[kump] is ill-formed in Dutch. Only the short vowels, [ɪ, ɛ, ɔ, ʏ, ɑ], can be followed by two coda consonants.

Booij 1995 analyzes this pattern as a restriction on syllable structure. He argues that the Dutch rhyme consists of a maximum of three positions on the X-tier. A long vowel occupies two positions and hence can be followed by only one consonant; a short vowel occupies one position and hence can be followed by two consonants.

This syllable-structure restriction provides a test of whether intrusive vowels are creating a new syllable. If vowel intrusion into a /CVCC/ input creates a CV.CəC output, then the first syllable should be able to license a long vowel. Long vowels occur in words like [ro.dər] ‘redder’ or [e.tər] ‘eater’, where the [ə] is underlying and segmental. There is even a class of words where vowels lengthen when the syllable they are in is opened by addition of a [ə]-initial suffix, as in [wɛg] ‘road’ vs. [wɛ.gən] ‘roads’ (Booij 1995:72).

If vowel intrusion caused the preceding syllable to become open, words like *[kiləm] or *[kuləm] (underlying /kilm/, /kulm/) should be possible. Yet they are not, according to Booij 1995:15. This is very simply explained if these words are monosyllabic: the rhyme consists of the segmental string [ilm] or [ulm], and is ruled out by the same syllable structure constraints that rule out words like *[kimp] and *[kump]. The non-opening of a preceding syllable is one example of the way that the intrusive [ə] fails to act syllabic.

2.2.3.7. The unmarkedness of RC clusters

Another, more indirect argument for the intrusive [ə] not being an epenthetic segment is the lack of motivation for epenthesis in this position. Donselaar et al. 1999:60 present evidence from Dutch truncation processes that the RC clusters broken by vowel intrusion are not treated as marked by other processes in the grammar. As mentioned in chapter 1, it is a general characteristic of vowel intrusion that it does not target clusters based on their markedness.

If the appearance of [ə] were a type of epenthesis, it would need to be motivated by high-ranked markedness constraint penalizing RC clusters of the particular kind that trigger [ə]-insertion. We would expect to find that the grammar avoided such clusters in other ways as well. Truncation is one situation in which the avoidance of marked clusters can be seen. A cluster that is heterosyllabic in a long word- for example, the [rb] of *Barbara*- may be tautosyllabic in the truncated form of the word, as in *Barb*. When the usual truncation pattern of a language would result in a marked coda, the grammar may repair this problem by truncating more than usual. In English, for example, the name *Albert* truncates not to *Alb*, as would be expected by comparison to *Barb*, but to *Al*. As

John McCarthy (p.c) notes, this is probably because [lb] is an extremely rare coda in English, occurring only in a few low-frequency words (*bulb* and *alb*).

Thus, if clusters like [rk] trigger vowel intrusion due to being marked codas, they might also be avoided in truncation processes. But in fact, Dutch truncation does not avoid creating the type of clusters that are subject to vowel intrusion. For example, the name *Marcus* can be truncated to *Marc* [marək], and a *directeur* (director) can be called the *dirk* [dirək]. The grammar doesn't take the option of avoiding the [rk] coda by truncating to **Mar* or **dir*.

This supports the idea that vowel intrusion does not function to remove an undesirable coda cluster by resyllabification, but simply reflects a certain timing relation within a coda cluster. Clusters like [rk] and [lp] are not especially marked clusters that are avoided in Dutch; they are perfectly acceptable clusters that simply need to be articulated in a way that results in the percept of a [ə] between them.

2.2.3.8. Against ordering

One response to the phonological arguments presented above might be that rule-ordering is involved. [ə]-epenthesis could simply apply after processes like [n]-deletion, and this would explain why such processes ignore epenthetic [ə]: it isn't present when they apply. Such an analysis is not available within Optimality Theory, which is a non-serialist framework, but it would be the natural conclusion in other frameworks.

If this were the case, we would expect to find that other orderings were possible in other languages. Cross-linguistically, there are certainly many cases of epenthesis that have to be ordered before other rules, and there is no obvious reason that the type that breaks RC clusters should be different.

Synchronic vowel insertion with the characteristics of the vowel intrusion syndrome, however, seems to occur exclusively after other processes. This consistent ordering is unexplained under the serial derivation theory. While universally ordering this type of epenthesis after other rules would account for the data, it would do so in a stipulative and unexplanatory way. No connection is drawn between the derivational lateness of the epenthesis and the nature of the epenthesis. In the theory presented here, there is a better explanation of which 'inserted' vowels are visible to other processes. Those that are visible are the ones that have a conditioning environment straightforwardly based on avoiding marked syllable structures—i.e, the ones that are truly segments inserted to cause resyllabification. Vowel intrusion does not affect syllable structure because it does not repair syllable structure, and vice versa.

2.2.4. Discussion: how can a vowel not be a syllable?

I have presented several pieces of evidence above that intrusive vowels act non-syllabic in Dutch- as I contend they do in all languages with vowel intrusion. The arguments in the case of Dutch include phonetic duration, phonological patterning, and perhaps most importantly, speaker intuitions as revealed through both casual questioning and psycholinguistic experiments.

Despite this evidence, it is the norm for researchers on Dutch to assume that these [ə]s are syllabic, and the same is true for many other languages with intrusive vowels. There is often an unstated assumption that where there is a vocalic-sounding period of a certain duration or perceptual prominence, there must be a syllable. I claim, on the other hand, that syllables are built out of segments, not out of sounds, and that a word may contain a very distinct vocalic-sounding period that does not correspond to any independent segment. Such a vocalic period cannot be the nucleus of a syllable.

It is important to remember that syllables are not a property of sound streams per se. It would be meaningless to talk about the syllable structure of a dog's barking, or even of human non-speech sounds like laughter or crying. Syllables are only a property of language. But even in language, they cannot be directly deduced from an acoustic record.

To demonstrate this, it may help to think about the difficulty, probably familiar to most linguists, of trying to count the syllables of a word in a foreign language. Other phenomena besides acoustic release may cause confusion. For example, the Afrikaans name *Coetzee* ends in a diphthong [iə] that sounds disyllabic to English speakers (as much so as the last two vowels in *Maria*) but monosyllabic to Afrikaans speakers. Since there is no corresponding English diphthong, the two vowels must be interpreted by the English speaker as nuclei of two syllables. On the other hand, the bisyllabic Hebrew word ['na.al] 'shoe' is usually heard by English speakers as one syllable. There is no clear demarcation of hiatus between the two identical vowels, such as a glottal catch, and English speakers assume that an unbroken vocalic-sounding period must be a single syllable peak. Native Hebrew speakers hear ['na.al] as clearly bisyllabic.

In such cross-language misperceptions, both speakers are right in one sense—they have correctly counted the number of syllables that such an acoustic record corresponds to *in their own language*. The reason they come up with different results is that the translation of an acoustic record to a syllable count goes through the intermediate step of interpretation by a language-specific phonology, and phonologies do not necessarily make a one-to-one association between vocalic-sounding periods in the signal and vowel segments. A single vocalic-sounding period may correspond to no segment, as with intrusive vowels, to one segment, or to two segments, as in [na.al]. Since syllables organize segments, a non-segmental sound such as an acoustic release will not be heard as syllabic by native speakers, and a bisegmental vocalic period like the Hebrew [a.a] will be heard as bisyllabic by native speakers.

Yet in describing the phonology of a language, there is a widespread and usually tacit assumption that "vocalic sound = syllable". For example, even as Donselaar et al. 1999:64 produce strong evidence that "the realizations of real words with schwa epenthesis are represented by listeners as monosyllabic," they still assume that "obviously, adding a vowel between two consonants adds an extra syllable to the word; the optional form with epenthesis has one more syllable than the underlying form without." They later comment that "*from the speakers' point of view*, schwa epenthesis may not arise via insertion of a segment as such, but simply via realization of the gestures corresponding to articulation of the consonant cluster" (p. 74, emphasis added). The unstated assumption is that segments and syllables have some type of reality outside of the speaker's representation of them. It is precisely this that I wish to argue against. Syllables exist in the mind, not in the air.

2.2.5. Intrusion and [l]-allophony

Warner et al. 2001 present a challenge to the analysis of intrusive [ə] as non-syllabic. Based on an articulatory study, they show that the realization of [l] before intrusive [ə] is more similar to that of onset [l] than coda [l]. They argue that this shows [l] has been resyllabified into onset position, and disproves the gestural timing hypothesis (which has been considered by other researchers, as shown by the Donselaar et al. quote above, although it has not to my knowledge been defended in print). I argue that there is an alternative explanation to these facts under the gesturalist view.

Similar to English, some Dutch dialects have ‘light’ [l] in onsets and ‘dark’ [l] in codas. An [l] consists of two gestures: a raising of the tongue tip to touch the alveolar ridge, and a backing of the tongue body (Sproat & Fujimora 1993). A light [l] is one that has a strong tongue tip raising gesture and a weaker tongue body gesture; a dark [l] has a stronger tongue body gesture and weaker tongue tip gesture.

Warner et al. compare tongue tip positioning for triplets like [film], [filəm], and [vɪləm]: that is, the same word pronounced with and without intrusive [ə] versus a word with an underlying schwa in the same position. For all seven of their subjects, the tongue tip was significantly higher when an intrusive [ə] was present, as in [filəm], than when it was not, as in [film]. They conclude that this shows the [ə] to be a phonologically inserted vowel.

In order for the schwa to condition allophonic variation, it must be present as a phonological unit, because the allophonic variation involves timing of the /l/ gestures relative to the vowel. If the schwa were simply a period of time without gestural specifications, which happens to be interpreted perceptually as a schwa-like sound, this targetless schwa would be merely a perceptual epiphenomenon, not a linguistic unit, and could not possibly condition allophonic variation. (395)

It is important to distinguish between conditioning and correlation: the fact that intrusive [ə] tends to cooccur with a light [l] does not necessarily mean that the schwa conditions the light [l]. If the schwa percept itself is a result of a particular gestural timing configuration within a cluster, then that same timing configuration could also be the cause of the [l]’s lightness.

In fact, there are two plausible reasons to think that the timing that produces intrusion would also lighten the [l]. The phasing of [filəm] differs in two ways from that of [film]: the [l] more heavily overlaps the vowel, and less heavily overlaps the [m] in [filəm]. Both of these facts would tend to produce a lighter [l], in different ways.

First, overlap between consonantal gestures tends to weaken them. This has been shown experimentally for English by Browman & Goldstein 1995, and van Reenan 1986’s questionnaire study suggests that it is also a factor in the weakening of the tongue-tip gesture in Dutch. Van Reenan asked subjects to report on vocalization of [l], which is an extreme form of darkening in which the tongue tip fails to make contact with the alveolar ridge. For each word where [l] preceded a consonant, 31% to 64% of respondents reported that they vocalized the [l], with particularly high percentages of

vocalization before stops. But for each word where [l] was word-final, only 26% - 34% vocalized the [l]. Thus, part of the coda [l]'s darkness in Dutch may be due to overlap with the following consonant. As suggested by Louis Goldstein (p.c.), a configuration where there is less overlap between the consonants, as in vowel intrusion, allows a stronger tongue tip articulation and hence a 'lighter' [l].

A second reason for the correlation of intrusion and lightening is that heavy overlap of the [l] with the vowel brings a conflict between the tongue body gestures of the [l] and the vowel. Both gestures want to use the same organ, and the conflict must be resolved. One potential resolution is to weaken the vowel's articulation.

There is a case similar to this in Scots Gaelic. Scots Gaelic has sonorants with strong secondary articulations of palatalization and velarization. In some dialects, these secondary articulations optionally disappear when the sonorant is involved with vowel intrusion. For example, when the palatalized [r'] is timed to overlap a vowel, it may depalatalize to [r]. If [r'] depalatalizes, then the intrusive vowel has the same quality as the preceding vowel; if it does not, then the intrusive vowel sounds like [i]. I interpret this to mean that the palatal gesture on [r'] is in conflict with the vowel, and one or the other must be eliminated.

- (90) Ross-shire depalatalization Borgstrøm 1941:140
- | | | |
|----|--|-----------------|
| a. | arəkət / ar'ɪ:kət | 'silver' |
| b. | t ^h araj / t ^h ar'ɪ: | 'bulls' |
| c. | duruj / dʉur'ɪ: | 'fishing-lines' |

In this case the depalatalization of [r'] could not be attributed to resyllabification as an onset: [r'] exists as an onset, even before back vowels as in [r'^hu:ms] (Borgstrøm 1941:148; no gloss).

This hypothesis also helps explain some of the variability found in Warner et al.'s data. In the measurement of tongue-tip raising, three of their seven subjects had significant differences between the [l] in [fɪləm] and that in [vɪləm], in addition to the significant differences between [fɪləm] and [fɪlm] (p. 404). In effect they were showing a third allophone of [l], rather than a fully onset-like [l]. This is problematic for the theory that [ə] causes resyllabification of [l], but unsurprising under the theory that [l] before intrusive [ə] is in a timing configuration unlike onset [l] or other coda [l]s.

2.2.6. Other allophony

In general, articulatory phonology analyses have not treated allophony with governed by rules of the form "use light [l] in onsets and dark [l] in codas." Rather, different productions of a segment fall out of rules of intra- and inter-syllabic coordination (such as the asymmetry in English between the way onsets and codas are phased with respect to the vowel), a few constraints that come into play when there is conflict between articulatory demands, and general principles of task dynamics. Different allophones are not categorically different objects in the mind (Sproat & Fujimora 1993).

Intrusive vowels sometimes do and sometimes do not condition allophonic processes where ordinary vowels would. In Tiberian Hebrew, for example, stops are normally spirantized after a vowel. This is shown in the contrast between a) and b) below, where the consonant-final root causes the feminine singular perfective suffix /t/ to become [θ]. When a root ends in a guttural, an intrusive vowel appears before the [t] suffix. As shown in c), [t] does not spirantize after the intrusive vowel.

- (91)
- | | | |
|----|----------|---------------------------------|
| a. | katav-t | ‘write 2fs. perfective’ |
| b. | gali-θ | ‘go into exile 2fs. perfective’ |
| c. | ʃalaha-t | ‘send 2fs. perfective’ |

In this case, an intrusive vowel fails to condition an allophonic variation in the way a normal vowel would.

In Saami there is optional degemination of a sonorant preceding an intrusive vowel, but not before other vowels. For example, [skuol:əfi:] ‘owl, nom. sg.’ can also be pronounced [skuoləfi:]. (This “degemination” may be simply a shortening of the gesture; I have seen no argument that a mora is actually deleted. If it does delete, this poses an opacity problem, since non-geminate sonorants do not normally cause vowel intrusion). In this case, an intrusive vowel conditions allophonic variation where a normal vowel would not.

In short, there is no single generalization about vowel intrusion and allophonic variation in neighboring consonants. Intrusive vowels may condition the same alternations that normal vowels do; they may condition alternations that normal vowels don’t; or they may fail to condition any alternations. The cause of each pattern must be sought in the particular pressures that lead to each type of allophony. For this reason, I do not consider the fact that Dutch intrusive vowels correlate with a pattern of [l] allophony to be evidence that the intrusive vowels are syllabic.

2.2.7. Summary

Dutch vowel intrusion is a variable, optional phenomenon, which speakers are often conscious of. Despite this awareness, they do not treat the vowel as syllabic or segmental, either in psycholinguistic experiments or in phonological patterning. Phonetically, vowel intrusion consists of an earlier production of the sonorant in a VRC sequence, while the duration of the whole sequence remains constant. This timing appears to make the word, and particularly the sonorant, more easily perceptible. This segmental retiming happens only within syllables.

2.3. Finnish

Finnish has vowel intrusion in heterorganic RC clusters. As in Dutch, intrusion depends on syllable boundaries, but with the opposite result: intrusion happens only between syllables, and not within them. There is evidence that speakers do not consider the intrusive vowels syllabic.

2.3.1. Conditioning environment

The following is a chart of intervocalic CC clusters in the Ostrobothnian dialect of Finnish, based on Harrikari 1999. The clusters that all sources agree not to have vowel intrusion are unshaded; the clusters agreed to have vowel intrusion are shaded. There is disagreement over whether there is intrusion after [r] (see Suomi 2000 vs. Harrikari 1999); rC clusters that may have intrusion are followed by a question mark.

(92) Ostrobothnian Finnish intervocalic clusters

| | p | t | k | v | s | r | l | m | n | ŋ | j | h |
|---|-----|----|-----|-----|----|----|----|--------|----|----|-----|-----|
| p | pp | | | | ps | pr | pl | | | | | |
| t | | tt | tk | tv | ts | tr | | | | | tj | |
| k | | | kk | | ks | kr | kl | | | | | |
| v | | | | | | | | | | | | |
| s | sp | st | sk | sv | ss | | sl | sm | | | | |
| r | rp? | rt | rk? | rv? | rs | rr | | rm? | rn | | rj? | rh? |
| l | lp | lt | lk | lv | ls | | ll | lm | | | lj | lh |
| m | mp | | | | | | | m m | | | | |
| n | | nt | | | ns | | | | nn | | | nh |
| ŋ | | | ŋk | | | | | | | ŋŋ | | |
| j | | | | | | | | | | | | |
| h | | ht | hk | hv | | hr | hl | hm | hn | | hj | |

Vowel intrusion happens only after stressed syllables (Harms 1976:75), which are normally initial. Examples of each cluster type that triggers vowel intrusion are given below.

| | | | |
|------|--|--------------------|----------------|
| (93) | Finnish CC clusters with vowel intrusion | Harrikari 1999:6-7 | |
| a. | hv | vah <u>ava</u> | ‘strong’ |
| b. | hj | lah <u>aja</u> | ‘gift’ |
| c. | hm | tuh <u>uma</u> | ‘naughty’ |
| d. | hn | tah <u>ana</u> | ‘spread’ |
| e. | hl | kah <u>alita</u> | ‘to chain’ |
| f. | hr | oh <u>ora</u> | ‘barley’ |
| g. | lk | hal <u>akaista</u> | ‘to split’ |
| h. | lv | kal <u>avo</u> | ‘transparency’ |
| i. | lj | kal <u>aja</u> | ‘beer’ |
| j. | lh | kulu <u>ho</u> | ‘bowl’ |
| k. | lm | kyly <u>mä</u> | ‘cold’ |
| l. | lp | hal <u>apa</u> | ‘cheap’ |
| m. | rp | turu <u>pa</u> | ‘muzzle’ |
| n. | rk | kor <u>okea</u> | ‘high’ |
| o. | rv | kar <u>avas</u> | ‘bitter’ |
| p. | rj | har <u>aja</u> | ‘brush’ |
| q. | rh | kere <u>ho</u> | ‘club’ |
| r. | rm | ker <u>ema</u> | ‘cream’ |
| s. | nh | van <u>aha</u> | ‘old’ |

This list of clusters shows several restrictions that are cross-linguistically common, as discussed in chapter 1. The intrusive vowels do not appear in obstruent-initial clusters, because vowels only overlap sonorants and [h]. No intrusive vowel appears in homorganic clusters, even if these are sonorant initial, such as [lt, ls, mp, ns, nt, ŋk, rn, rt, rs]. And, as is typical, the clusters with vowel intrusion are not those with especially marked sonority profiles: intervocalic [tk], [ps], [tv], and [ks] surface without the [ə], despite the fact that languages usually prefer sonority to fall across syllable boundaries (Venneman 1980).

2.3.2. Phonetic realization

Wiik 1965:142-3 reports that intrusive schwa is in free variation with zero, and has a duration that varies from 0 up to about 60 ms. Its formant positions are close to those of the nearest preceding vowel, but are more centralized. The centralization is a direct prediction of the gestural account, since it is the end of the vowel gesture that is being heard, and variability in length is also characteristic of intrusive vowels. The intrusive vowel is transcribed as a copy vowel by Harrikari 1999 and Wiik 1965 but as a [ə] by Harms 1976; this may reflect dialectal differences or differences in perception. Unlike Dutch, Finnish does not have a non-intrusive [ə].

Wiik 1965 mentions that the intrusive vowel sounds very much like an English unstressed vowel, and that Finnish learners of English in fact have difficulty distinguishing between words like *scalping* [skælpɪŋ] and *scalloping* [skæləpɪŋ] for this reason. Finns tend to perceive these words as sounding the same and produce both in a way that English speakers interpret as *scalloping*. Harms 1976:74 draws a similar comparison to English [ə] in describing Standard Finnish intrusive vowels:

[mɛləkein] (*melkein*) ‘almost’ has essentially the same vowel qualities ([ɛ, ə, ei]) and relative durations as the English verb *delegate*—[dɛləgeɪt]. From a descriptive phonetic point of view, the Finnish epenthetic schwa and the English reduced-vowel schwa represent very nearly identical classes of vowel sounds; i.e., they vary over a wide central area, with their range of variation conditioned by the preceding and following segments. But here the similarity ends. The schwa in the above Finnish forms is purely transitional in nature. Speakers perceive these forms as containing only two syllables, not three.

Harms’ observation supports the claim that the difference between intrusive vowels and segments is not primarily phonetic but phonological. There is no threshold of duration or audibility that determines whether a sound is segmental (and hence syllabic); speakers can learn to regard exactly the same phonetic signal as segmental or non-segmental depending on their native phonology.

2.3.3. Related phasing effects

Harms 1976 has already analyzed Finnish vowel intrusion as essentially a gestural phasing effect. “[l] is released and the transition to the following consonant is perceived as a short vocoid. Of course, this transition does not occur if a homorganic dental or alveolar consonant follows” (75). Harms explains vowel intrusion as a result of two factors: “the prosodic rules governing syllable stress and timing” and “the universal constraints on segment-to-segment transitions.” In Articulatory Phonology terms, these are instantiated as constraints on phasing combined with universal task dynamics.

Significantly, Harms notes that *all* sonorant or [h]-initial clusters have a distinctive phonetic realization when they follow the main stressed syllable. He attributes these distinctive realizations to a common goal of providing a clear separation between syllables.

Of special relevance for the epenthesis case... is the careful control of the syllable division, providing a clear separation between the final consonant of the first syllable and the initial consonant of the following syllable. This ‘control’ process occurs with all nongeminate sonorant plus consonant clusters, both homorganic (as in *valta* ‘power’, *parta* ‘beard’, *kansa* ‘folk’) and nonhomorganic (e.g., *valmis*, *kalja* ‘near beer’, *surma* ‘death’, *korko* ‘interest’). The same process is observed with clusters of [h] plus voiced consonant, as in *lähde* ‘spring’, *kahvi* ‘coffee’, *mahla* ‘sap’. In all these clusters, to a greater or lesser extent, the energy of the first syllable is ‘spent’ before the onset of the next syllable, and the result is often

a very short pulse of energy, vocoid-like in nature, at the end of the syllable. [r] clusters are basically no different from [l] clusters in this regard, although the available energy generally results in a stronger trill instead of a vocoid-like release. Even with [h] clusters under stress, a short voiceless or murmured vocoid can result; e.g., [kah₃vi]. (p. 77)

This observation suggests that all heterosyllabic RC clusters, including those without intrusive vowels, have a low-overlap phasing relation such as CENTER = ONSET. In heterorganic [l]-initial clusters, this alignment results in the percept of an intrusive vowel, but for other cluster types there are other phonetic effects: an extra-strong trill in [r]C clusters, a voiceless vowel in [h]C clusters, and a dip in energy in homorganic clusters.

The existence of these phenomena in other R.C clusters strongly supports the claim that what the grammar regulates is gestural phasing rather than the presence of intrusive vowels per se. Intrusive vowels are just one byproduct of a particular gestural phasing; the grammar does not recognize them as an entity. The gestural alignment that produces vowel intrusion in heterorganic some RC clusters can produce different effects in other cluster types.

If intrusive vowels were seen as epenthetic segments, there would be no reason to expect those RC clusters that were not broken by epenthesis to have any special realization.

2.3.4. Syllable boundary effects

While in Dutch, only tautosyllabic clusters have vowel intrusion, in Finnish only heterosyllabic ones do. Harrikari 1999 reports that an [rk] cluster is broken up, as in [korokea] ‘high’, while an [rkt] cluster is left intact, as in [arktinen] ‘arctic’.

The constraint types proposed above for Dutch can also explain the Finnish pattern. There is a family of constraints on the alignment of segments within syllables; in Finnish, one favoring a high degree of overlap is high ranked. Another family of constraints governs CC phasing without regard to syllable structure; in Finnish, a constraint favoring a low degree of overlap between segments is high ranked.

(94) ALIGN (R, CENTER; C, ONSET)

In a C₁ C₂ string, C₁ a sonorant, the center of C₁ is aligned with the onset of C₂.

(95) ALIGN (R, RELEASE; C, TARGET) IN σ

In a C₁ C₂ string, C₁ a sonorant, where C₁ and C₂ belong to the same syllable, the release of C₁ is aligned with the target of C₂.

As in Dutch, the syllable-internal phasing constraint is ranked above general CC alignment constraint, so CC clusters have different alignments depending on whether they are tautosyllabic. The constraints introduced for Dutch are also included in the following tableaux, as a reminder that the same constraints are present in every grammar, but they are low-ranked and have no effect.

(96) Vowel intrusion in Finnish heterosyllabic clusters

| /korkea/ | ALIGN (R, RELEASE, C, TARGET) IN σ | ALIGN (R, CENTER, C, ONSET) | ALIGN (R, RELEASE, C, TARGET) | ALIGN (R, CENTER, C, ONSET) IN σ |
|---|---|-----------------------------|-------------------------------|---|
| <p>a.</p> <p>(... r)σ(k ...)σ</p> <p>[koro<u>ke</u>a]</p> | | | * | |
| <p>b.</p> <p>(... r)σ(k ...)σ</p> <p>[kor<u>ke</u>a]</p> | | *! | | |

(97) No intrusion in Finnish tautosyllabic clusters

| /arktinen/ | ALIGN (R, RELEASE, C, TARGET) IN σ | ALIGN (R, CENTER, C, ONSET) | ALIGN (R, RELEASE, C, TARGET) | ALIGN (R, CENTER, C, ONSET) IN σ |
|---|---|-----------------------------|-------------------------------|---|
| <p>a.</p> <p>(... r k)σ</p> <p>[ar<u>akt</u>inen]</p> | *! | | * | |
| <p>b.</p> <p>(... r k)σ</p> <p>[ar<u>kt</u>inen]</p> | | * | | * |

Thus, both Dutch and Finnish show that gestural phasing within the syllable is distinct from the phasing between syllables. There is no universal pattern as to whether hetero- or tautosyllabic clusters will show more overlap, however.

2.3.5. Geminates

Standard Finnish does not have vowel intrusion before geminates (Harms 1976), but other dialects do. Harrikari 1999, quoting Karlsson 1983:109, reports vowel intrusion before geminates in [lk:, lp:, rk:, rp:] in Ostrobothnian.

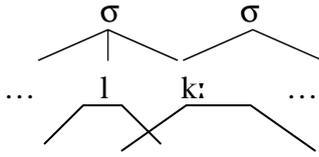
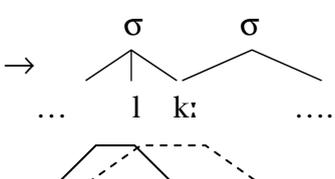
(98) Vowel intrusion in Finnish RC: Harrikari 1999:19

- a. palak:a 'salary'
- b. tylyp:ä 'blunt'
- c. kirik:o 'church'
- d. korop:i 'raven'

These two phasing patterns for geminates can be produced by different rankings of existing constraints.

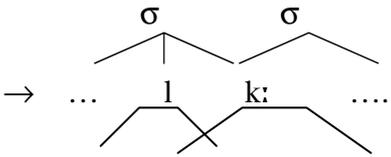
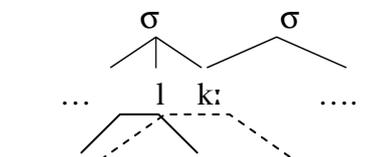
If we assume that geminates are ambisyllabic, then the ranking used above predicts no intrusion before them, since there is no intrusion within the syllable. The special constraint on geminate coordination proposed in chapter 1, ALIGN (C, CENTER, C:, ONSET), must be lower ranked.

(99) Standard Finnish: no intrusion before geminates

| /palk:a/ | ALIGN (R, RELEASE, C, TARGET) IN σ | ALIGN (R, CENTER, C, ONSET) | ALIGN (C, CENTER, C:, ONSET) |
|--|---|-----------------------------|------------------------------|
| a.  [palak:a] | *! | | |
| b.  [palk:a] | | * | * |

For those dialects that do have intrusion in RC: clusters, the special geminate phasing constraint must be higher ranked than ALIGN (R, RELEASE, C, TARGET) IN σ .

(100) Ostrobothnian Finnish: intrusion before geminates

| /palk:a/ | ALIGN (C, CENTER, C:, ONSET) | ALIGN (R, RELEASE, C, TARGET) IN σ | ALIGN (R, CENTER, C, ONSET) |
|--|------------------------------|---|-----------------------------|
| <p>a.</p>  <p>[palak:a]</p> | | * | |
| <p>b.</p>  <p>[palk:a]</p> | *! | | * |

2.3.6. Vowel intrusion as contrast enhancement

Why should one language prefer a timing pattern in which segments show less overlap within than between syllables, while another language has exactly the opposite preference? This may relate to the different inventories of segment and syllable types within each language, and the different types of contrasts that need to be perceptible.

As Harms 1976 points out, the low overlap between heterosyllabic consonants in Finnish makes the contrast between RC and RC: clusters clearer. In standard Finnish, which has no vowel intrusion in RC: clusters, the presence of the intrusive vowel is a cue for distinguishing minimal pairs like [arək̚i] ‘weekday’ and [ark̚i:] ‘sheet of paper’. In dialects that have intrusive vowels in both words, a low degree of CC overlap may still help distinguish the two words. Releasing the sonorant’s constriction before the achievement of constriction for the stop should make it easier to perceive the length of the stop’s closure. Geminates do not occur within syllables, so enhancing the geminate / singleton contrast does not require vowel intrusion in tautosyllabic clusters, and none occurs. Furthermore, this particular functional motivation could only exist in a language like Finnish which has geminates; it would be irrelevant to Dutch, which has none. The difference between the types of clusters possible in Dutch and Finnish may influence which constraints on gestural phasing they rank highly.

According to the analysis given here, Dutch and Finnish differ in their ranking of the general (not syllable-specific) constraints on CC alignment, with Dutch preferring a high degree of overlap and Finnish a low degree. It is tempting to relate this to the fact that Dutch has a lexical [ə], which is confusable with intrusive [ə], while Finnish does not.

It is known that epenthesis may target CCC clusters and not CC clusters: for example, one of the [e]-epenthesis processes in Mohawk does so (Michelson 1988). But why would epenthesis break up CC clusters, as in [korokea], while leaving CCC alone, as in [arktinen]?

Such a pattern goes against all established motives for epenthesis. Epenthesis is usually used to remove segments from positions where they are unlicensed, by the creation of a new syllable. We expect epenthesis to remove marked structures. For example, some languages do not allow branching codas and insert an epenthetic vowel to turn one of the coda segments into an onset. But such languages would epenthesize into RC.C, not R.C. Some languages don't allow segment with certain features in coda position; obviously such a language would not allow [rk] codas while removing [r] codas. Epenthesis could be motivated by syllable contact law (Venneman 1980), which states that sonority is preferred to fall across a syllable boundary. By this criterion, [r.k] is again less marked than [rk.t].

To my knowledge, no well-motivated constraint on syllable structure prefers [rk.t] to [r.k]. On the other hand, it is well accepted that gestural phasing depends on syllable structure, and that heterosyllabic segments may not show the same phasing as tautosyllabic segments. Treating the vowels in Finnish RC clusters as intrusive rather than epenthetic removes an otherwise thorny analytical problem.

2.3.9 Creeping segmentization?

Harms 1976 claims that while vowel intrusion in standard Finnish is “purely transitional”, in other dialects, the intrusive vowel has been reanalyzed as a segment.

He gives two pieces of evidence for this. The first is that the inserted vowels in these dialects have the durations and qualities of normal unstressed vowels, rather than the short, variable duration and weak quality of the intrusive vowels in standard Finnish. Typological evidence shows this to be a weak argument. There are other languages, such as Scots Gaelic, where intrusive vowels are quite long and have distinct qualities, yet act clearly non-syllabic both in their phonological patterning and in speaker intuitions.

The second argument, however, carries more weight: Harms reports that the intrusive vowel is treated as a syllable by the alternating secondary stress pattern in some dialects, as in ['kele₂kasta] ‘from the sled’. This is evidence that the intrusive vowel has come to be syllabic in these dialects- and hence, has ceased to be an intrusive vowel.

Reanalysis as a segment is an attested, but not universal, historical fate for intrusive vowels. It seems to have happened in Irish Gaelic, for example, but not Scots Gaelic. Such a reanalysis presumably happens when the auditory difference between intrusive and non-intrusive vowels becomes too slight for speakers to acquire the difference consistently, and perhaps when there are few phonological diagnostics for syllabicity.

Importantly, the onset of segmental behavior correlates with the loss of the other properties of the vowel intrusion syndrome described in chapter 1. In the Lapua dialect of Finnish, for example, the vowel no longer copies the vowel that is adjacent over the sonorant. Instead, it copies the following vowel in at least some words, like [kelakka] ‘sled’. (It is not clear from published sources whether the pattern of copying the

following vowel is general. Harms points out that for this word, the choice of vowel could be influenced by the fact that Finnish has many stems ending in [-akka] but none in [-ekka]). Once the intrusive vowel has been reanalyzed as an independent segment, it no longer shows the restrictions that once arose from its gestural nature.

2.4. Conclusion

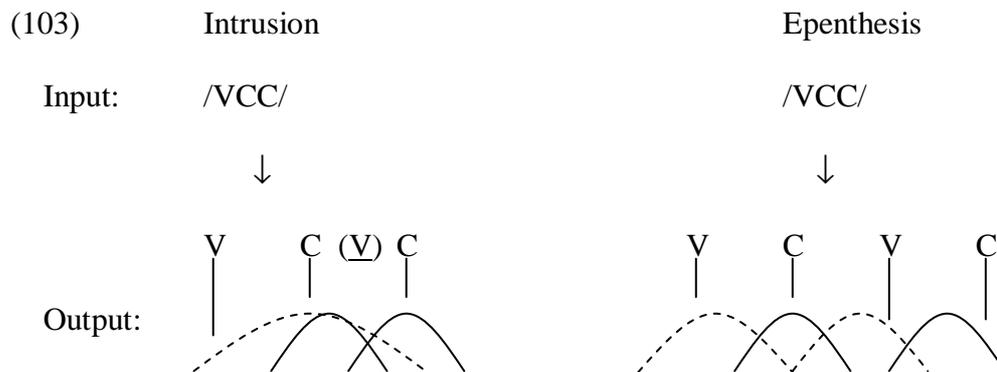
The typology of vowel intrusion bears out the claim that gestural phasing is syllable-dependent. Dutch and Finnish both phase heterosyllabic consonant clusters differently from tautosyllabic ones. However, the type of phasing chosen for each cluster type is not consistent across languages. Dutch has low overlap between consonants within the syllable but high overlap between heterosyllabic consonants, while Finnish has the opposite pattern.

It is suggested here that the choice of phasing arrangements may relate to the type of contrasts that need to be made perceptible in each language. In Finnish, the low degree of overlap at syllable boundaries helps distinguish geminates from singletons, a consideration not present in Dutch. In Dutch, a low-overlap phasing within syllables reduces the tendency of [l] (and probably [r] as well) to lose its alveolar constriction in complex codas.

In each language, there is evidence that intrusive vowels are not syllabic, despite their auditory similarity to syllabic sounds in the same or other languages. The non-syllabicity of intrusive vowels is related to the fact that they do not have the function of repairing syllable structure. The next chapter focuses on the difference between intrusive and epenthetic copy vowels, showing how syllabic behavior correlates with conditioning environment.

CHAPTER 3. INTRUSION VS. EPENTHESIS

In the previous chapters, I have argued for the existence of non-segmental “intrusive vowels”: copy vowels (or schwas) heard in RC or CR clusters, which are not independent segments but rather the edges of adjacent vowel gestures, heard during an interconsonantal release. This chapter concentrates on the distinction between vowel intrusion and copy vowel epenthesis. While an intrusive vowel is a vocalic interval that is not segmental or syllabic, an epenthetic vowel is segmental and syllabic, but not underlying. In the literature, both are often labeled ‘epenthesis’, but they have quite different representations, as evidenced by the differences in their conditioning environment and behavior. A VCV sequence with an intrusive vowel involves only one vowel segment and gesture, while copy vowel epenthesis involves insertion of both a segment and a gesture, as shown below.



Because copy vowel epenthesis does not require a vowel gesture to surround a consonant, it is not restricted by *C IN V constraints. I.e., copying does not happen more often over certain consonants than others.

I have found only one class of historically epenthetic vowels that show restrictions on the consonants they copy over: vowels epenthesized into loanwords. These vowels likely began as intrusive vowels, and still display one characteristic of vowel intrusion, a tendency to copy over sonorants. However, synchronically these vowels appear to have been reanalyzed as underlying.

3.1. Copy vowel epenthesis

True epenthetic copy vowels are fundamentally different from intrusive vowels. While intrusive vowels are a non-segmental percept, and have a ‘copied’ quality only because they are part of the gesture of another vowel, epenthetic vowels are segments, and I will argue that their copied quality does not result from gestural overlap.

As argued in chapter 1, a fixed hierarchy of *C IN V constraints restricts vowels from fully overlapping different types of consonants. Therefore, a restriction on intervening copy type can be considered a diagnostic of gestural vowel “copy”. Epenthetic copy vowels do not meet this diagnostic. This suggests that the copying

operates by an entirely different mechanism. I will adopt that proposed by Kitto & de Lacy 2001.

Briefly, Kitto & de Lacy propose that copied quality in epenthetic segments is enforced in the same way as the copying that occurs in reduplication, which McCarthy & Prince 1995 analyze with correspondence constraints. A correspondence relation can hold between an epenthetic segment and another output segment (the “base”), and the constraint BE-IDENT-F demands that the two segments have the same feature settings. The choice of which vowel to use as the base is determined by competition among other constraints.

- (104) BE-IDENT-F Kitto & de Lacy 2000:3
 An epenthetic segment E and its base have identical values for feature F.

In a purely gestural theory, this constraint can be reformulated to demand identity between the gestures of an epenthetic vowel and its base. Under this view, the copying that happens in epenthesis has nothing to do with gestural overlap: the two segments have identical but separate gestures. Epenthetic copy vowels are not predicted to show the restrictions ascribed to effects of gestural overlap, such as copying only over sonorants.

Lest it seem undesirable to have two separate mechanisms leading to copying (gestural overlap and segment-to-segment correspondence), it is important to recognize that correspondence between output segments, or some similar mechanism, is independently necessary to explain the non-local vowel copying that happens in reduplication and language games. In the English game *Urupu*, for example, every vowel is preceded by [rəp] and a copy of that vowel (Maira Yip, p.c.). In the examples below, spaces are inserted for ease of reading; they do not indicate pauses.

- (105) *Urupu* game
- | | | | | | |
|-------------|------|---|--------------|---|------------|
| <i>sigh</i> | saj | → | sa rəp 'aj | / | saj rəp aj |
| <i>pen</i> | pɛn | → | pɛ rəp 'ɛn | | |
| <i>sit</i> | sɪt | → | sɪ rəp 'ɪt | | |
| <i>soon</i> | sun | → | su rəp 'uwn | | |
| <i>seen</i> | sin | → | sɪ rəp 'ijɪn | | |
| <i>cute</i> | kjut | → | kjʊ rəp 'uwt | | |

In this kind of copying, the two vowels cannot possibly share a continuous gesture, since a different vowel gesture occurs in the intervening syllable [rəp]. Another indication of gestural independence is that the quality of a tense vowel is not copied perfectly; the unstressed copy is lax. The copy vowel can undergo regular contextual variation in quality because it has a separate gesture.

Similarly, in a language that reduplicates multiple syllables ([paku- pakutu]), the correspondence between, for example, the [a] in the reduplicant and the [a] in the base cannot be a result of a single gesture extending from one to the other, since there is an intervening [u]. Since a mechanism not involving gestural spreading is necessary to

analyze long distance copying, there is no reason that this mechanism should not be available for local copying as well.

3.2. Diagnostics of non-gestural copying

3.2.1. Welsh: true epenthesis

The representational difference between epenthetic and intrusive vowels predicts differences in behavior, under the theory proposed here. These differences will be demonstrated through the example of copy vowel epenthesis in Welsh (Awbery 1984). I believe that the highlighted characteristics of Welsh are common to most or all epenthetic copy vowels. Welsh epenthesizes copy vowels to break up marked coda clusters in inputs like /gwadn/, which surfaces as [gwa:dan]. Several characteristics of these vowels suggest that they do not involve gestural overlap, and are true segments.

First, I have argued that gestural overlap is governed by a universal hierarchy of *C IN V constraints, which prohibit vowels from fully surrounding certain classes of consonants. If gestural overlap is not involved in copy vowel epenthesis, there should be no restrictions on the type of consonants that can be copied over.

This holds true for Welsh, which inserts an epenthetic copy vowel into any underlying final cluster that consist of an obstruent followed by a sonorant, and also into certain sonorant-sonorant clusters. Any consonant may be copied over, including [d, v, χ, l, m] as in the examples below. Alternations are given to show the epenthetic nature of the copy vowel.

(106) Welsh copy vowel epenthesis

Awbery 1987:88-9

| | | | | |
|----|-------------|---|----------|--------------|
| a. | /gwadn/ | → | 'gwa:dan | 'sole' |
| | /gwadn + e/ | → | 'gwadne | 'soles' |
| b. | /kevn/ | → | 'ke:ven | 'back' |
| | /kevn + e/ | → | 'kɛvne | 'backs' |
| c. | /pudr/ | → | 'pu:dur | 'rotten' |
| | /pudr + i/ | → | 'pədri | 'to rot' |
| d. | /oχr/ | → | 'o:χor | 'side' |
| | /oχr + i/ | → | 'ɔχri | 'to side' |
| e. | /helm/ | → | 'he:lem | 'cornstack' |
| | /helm + i/ | → | 'hɛlmi | 'cornstacks' |
| f. | /aml/ | → | 'amal | 'often' |
| | /aml + aχ/ | → | 'amlax | 'more often' |

A second prediction is that, since the epenthetic vowel is a true segment and its presence involves unfaithfulness to the underlying segmental string, it should only appear when a markedness constraint forces its presence. Epenthesis should always remove a structure that shows the characteristics of markedness, such as being typologically rare, acquired late by children, and actively avoided through other means besides epenthesis. As shown in chapter 1, this is *not* true of intrusive vowels; they actually tend to occur in rather unmarked clusters.

In the case of Welsh, epenthesis clearly functions to satisfy independently motivated syllable structure constraints. It removes codas of rising sonority, which are cross-linguistically more marked than those of even or falling sonority. Less-marked codas, of falling sonority, are left alone as in the words below (note that several of these words would be prime candidates for vowel *intrusion*.)

(107) Welsh coda clusters

Awbery 1984:87

| | | |
|----|-------|----------|
| a. | pask | 'Easter' |
| b. | gwałt | 'hair' |
| c. | darn | 'piece' |
| d. | fərm | 'farm' |
| e. | pɪmp | 'five' |
| f. | bɔrd | 'table' |
| g. | balχ | 'proud' |

A restriction against CR codas is familiar from numerous languages, and they are actively avoided through other processes in Welsh. In words of two syllables, final CR clusters are repaired by deletion of one of the consonants:

| | | | |
|-------|--------------------------------------|---|----------------------|
| (108) | Welsh cluster resolution by deletion | | Awbery 1984:89 |
| a. | /fe:nestr/ | → | 'fe:nest 'window' |
| | /fe:nestr + i/ | → | fɛ'nɛstri 'windows' |
| b. | /anadl/ | → | 'anal 'breath' |
| | /anadl + i/ | → | a'nadli 'to breathe' |

Some dialects also sporadically metathesize final CR, or change [v]R clusters to [w]R (Awbery 1984:90). In short, epenthesis is part of a 'conspiracy' of processes that remove the same clusters. This is in striking contrast to vowel intrusion, which happens in clusters that are not particularly marked cross-linguistically, and are not in general avoided within the language (see, for example, the discussion of Dutch truncation in chapter 2).

A third prediction is that, for an epenthetic vowel to repair a marked structure, it must be phonologically "present": it is a new segment that creates a new syllable, and should act syllabic for other diagnostics. Luckily, Welsh provides one. According to Awbery 1984:69, a long vowel does not occur before a consonant cluster, presumably because it would be in a closed syllable. If the copy vowels that appear in /CVCR/ words were intrusive, then the segmental representation would still be C-V-C-R and the word would be monosyllabic. In that case, these words should be able to contain only short vowels. If, on the other hand, the CR cluster is phonologically broken up by the epenthetic vowel, then the preceding vowel can be long (in fact, before certain consonants it must be long).

As shown in (106), epenthesis into a CR cluster does allow the preceding vowel to be long.

| | | | |
|-------|--------------|---|------------------|
| (109) | Welsh CV:CVR | | |
| a. | /gwadn/ | → | 'gwa:dan 'sole' |
| b. | /kevn/ | → | 'ke:ven 'back' |
| c. | /pudr/ | → | 'pu:dur 'rotten' |
| d. | /oɣr/ | → | 'o:ɣor 'side' |

This is the pattern we expect to see if the epenthetic vowel is creating a new syllable: it causes the preceding vowel to behave as if it is in an open syllable.

It is useful to compare the vowel length pattern with the Dutch vowel intrusion discussed in chapter 2. Dutch has a restriction on the distribution of long vowels that is similar to that of Welsh. Long vowels, like [i], cannot occur before a coda cluster, making words like *[kimp] impossible. When Dutch has an intrusive vowel in a final cluster, the intrusive vowel does not allow the preceding vowel to be long. It does not

cause the vowel to act as if it were in an open syllable. Words like *[kiləm] are impossible for the same reason as *[kimp]: the [i] cannot precede a cluster.

In conditioning environment, purpose, and phonological behavior, epenthetic copy vowels are unlike intrusive copy vowels. These differences in behavior are predicted by the different representations proposed in (103).

3.2.2. Stress and epenthesis interaction

I have claimed that true epenthetic vowels are always syllabic. This generalization is superficially contradicted by certain cases of stress / epenthesis interaction; it must be made clear that these do not actually involve non-syllabic vowels.

Stress often appears to skip epenthetic vowels (Broselow 1982). For example, Selayarese normally has penultimate stress, but shifts stress to the antepenult if the final vowel is epenthetic.

| | | | |
|-------|-------------------|-----------------------|---------------|
| (110) | Selayarese stress | | Broselow 1999 |
| | normal: | sam ¹ pulo | ‘ten’ |
| | final epenthesis: | ¹ sahala | ‘profit’ |

This skipping does not, however, result from the vowels’ not being syllabic, or not being phonologically present. In most cases of skipping, the stress system actually does recognize the presence of the vowels, and will stress or foot them under specific circumstances.

In Selayarese, for example, epenthetic vowels are not skipped if this would cause stress to fall outside of the final three syllables. When epenthetic vowels appear both in the final and antepenultimate syllables, stress occurs on the penult as usual.

| | | | |
|-------|--|------------------------|------------------|
| (111) | Selayarese stress; multiple epenthesis | | Broselow 1999 |
| | a. | solo ¹ dere | ‘weld’ |
| | b. | tapa ¹ sere | ‘interpretation’ |
| | c. | kara ¹ tisi | ‘ticket’ |

This shows that stress actually does “see” the epenthetic vowels, and treats them as syllabic, but simply prefers to avoid them. There are several analyses of this fact available within OT: Alderete 1999 proposes a constraint, HEAD-DEP, that penalizes the stressing or footing of epenthetic elements; Hall 2001 proposes that the phonology prefers to maximize the presence of underlying material in prosodically prominent positions. There is not reason to assume that the epenthetic vowel is not phonologically present.

3.2.3. Typological predictions

In chapter 1, I identified a cluster of properties that constitute the vowel intrusion syndrome, including the following:

- (112)
1. A conditioning environment that involves a sonorant
 2. “Copying” of the vowel over the sonorant
 3. Appearance of “copied” vowels in otherwise unmarked clusters
 4. Failure of the “copied” vowel to behave like a syllabic nucleus

The theory of copy vowel epenthesis presented above predicts that there is also a correlation between the properties below, which are diagnostics of true epenthetic vowels.

- (113)
1. Vowel copying not constrained by intervening consonant type
 2. The copy vowel serves to change a marked structure
 3. The copy vowel behaves like a syllabic nucleus

The difference between these two types of behavior becomes even more striking when epenthetic and intrusive copy vowels occur within the same language. This happens in Kekchi and Mono, described in the following section.

3.3. Languages with both epenthetic and intrusive copy vowels

3.3.1. Kekchi

The Cobán dialect of Kekchi, a Mayan language of Guatemala, has both epenthetic and intrusive copy vowels. The two behave differently in a language game, showing that speakers do not represent them the same way. All data in this section come from Campbell 1974.

A copy vowel that I analyze as intrusive appears within final ?C clusters, as shown below.

(114) Kekchi vowel intrusion

- a. poʔot 'huipil (blouse)'
- b. xaʔax 'the inside of one's mouth'
- c. ʃqaʔal 'girl'
- d. kaqtuʔuj 'red ant'
- e. malkaʔan 'widow'
- f. paʔat 'twins'
- g. tʃʰaʔax 'difficult(y)'
- h. iʃiʔix '(finger)nail'
- i. tʃaʔal 'part'

The intransitive infinitive suffix [-k] triggers an alternation with the intrusive vowel. When this suffix attaches to a [ʔ]-final root, a copy vowel appears within the [ʔk] cluster.

(115) Kekchi intransitive infinitive

- a. kwa:r-k 'to sleep'
- b. tʃʰiʔ-k 'to get bored'
- c. kwaʔ-ak 'to eat' vs. kwaʔ-ok 'to eat (transitive)'
- d. seʔ-ek 'to laugh'
- e. kwuʔteʔ-ek 'to howl'

Example e) demonstrates that intrusive vowels occur only in final clusters: the medial [ʔt] cluster is not broken. This may indicate that vowel intrusion is limited to tautosyllabic clusters, as in Dutch, or perhaps to stressed syllables, since stress in Kekchi is final.

Besides intrusive vowels, Kekchi also has true epenthetic copy vowels, shown in bold below, whose conditioning environment is different. Campbell describes them as appearing before [b'] or [m] in polysyllabic verb forms. Most of Campbell's examples involve the suffixes **-[b']**, as in (a-e) below, or **-[b'a:nk]**, as in (f-i).¹²

¹² The article contains a few unexplained apparent exceptions to the rule, such as [molb'-ek] 'to lay eggs' and [kwaxb'-ak] 'to play (an instrument)'.

- (116) Kekchi vowel epenthesis
- | | | |
|----|--------------|------------------------|
| a. | ninkwiq'ib' | 'I bend it' |
| b. | nink'oxob' | 'I begin it' |
| c. | ninpetseb' | 'I sit on the ground' |
| d. | ninatʃ'ab' | 'I loosen it' |
| e. | ninhupub' | 'I turn it over' |
| f. | kwiq'ib'a:nk | 'to bend' |
| g. | k'oxob'a:nk | 'to begin' |
| h. | petseb'a:nk | 'to sit on the ground' |
| i. | atʃ'ab'a:nk | 'to loosen' |
| j. | lekemak | 'to spoon out' |

These vowels copy the quality of the vowel to the left, regardless of the identity of the intervening consonant. Copying can happen over obstruents like [p], [x], and [tʃ]. As argued in section 1, this is a diagnostic of non-gestural copying. Many of the clusters in which the vowels appear (such as final [q'b']) are clearly marked, another diagnostic of true epenthesis as opposed to intrusion.

Interestingly, these two types of copy vowels, intrusive and epenthetic, are treated differently in the language game Jerigonza. In the Kekchi version of this originally Spanish game, every vowel is followed by [p] and a copy vowel, as shown in (117). The inserted segments are italicized. Spaces are placed after each [pV] for visual clarity; these do not indicate pauses.

- (117) Kekchi Jerigonza game
 xerigonsa → xepe *ripi* *gopon* *sapa*

For words that contain true epenthetic copy vowels, there are two possible outputs in the game. Either [pV] can be inserted after the epenthetic vowel (as well as after the base vowel that it was copied from), or the epenthetic vowel can delete. Both possibilities are shown for each word below.

- (118) Kekchi Jerigonza game
- | | | | | |
|----|--------------|---------------|---|------------------------------------|
| a. | kwiq'ib'a:nk | 'to bend it' | → | <i>kwipi</i> <i>q'ipi</i> b'apa:nk |
| | | | | or <i>kwipiq'</i> b'apa:nk |
| b. | k'oxob'a:nk | 'to begin it' | → | <i>k'opo</i> <i>xopo</i> b'apa:nk |
| | | | | or <i>k'opox</i> b'apa:nk |

Campbell suggests that the optional omission of the epenthetic vowel indicates that the game can access the underlying representation, in which these vowels are absent. In any case, this special treatment of epenthetic vowels shows that speakers distinguish them from underlying vowels.

When Jerigonza applies to the intrusive copy vowels that break [ʔ]C clusters, there are also two possible outcomes. As with the epenthetic vowels above, it is possible to insert a [pV] after each vocalic period. This may mean that these VʔV sequences are starting to be reanalyzed as disyllabic. But it is also possible to insert a [pV] only into the intrusive portion of the vowel, while leaving the other portion alone. Both possible forms are shown for each word below.

(119) Kekchi jerigonza

- | | | | | | | |
|----|--------|-------------|---|----|-------|----------|
| a. | poʔot | ‘blouse’ | → | | popo | ʔopot |
| | | | | or | | poʔopot |
| b. | tʃaʔax | ‘difficult’ | → | | tʃapa | ʔapax |
| | | | | or | | tʃaʔapax |
| c. | paʔat | ‘twins’ | → | | papa | ʔapat |
| | | | | or | | paʔapat |

The option of skipping the preceding vowel is not present with real epenthetic copy vowels.

As Campbell 1974:277 points out, “The very fact that jerigonza can skip over the first vowel demonstrates that the complex vocalic nucleus (V₁ʔV₁) is perceived in some sense as a single unit; otherwise, there would be no explanation for why one of the vowels is exempted.” In the gestural theory, we can formalize this by saying that such sequences are monosyllabic and the two vowels are one segment. The ‘original’ and ‘copy’ vowels are equally underlying. The reason that the intrusive portion is broken by the game might be that it is phonetically longer than the non-intrusive portion, as in Scots Gaelic. Campbell’s own explanation implies this: “The stress in Kekchi is always on the final vowel, which makes it difficult to ignore in jerigonza.”

Incidentally, V_iʔV_i sequences where the second vowel is non-intrusive must have a [pV] inserted after each vowel. There is no option of skipping the first vowel in a word like [tʃaʔ-aq], where the two vowels are part of two morphemes, as shown below.

- (120) /tʃaʔ + aq/ → [tʃaʔaq] ‘to say (future)’
- Jerigonza form: tʃapa ʔapaq
*tʃa ʔapaq

So the exceptional behavior of vowel intrusion sequences cannot be the result of some special rule in the game for treating V_iʔV_i sequences in general.

Kekchi Jerigonza shows that copy vowels are not all alike. Even within one language, intrusive and epenthetic vowels pattern differently in a game that taps speaker intuitions about syllabicity. The typological predictions of (65) and (113) are upheld: the copy vowels that appear only next to a guttural, and copy over that guttural, act non-

syllabic; while the copy vowels that can copy over anything act syllabic. This correlation between the conditioning environment and prosodic behavior of copy vowels is a core prediction of the gestural theory of vowel intrusion.

3.3.2. Mono

Mono, a Niger-Congo language of Congo, also has two classes of copy vowels (Olson 2003, 2000). As in Kekchi, the vowels that copy over only sonorants behave as non-syllabic, while the vowels that copy over any consonant behave as syllabic.¹³

All words in Mono must be disyllabic. If a root is monosyllabic, a vowel is added to the beginning of it. This vowel copies the quality and tone of the root vowel, regardless of the identity of the intervening consonant.

| | | | | | | |
|-------|----|-------|---|------|----------|------------|
| (121) | a. | /ɔ̄i/ | → | īɔ̄i | ‘tooth’ | Olson 2003 |
| | b. | /ɗi/ | | ɗi | ‘horn’ | |
| | c. | /ngú/ | | úngú | ‘water’ | |
| | d. | /bè/ | | èbè | ‘liver’ | |
| | e. | /rə/ | | ərə | ‘thing’ | |
| | f. | /gò/ | | ògò | ‘hunger’ | |
| | g. | /mà/ | | àmà | ‘mouth’ | |
| | h. | /lò/ | | òlò | ‘sun’ | |
| | i. | /geà/ | | àgeà | ‘animal’ | |
| | j. | /koà/ | | àkoà | ‘work’ | |

These copy vowels clearly show all the properties of true epenthetic copy vowels, as given in (113): they copy over any consonant, including obstruents like [d] and [g]. They appear for the purpose of bringing the word up to a bimoraic minimum, a well-known markedness constraint. To serve this purpose, they obviously must add a syllable to the word. Evidence that the vowels are epenthetic comes from the fact that they disappear in compounds, and are absent when the same roots occurs in verbal forms, which are more than one syllable due to affixes.

Mono also has copy vowels that occur in CR clusters.

| | | | | | | |
|-------|----|-------------|---|------------|------------|------------|
| (122) | a. | /gàfrū/ | → | gàfūrū | ‘mortar’ | Olson 2003 |
| | b. | /plézū/ | | pélézū | ‘bat’ | |
| | c. | /jābrù/ | | jābūrù | ‘goat’ | |
| | d. | /dóklongbā/ | | dókólóngbā | ‘scorpion’ | |

These copy vowels show the properties of intrusive copy vowels. They copy only over a sonorant, and they are optionally absent in casual speech. Most importantly, they do

¹³ Thanks to Markus Hiller for bringing this example to my attention.

appear to add a syllable to the word. This can be seen by the fact that vowel intrusion is not sufficient to bring a word up the disyllabic minimum: even if a root like /ʃrí/ ‘shadow’ is pronounced with an intrusive copy vowel, an epenthetic copy vowel must also be added.

| | | | | | | |
|-------|----|--------|---|--------|--------------|------------|
| (123) | a. | /ʃrí/ | → | íʃrí | ‘shadow’ | Olson 2003 |
| | b. | /ʔrī/ | | īʔrī | ‘name’ | |
| | c. | /kplú/ | | úkpúlú | ‘heap’ | |
| | d. | /gré/ | | égré | ‘big, large’ | |
| | e. | /bró/ | | óbáró | ‘quarrel’ | |
| | f. | /prō/ | | ōpōrō | ‘egg’ | |
| | g. | /gbrà/ | | àgbàrà | ‘bridge’ | |
| | h. | /krō/ | | ōkōrō | ‘skull’ | |

As Olson 2003 points out, these two types of copy vowels create an opacity problem if we consider the vowel breaking up CR clusters to be syllabic. Within OT, it is difficult to explain why the prothetic copy vowel is added to a word that would be disyllabic without it. But under the present approach, the two processes have a non-opaque interaction. Vowel intrusion into a CRV root does not make the root disyllabic, so it is fully expected that the initial epenthesis will occur as well.

The importance of these patterns in Mono is that they, like Kekchi, show that the correlation between conditioning environment and syllabic behavior holds even of two types of copy vowels within the same language. The type of vowel copy that occurs over only sonorants does not appear to create a new syllable, while the type of vowel copy that occurs over any consonant does create a new syllable.

3.4. Vowel intrusion as precursor to epenthesis in loanwords

There is one situation in which gestural overlap does appear to play a role in determining epenthetic vowel quality. I have not found cases of true epenthesis, such as that in Welsh, where a clearly syllabic copy vowel copies only over certain consonants, the basic diagnostic I have proposed for gestural overlap. However, such restrictions are quite common in epenthesis into loanwords. For example, Mawu epenthesizes a (syllabic) copy vowel to break up C[r] clusters in loans, but inserts a default epenthetic vowel into other CC clusters. Japanese inserts a copy vowel to remove [h] codas but a default vowel to remove all other codas. Epenthetic vowels in Cook Islands Maori take a copied quality most consistently over [r], less consistently over [n], and rarely over [t]. In short, each of these languages shows vowel copy over exactly those consonants that I have argued to be most amenable to being overlapped by a vowel gesture.

A number of characteristics of these cases, however, suggest that these vowels do not synchronically involve gestural overlap, and are not even synchronically considered epenthetic, but have been reanalyzed as underlying. I propose that gestural overlap does not play a role in their current representation, but rather, was a characteristic of an earlier

stage of representation. Specifically, gestural overlap probably plays a role in the stage of “inter-language” used by bilingual speakers, when loanwords have not yet been fully assimilated. The cases of Cook Islands Maori, Mawu, and Japanese are discussed in turn below.

3.4.1. Cook Islands Maori

Cook Islands Maori (CIM) has copy vowel epenthesis in loanwords which shows restrictions on the identity of the consonants and vowels involved, a property that is a hallmark of gestural overlap. The pattern is statistical and unpredictable, however, suggesting that it is a relic of a path of historical development that involved gesture-sharing at some point, rather than a synchronic case of gestural overlap.

In Cook Islands Maori, vowel epenthesis is used to repair loanwords that contain final consonants, which are not permitted in the language. Several examples are given below, with epenthetic vowels in bold. Most epenthetic vowels are either copies of the preceding vowel, as in a)-d), or a default [i], as in e)-g).

(124) CIM loanword epenthesis

Kitto 1997:110-111

- | | | |
|----|---------|----------|
| a. | pe:re | ‘bail’ |
| b. | ʔa:para | ‘apple’ |
| c. | vu:ru | ‘wool’ |
| d. | ri:pene | ‘ribbon’ |
| e. | mere:ni | ‘melon’ |
| f. | kati | ‘gut’ |
| g. | ti:keti | ‘ticket’ |

Kitto 1997 provides statistics, given below, on the quality of the epenthetic vowel in various environment. The numbers indicate percentages of the epenthetic vowels in a particular environment that take the quality in that column. The predominant pattern for each environment is highlighted. There is total avoidance of [i] after [r], which Kitto & de Lacy 2000 attribute to a constraint *[ri]. Leaving this aside, the numbers shows a competition between a copied quality and a default [i] quality for each vowel.

(125) CIM epenthetic vowel quality, by percentage

Kitto 1997:57

| Epenthetic vowel → | i | e | a |
|--------------------|-------------|-----------|------------|
| Environment | | | |
| ↓ | | | |
| it_ | 100% | | |
| in_ | 71 | 7 | 22 |
| ir_ | | 33 | 66 |
| et_ | 84 | 16 | |
| en_ | 55 | 45 | |
| er_ | | 82 | 18 |
| at_ | 85 | | 15 |
| an_ | 82 | 9 | 9 |
| ar_ | | | 100 |

[r] shows the strongest tendency to condition copy vowels: [a] is copied over [r] in all cases, and [e] in 82% of cases. There is some copying of vowels over [n], but it is less consistent and depends on the identity of the vowel. [e] is copied over [n] in 45% of cases, but [a] rarely. After [t], a default [i] is the predominant choice, although a copy vowel is still chosen about 15% of the time ([ete] and [ata]). The following scale describes the likelihood of a consonant being copied over:

(126) Cs least > most transparent to V copy (Cook Islands Maori)

t > n > r

This is exactly the scale proposed in chapter 1 for the *C IN V constraints: vowels overlap well with [r], less well with [n], and still less with [t].

(127) *OBSTRUENT IN V >> *NASAL IN V; *GLIDE IN V >> *[l] IN V >> *[r] IN V >> *GUTTURAL IN V

The tendency for articulatorily similar V / C pairs, like [n] and [e], to overlap better than more dissimilar pairs like [n] and [a] is also known from vowel intrusion. In Negev Bedouin Arabic, gutturals are overlapped only by [a], which involves a similar tongue body position. In short, CIM chooses the copying option for epenthetic vowels in exactly the environments where gestural overlap would be least marked. This could be taken as evidence that CIM epenthetic copy vowels get their quality via gesture-sharing.

However, a problem with analyzing copy vowel epenthesis as gestural overlap is its unpredictable nature. In nearly every environment, some epenthetic vowels are copies and some are not. A few epenthetic vowels are neither the default [i] nor a copy, but take a third quality. Such optionality is not characteristic of vowel intrusion, which is highly regular and predictable. If the quality of epenthetic vowels were governed by constraints on gestural alignment, these constraints should decide consistently between candidates.

I suggest that gestural overlap has played a role in the epenthetic vowels' development, but does not currently figure in their representations. The following scenario is one way that this could happen: suppose that as these words were borrowed, they were not assimilated to the native phonology immediately. Instead, there was an intermediate stage or "inter-language" where bilingual speakers pronounced the foreign words without a final vowel, but perhaps with a final acoustic release. As monolingual CIM speakers adopted the words, they interpreted the final release as a vowel, since their phonology required a vowel in that position, and they pronounced the vowel with the quality closest to the quality they heard in the release.

The quality they heard in the final consonant's release was influenced by the degree of overlap between that consonant and preceding vowel. Since overlap with [r] is least marked, vowels overlapped [r] more than [n], and [n] more than [t].

(128)



Because the preceding vowel gesture was active at the end of [r], the quality of [r]'s release was strongly influenced by that vowel. The vowel had less effect on [n]'s release, since the vowel overlapped [n] only partially, and even less effect on [t]. As listeners went about the somewhat variable process of interpreting releases as full vowels, they created copy vowels more after codas whose releases had a "copied" quality. The epenthetic vowels themselves may have always been independent gestures, and in fact their unpredictable quality requires that they now be represented underlyingly.

Under this account, the role of *C IN V constraints in determining epenthetic vowel quality is indirect. *C IN V constraints affect the sound patterns of the source language or the intermediate stage when words have not been assimilated. Speakers' perception of these patterns guides them in assigning qualities to the vowels they epenthesize to make the words more native-like. But the copy vowels, once added, do not involve gestural overlap to a greater degree than any other V₁CV₁ sequences in the language. Thus, the *C IN V constraints of the speakers' own grammars do not make any direct contribution to the pattern.

If the role of gestural overlap in determining epenthetic vowel quality is indeed limited to its effect on perception, it is predicted that only epenthesis into loanwords should be influenced by the *C IN V hierarchy. Epenthesis that involves synchronic alternations within the grammar, like that of Welsh, is not based on perceptual accidents, but actively shaped by constraints. This prediction appears to be true. While there are numerous languages where copy vowel epenthesis in loanwords is affected by intervening consonant type, I do not know of any cases where copy vowel epenthesis within native words, evidenced by synchronic alternations or other diagnostics, is subject to similar restrictions. I conclude therefore that epenthetic vowels participate in gesture-sharing only to the extent that other vowels in the language do. The similarities between intrusive copy vowels and epenthetic copy vowels in loanwords are an artifact of their historical connection.

3.4.2. Mawu

Mawu, a Manding language of Côte d'Ivoire (Moussa 1996, Kenstowicz 2001) provides additional evidence that gestural overlap affects the process of borrowing, but does not figure in the final representation. Like, CIM Mawu has a pattern of epenthesis into loanwords that shows restrictions characteristic of gestural overlap- but it is clear that the restrictions must have applied either in the source language or inter-language rather than in Mawu itself.

In adapting French loanwords, Mawu breaks up French C[ɣ] clusters with an epenthetic copy vowel, but C[l] clusters with a default high vowel. The significance of the copy vs. non-copy epenthesis conditions is that they conform to the *C IN V hierarchy developed in chapter 1, based on vowel intrusion:

- (129) *OBSTRUENT IN V >> *NASAL IN V; *GLIDE IN V >> *[r] IN V >> *[l] IN V >> *[ɣ] IN V, *[ɣ] IN V >> *GUTTURAL IN V

The Mawu pattern of copying over a rhotic but not a lateral is reminiscent of vowel intrusion in Sanskrit and Spanish.

But the striking twist is that French [l] and [ɣ] are both realized as [l] in Mawu.

- (130) *brosse* bɔ̀lɔ̀sí *bloque* búlókí
France fàlàzì *plan* pílá

If *C IN V constraints indeed are the reason for the different choices of epenthetic vowel quality before [l] and [ɣ], the arena of their influence cannot possibly be located within the *Mawu* grammar: there is no distinction between [l] and [ɣ] for the constraints to refer to. It is more likely that the loanwords reflect the Mawu speakers' sensitivity to a greater overlap of vowels with [ɣ] in *French*, or perhaps in the inter-language used by bilingual speakers. The French encountered by Mawu speakers may have a slight intrusive vowel in C[ɣ] clusters, which Mawu monolinguals expand to a full vowel. There is less quality to the release (if any) in C[l] clusters, so here speakers insert a default vowel. But the unpredictability of the historically epenthetic vowel's quality indicates that it must now be represented underlyingly, and not shaped purely by markedness constraints in the way that a synchronically epenthetic vowel is.

3.4.3. Japanese

Japanese also shows restrictions on copy vowel epenthesis in loanwords that conform to the *C IN V hierarchy. Japanese epenthesizes vowels into loanwords to remove non-nasal coda consonants, which are not permitted in the language. Generally, the epenthetic vowel is [u], or [o] after [t, d] to avoid affrication.

- (131)
- | | | |
|----|-------------------|-------------|
| a. | bazu | ‘buzz’ |
| b. | supuraito | ‘Sprite’ |
| c. | kurisumasu | ‘Christmas’ |

However, a copy vowel is epenthesized after the guttural [h]. Most occurrences of these sounds in loanwords are adaptations of German or Dutch [x]. (I do not show [h]’s allophones [ϕ] and [ç] below.)

- (132)
- | | | | |
|----|---------------------|-------------------|---------------|
| a. | bahha | ‘Bach’ | Kawahara 2003 |
| b. | mahha | ‘Mach number’ | |
| c. | zahhatorute | ‘Zach torte’ | |
| d. | ruubahha | ‘Rubach’ | |
| e. | ʃuumahha | ‘Schumacher’ | |
| f. | gohho | ‘Gogh’ | |
| g. | dohho | ‘doch (yes)’ | |
| h. | kohho | name | |
| i. | ihhi | ‘ich (I)’ | |
| j. | dihhi | ‘dich (you acc.)’ | |
| k. | tʃuurihhi | ‘Zurich’ | |
| l. | buuhu | ‘buch (book)’ | |
| m. | raatoburuhhu | ‘Radbruch’ | |

The sole consonant that Japanese copies over in loanwords is [h], which belongs to the class of sounds that is cross-linguistically most amenable to vowel intrusion. For Japanese, I do not know of any evidence as to whether the epenthetic vowel shares a gesture with the preceding vowel or not. I include this example, however, because it is another case of epenthetic copy vowels that appear in environments that respect the *C IN V hierarchy, making the cut between default and copy vowels at a different point in the hierarchy than Cook Islands Maori or Mawu.

3.5. Conclusion

It is common in the literature for percepts based on gestural overlap- intrusive vowels, intrusive consonants, etc.- to be referred to as epenthetic. But true epenthetic segments do not behave like intrusive sounds. An epenthetic segment is not part of the underlying representation of the word, and so its quality and location are fully predictable, but it is represented as a segment in the output. An intrusive vowel is not a phonological entity either in the lexical representation or the output representation. The two types should be carefully distinguished. A list of diagnostics is developed here, and is

shown to differentiate the two copy vowel classes even within single languages, such as Kekchi and Mono.

Furthermore, epenthetic copy vowels do not seem to involve gestural overlap.

The cases where segmental copy vowels do show restrictions characteristic of gestural overlap constraints are cases of loanword adaptation. Constraints on C / V overlap help shape the quality of these epenthetic vowels during the process of borrowing. These words do not appear to synchronically involve two vowels sharing a gesture, and the vowels are in many cases not even synchronically represented as epenthetic. The gestural theory of vowel intrusion can make a contribution to the study of loanword adaptation, however, as vowel intrusion is likely a very common phenomenon in inter-languages, and an influence on the course of nativization.

CHAPTER 4. SCOTS GAELIC

4.1. Introduction

The case studies in chapters 1 and 2 demonstrate that gestural phasing depends on two factors: the segments involved and the syllable structure. Heterorganic consonant clusters are more likely to have an acoustic release, and sonorants overlap better with vowels than other consonants do. Also, heterosyllabic clusters are often phased differently than tautosyllabic clusters.

Scots Gaelic and Hocank, discussed in this and the following chapter, show that gestural phasing is affected by a third factor: constituent structure within the syllable. A sonorant adjacent to a vowel can be placed in one of two structural positions, which differ in the “closeness” of the vowel and the sonorant, and this affects the phasing of the sonorant with respect to the vowel and other consonants. In the closer position, the vowel and the sonorant are adjoined into a single unit that I call α , which is essentially equivalent to the traditional idea of the syllable nucleus.

Two segments dominated by α are treated by certain alignment constraints as if they were in the same position. In effect, the two gestures compete to occupy the same stretch in time, and this causes them to be centered on the same timepoint. The sonorant gesture is roughly in the middle of the vowel gesture, resulting in an intrusive vowel that is unusually long. I call this “symmetrical vowel intrusion”.

4.1.1. Background: dialects, transcription conventions

This section provides some background facts for the more detailed presentations of data that follow. Scots Gaelic has vowel intrusion, traditionally known as svarabhakti or epenthesis, in many but not all heterorganic RC clusters. A full chart of clusters with and without vowel intrusion is given in the appendix. The clusters that trigger vowel intrusion occur only after initial syllables, which are always stressed. The preceding vowel must be short for intrusion to occur. Vowel intrusion can also occur before hiatus or word boundaries, as discussed in section 3.1.

| | | | | |
|-------|---------------|---|----------------------|-------------------------|
| (133) | Barra dialect | | | Borgstrøm 1940:153, 212 |
| a. | /ʃaLk/ | → | ʃaLak | ‘hunting’ |
| b. | /kɛN’p/ | → | k ^h ɛN’ɛp | ‘hemp’ |

The intrusive vowel is a copy of the preceding vowel, except when it coarticulates with a secondary articulation on the sonorant, as in [tʁr’ev] “bulls” (see section 6). The intrusive vowel has about the same duration as the preceding vowel portion, and the overall VRV sequence is apparently longer than a short syllable. Intrusive vowel groups have a different pitch pattern than disyllables, making them recognizable even in words where they don’t alternate. Intrusive vowels are not written in traditional orthography¹⁴.

This chapter concerns mostly the ‘archaic’ dialects of the Outer Hebrides, particularly those spoken on the islands of Barra and Lewis (which includes the villages

¹⁴ Borgstrøm 1940:15 mentions one exception, *anaceartes* [anak’æstəs] ‘bad treatment’.

Bernera and Leurbost). Dialects of Scots Gaelic can be different enough to cause problems with mutual intelligibility, according to Ternes 1973:2 (quoting Dorian 1965:18). The conclusions reached here do not necessarily hold for other dialects. The data come mostly from Borgstrøm 1937, 1940, Oftedal 1956, and occasionally Holmer 1938, abbreviated as B37, B40, O, and H.

I use the traditional notation for Scots Gaelic's complex sonorant inventory, in which capitalization indicates tenseness and an apostrophe, palatality. Both are phonological rather than strictly phonetic classifications: they describe how the consonants interact in patterns of mutation. The phonetic realization of these contrasts differs from dialect to dialect.

The main sources, Borgstrøm 1937, 1940, and Oftedal 1956, all use slightly different systems of transcription. To standardize them, and to eliminate possible confusion, I have made the following changes: the high back unrounded vowel is [ɯ] rather than Borgstrøm's backward lambda, the mid back unrounded vowel is [ɤ] rather than [ø], aspiration is [ʰ] rather than a reversed apostrophe, the sound that Borgstrøm writes as [b] in 1937 and [b] in 1940 is simply [b] (likewise other voiced consonants). An apostrophe indicates palatalization.

4.2. Evidence for monosyllabicity

In a case like Scots Gaelic where the intrusive vowel is phonetically long, having the same duration as an ordinary stressed vowel, the claim that the intrusive vowel group (CVRVC) is monosyllabic can seem more surprising than it does in a language where the intrusive vowel is short and clearly transitional. However, there is evidence from speaker intuitions and phonology that Scots Gaelic intrusive vowel groups are indeed monosyllabic. Most of these arguments have been pointed out by Smith 1999, and by Bosch (n.d.), who proposes the first gestural analysis for Scots Gaelic.

4.2.1. Speaker intuitions

The early fieldworkers Borgstrøm, Holmer and Oftedal all suggest that CVRVC sequences with intrusive vowels are in some sense monosyllabic rather than disyllabic. They note that intrusive vowel sequences sound unlike normal disyllables and that speakers consciously differentiate the two. These linguists tend to be inconsistent, however, in their use of the term *syllable*. They sometimes refer to the first syllable and second syllable of an intrusive vowel sequence in the same discussion where they claim that the sequence is monosyllabic. This is because they distinguish between 'phonetic syllables', apparently meaning sonority peaks that the fieldworker hears as syllabic, and 'phonemic syllables', meaning the syllables recognized by native speakers and by the phonology. I use *syllable* only in the sense of 'phonemic syllable'. It is not impossible that phonetic syllables have some phonological status as well— for example, my impression is that people may use them in rhyming— but they are not units that ordinary phonological rules refer to.

Borgstrøm reports that speakers pause at a different place in intrusive vowel sequences than in normal disyllables. He marks intrusive vowel sequences with square brackets.

In conclusion I give some remarks by Mr. Neil Sinclair, of Barra, regarding the two types *aran* and *m[ara]v*. Comparing the two words *fæ̃Nak* “a crow” (feannag, type *aran*) and *f_laLa_jk* “hunting” (sealg, type *m_lara_jv*) he said: In *fæ̃Nak* there is a “space” between the two syllables, so that he could pronounce *fæ̃N – ak*. In *f_laLa_jk* the *L* and the following *k* are so “close together” that such a separation is impossible; the word is “nearly monosyllabic, but not quite monosyllabic”. (B40:153)

The consultant’s own explanation for why he can’t pause in [*f_laLa_jk*] is not right in a purely phonetic sense. Bosch & de Jong 1997 show that consonants flanking an intrusive vowel are *not* physically closer together than those flanking a non-intrusive vowel. But speakers generally find it easier to pause between syllables than within a syllable, so the speaker’s difficulty with the task supports the idea that [*f_laLa_jk*] is monosyllabic. His intuition that the [L] and [k] are ‘close together’ probably reflects their structural closeness as tautosyllabic segments. Incidentally, this passage is sometimes quoted as support for the idea (which originates with Borgstrøm) that intrusive vowel sequences are a type of disyllable with a special syllable cut: the theory is that a normal CVCVC sequence is syllabified CVC.VC, but a sequence with an intrusive vowel is syllabified CV.RVC. However, Borgstrøm does not say that the speaker preferred to pause before the sonorant; he does not give any indication that the speaker could pause anywhere in the sequence.

Although the consultant Mr. Sinclair balked at calling an intrusive vowel sequence a monosyllable, he treated it as one when asked to count syllables¹⁵:

He declared that the word *f_læra_j-ætær* ‘towel’ (*f_læra_jtær*) contained three syllables, which he wrote down in the following manner: *seara-ad-air*, in phonetic spelling *f_læra_j-æt-ær*; he said that the first “syllable” *seara-* is long and stressed. The ordinary spelling of the word is *searhadair* or *searadair*. Miss Annie Johnston, unacquainted with Mr. Sinclair’s views, also divided the word into the same three syllables. From this it is evident that for native speakers the type *m_lara_jv* is equivalent to a monosyllable. (B40:153)

The speakers’ comments, with their slight inconsistencies, are reminiscent of the debates that can be sparked among English speakers over the question of whether *fire* is one or two syllables. Ternes 1973:101 mentions another Barra speaker who describes intrusive vowel sequences as “lighter” than disyllables.

¹⁵ [*f_læra_j.æt.ær*] exhibits two peculiarities of Scots Gaelic intrusive vowels: they can appear without a synchronic trigger (in this case, there is no consonant after the sonorant), and the intrusive vowel is not always identical with the preceding vowel. Both characteristics are discussed at length in following sections.

Similarly, for the Leurbost dialect Oftedal claims that “in *aràm* and *faLa`* there is one stress distributed on a monosyllabic group of vowel plus consonant plus vowel” (O27). Grave accents are his diacritic for intrusive vowels. He adds,

To the possible objection that interpreting *aràm*, *faLa`*, etc. as monosyllables means departing too far from the phonetic facts, it may be remarked:

- (1) that the only consonants which can appear between the two vowels of a svarabhakti group are the most sonorous consonants of the system (l-sounds, r-sounds, and nasals), and that the auditory impression (received by both Borgstrøm and myself) that *aràm* and *faLa`* are phonetically disyllabic may be due to unconscious comparison with similar sound sequences in other languages.
- (2) That svarabhakti groups are recognized as monosyllabic by educated native speakers. This may be partly due to the spelling, where the second vowel of a svarabhakti group is left out (*orm*, *falbh*); but it is significant that in songs, even local *òrain* that have never been written down, a svarabhakti group is sung on one note.” (p. 29)

Borgstrøm 1937:77 corroborates: “In songs the type *ma-rav* is sung on one note, as if monosyllabic.” (The dash is another diacritic for intrusive vowel sequences).

It is interesting that Oftedal draws a distinction between ‘auditory’, ‘phonetic’ syllables and the type of syllables that are recognized by native speakers and the phonological system. He acknowledges that the syllable is a mental organization of sounds, which cannot be read directly from an acoustic record, and that a linguist’s own language background can bias him to hear the syllable structure of another language incorrectly.

Poetry also treats intrusive vowel groups as monosyllabic. O’Rahilly 1932:201 observes that “in Scottish stress-verse...the epenthetic vowel is not recognized, and the vowel preceding the consonant group rimes either with a similar vowel followed by a similar group (much as in scholastic verse) or, less commonly, with a simple long vowel. Both usages are illustrated in the verse of Duncan Macrae, who, for example, rimes *folbh* at one time with *borb* (monosyllabic), at another time with *ól*.” Apparently, CVRVC does not rhyme with disyllables.

Many linguists who have first-hand acquaintance with Scots Gaelic agree with Borgstrøm and Oftedal’s observations. Holmer 1938:32 says of intrusive vowel sequences in the Skye dialect: “The first vowel generally carries the stress, but the ‘svarabhakti’ vowel is itself nearly as audible. Both vowels make only one syllable, and the duration of them together (including the consonant between them) is that of an ordinary syllable (consisting of a vowel and consonant of standard length).” Greene 1952:217 comments that “whereas in Irish this epenthetic vowel produces merely a new disyllable, in Scottish Gaelic it is felt rather to lengthen the syllable.” Bosch (n.d.:2), who has done fieldwork on the Barra dialect, suggests that “the syllable formed by the epenthetic vowel is properly understood to be an extension of the original syllable, as opposed to a second, new syllable position, thus pointing to the need for a gradient rather than discrete understanding of the syllable as constituent.” Ladefoged et al. 1998:2, in their phonetic study of the Leurbost dialect, also report that intrusive vowel sequences

“might be considered phonologically monosyllabic and certainly are so in the opinions of speakers.”

This conclusion is not universal, however. Ternes 1973:99 regards intrusive vowel groups in the Applecross dialect as disyllabic, although he acknowledges that “there is a phonetic difference of some kind” between original disyllables and intrusive vowel groups. The Applecross dialect is distant from the Outer Hebrides dialects and could very well have diverged from them, but Ternes appears to reject the monosyllabicity analysis for other dialects as well. Clements 1986 follows Borgstrøm’s suggestion that intrusive vowel sequences are disyllables with V.CV syllabification, as opposed to the default VC.V. Bosch & de Jong 1997 propose that intrusive vowel sequences are disyllables with second syllable stress; Green 1997:159 follows them.

Some theories essentially treat the sequences as both monosyllabic and disyllabic, by expanding the notion of the syllable. Bosch & de Jong 1998 argue for a structure consisting of two syllables dominated by a unit called a ‘supersyllable’. Smith 1999 presents a related theory in which the intrusive vowel heads a ‘recursive syllable’ which can form the coda of another syllable (see chapter 2).

I argue that Borgstrøm, Oftedal, and Holmer were right to classify intrusive vowel sequences as monosyllables. Phonologically, they behave as monosyllables, just as the sequences with short intrusive vowels discussed in the previous chapters do. Furthermore, there is no need for recursive syllables, gradient syllables, or supersyllables. A CVRVC syllable is not structurally unusual except in that V and R are adjoined. Its segments have a special timing relation, but the syllable itself is simply a CVRC syllable, composed of four segments, and behaves as such. There is no syllable-like entity within the syllable. Although the intrusive vowel creates the auditory impression of a RVC sequence within the syllable, this sequence does not phonologically have any syllable-like behavior or functions.

4.2.2. Duration and pitch

Phonetic evidence concurs with speakers’ impressions that intrusive vowel groups are monosyllabic. The syllable is a phonological entity which cannot be directly read from an acoustic record, but it is possible to compare intrusive vowel groups to clear-cut examples of monosyllables and disyllables to see which they resemble.

Intrusive vowel groups have a pitch pattern similar to that of long monosyllables and unlike that of disyllables. Ladefoged et al. 1998 compare the citation forms of intrusive vowel sequences, disyllables, and diphthongs in Lewis, and Bosch & de Jong 1997 present similar data from natural speech in Barra. Instrumental studies confirm fieldworker’s observations that the difference in pitch between an intrusive vowel word like [paLak] and a disyllable like [paLak] is like the difference between monosyllabic [tuan] and disyllabic [tu.an]. The diphthong and intrusive vowel word have purely rising intonation, while pitch in the disyllables rises, then falls. (Placement of the syllable cut below follows Borgstrøm 1940).

| | | | |
|-------|--------|---------|----------------------|
| (134) | | | Intonation |
| | paLak | ‘belly’ | Rising |
| | paL.ak | ‘skull’ | Rising, then falling |
| | tuan | ‘song’ | Rising |
| | tu.an | ‘hook’ | Rising, then falling |

Under the monosyllabicity hypothesis, the pattern is that pitch rises during the first syllable and falls during the second. Since [tuan] and [paLak] are both monosyllables, they both have rising intonation. These pitch patterns are what allow speakers to recognize intrusive vowels in cases where there are no alternations; Bosch (n.d.:9) reports that speakers are quick to point out an incorrect pitch pattern.

Intrusive vowel groups also have different durational patterns than disyllables, according to Bosch & de Jong’s 1997 study of Barra. In a normal CV₁CV₂C disyllable, V₁ is longer than V₂, presumably because Scots Gaelic has initial stress. In a CV₁RV₂C sequence where V₂ is intrusive, V₂ tends to be the same length or even longer than V₁. This suggests that the vowel and sonorant gestures are centered roughly on the same point. An intrusive V₂ is longer than a non-intrusive V₂, and V₁ is shorter if it precedes an intrusive vowel than if it precedes a non-intrusive vowel.

None of the instrumental studies compare the overall durations of intrusive vowel words and disyllables, but Borgstrøm 1937:77 states that words with intrusive vowels sound shorter than disyllables.

4.2.3. Positional licensing

Scots Gaelic phonology contains several patterns that count syllables or are sensitive to syllable structure, and these provide diagnostics for whether CVRVC is one syllable or two. For positional licensing, glottal stop epenthesis, mutations, and syncope, CVRVC patterns with monosyllables, lending additional support to the conclusions reached from speaker intuitions and phonetics.

Many languages, including Scots Gaelic, license a greater range of contrasts among segments in stressed or initial syllables than unstressed or non-initial syllables (Beckman 1998 and references therein). If intrusive vowels are part of the initial, stressed syllable in Scots Gaelic, we expect them to license the full inventory of vowel qualities, and they do, as noted by Bosch (n.d.:11).

In stressed syllables, Scots Gaelic allows nine short vowels.

(135) Stressed short vowels, Leurbost dialect (O43)

| | | | |
|--|-------|--------|---------|
| | Front | | Back |
| | | -Round | + Round |
| | i | ɯ | u |
| | e | ə | o |
| | ɛ | a | ɔ |

In unstressed syllables, the distinctions are far fewer. Oftedal states that the inventory of unstressed vowels is five, and that even these are in largely complementary distribution (147). Smith 1999 argues that there may be only a two-way contrast in unstressed syllables. However, intrusive vowels are not confined to this narrow inventory. All vowels except [o] are found in vowel intrusion groups; as Oftedal notes, the absence of [o] may be accidental.

To take one example, [ɯ] is not normally found in unstressed syllables. The only reported cases are [tʊɯɯɣ] ‘drought’ and [tʊɯɯs] ‘journey, time’, but Oftedal ascribes these to optional vowel harmony, since the words can also be pronounced [tʊɯəɣ] and [tʊɯəs] (O147). Yet intrusive [ɯ] is common, and does not have an alternate [ə] pronunciation.

- (136) a. tʊɯɯɯnəɣ (Nūāɣ) ‘(New) Testament’ O143
 b. sʊɯðɯj ‘to court, woo’ O143
 c. ɯɯɯxər ‘a shot’ O142
 d. ɯɯɯbəl ‘tail’ O142

The presence of a stable [ɯ] quality makes these intrusive vowels unlike typical unstressed vowels.

This pattern can be captured with constraints proposed by Beckman 1998. Markedness constraints of the type *SEG, banning segment types, interact with constraints that specify positions of the word where faithfulness is stronger.

- (137) *SEG
 Segment S is not permitted.

- (138) MAX-Position-SEGMENT (adapted from Beckman 1998 :131)
 A segment S in a prominent position in the input has a correspondent in the output.

The ranking MAX-STRESSED SYLLABLE-[ɯ] >> *[ɯ] >> MAX restricts [ɯ] to initial position. This will eliminate all underlying [ɯ]s in non-initial syllables, for example by changing them to [ə] (I know of no alternations to show what repair the language actually prefers), while preserving underlying [ɯ] in initial syllables.

(139)

| /CɯCɯ/ | MAX-STRESSED SYLLABLE-ɯ | *ɯ | MAX |
|-------------|-------------------------|-----|-----|
| a. 'Cɯ.Cɯ | | **! | |
| b. → 'Cɯ.Cə | | * | * |
| c. 'Cə.Cə | *! | | ** |

If intrusive vowels belong to the second, unstressed syllable, they should meet the same fate, but if they are not separate syllables, their ability to contain any vowel is explained. Intrusive [ʊ] is part of the stressed, initial syllable, so MAX-STRESSED SYLLABLE-[ʊ] preserves it.

(140)

| /suðɔ̃ɣ'/ | MAX-STRESSED SYLLABLE-ʊ | *ʊ | MAX |
|------------------------|-------------------------|----|-----|
| a. → 'suð <u>ʊ</u> ɣ'. | | * | |
| b. 'səð <u>ə</u> ɣ'. | *! | | * |

The monosyllabicity hypothesis thus correctly predicts the distribution of vowel qualities.

4.2.4. Glottal stop epenthesis

One dialect group has an epenthesis process that adds a coda to stressed open syllables. This epenthesis does not happen in CVRVC, supporting the theory that the whole sequence is one (closed) syllable.

In the Argyllshire dialects, short stressed open syllables (which are normally initial) are followed by an epenthetic glottal stop, unless the following consonant is an obstruent. The epenthetic [ʔ] is found before l/r/n sounds, vowels, and word boundaries.

(141) ʔ epenthesis after open stressed syllable, before l/r/n/ or vowel

- a. 'paʔlax 'boy' H36,37
- b. 'k^haʔraxəɣ 'move, stir'
- c. 'ʃiʔnjə 'older'
- d. 'ljeʔuar 'half hour'
- e. 'pɛʔin 'beasts'
- f. 'koʔur 'goat'

ʔ epenthesis in open monosyllables

- g. 't^hjeʔ 'hot'
- h. 'mɛʔ 'good'
- i. 'uʔ 'egg'

The epenthetic [ʔ] does not appear if the following onset segment is an obstruent, as in [ljɛxrun] 'half crown'. I assume that this is blocked by a phonotactic constraint against such consonant clusters.

[ʔ]-epenthesis appears to have the function of making the stressed syllable heavy. For this reason, it does not happen after a long vowel or a diphthong, since a syllable containing one of these is heavy already.

- (142) No ʔ epenthesis after a long vowel or diphthong
- | | | | |
|----|------------------------|-----------------|-----|
| a. | 't ^h i: | 'tea' | H28 |
| b. | 'ha: | 'there is, yes' | H27 |
| c. | 'sɔ̃:riçt(j)ə | 'special' | H29 |
| d. | 'mɛ:ri | name | H41 |
| e. | 'tjɛ:nəɣ | 'doing' | |
| f. | 't ^h rai | 'beach' | H52 |
| g. | 'k ^h uinjiç | 'remember' | H55 |

I analyze [ʔ] epenthesis as resulting from the constraint STRESS TO WEIGHT outranking the anti-epenthesis constraint DEP.

- (143) STRESS TO WEIGHT Kager 1999
 A stressed syllable is heavy.

Words with intrusive vowels do not have an epenthesized [ʔ] after their first vowel. The Argyllshire dialect has a shorter intrusive vowel than the other dialects mentioned in this chapter. Holmer usually transcribes it as [ə] or [i].

- (144) No ʔ epenthesis within an intrusive vowel sequence
- | | | | |
|----|-----------|---------------|-----|
| a. | 'menəv | 'fine, small' | H37 |
| b. | 'marəv | 'dead' | H37 |
| c. | 'fələv | 'go' | H37 |
| d. | 'tjaləvən | 'pictures' | H33 |

As Smith 1999:588-9 points out, this is evidence that the initial CV of an intrusive vowel sequence is not an open syllable, and supports the claim that the entire CVRVC is one syllable. [ʔ] epenthesis in this dialect is another way in which an intrusive vowel sequence patterns with CVRC words rather than CVRVC words.

4.2.5. Mutations

Intrusive vowel sequences also pattern with monosyllables in the system of 'mutations'. Scots Gaelic realizes many inflections by changing segments in certain positions within the word. For example, some nouns form their plural by palatalizing their final consonant.

(145) Palatalization mutation, Bernera dialect

| | <u>singular</u> | <u>plural</u> | | |
|----|-----------------|---------------|---------|-----------|
| a. | baLəx | baLiç | ‘boy’ | |
| b. | fið’əNəx | fið’əNiç | ‘man’ | |
| c. | iəRəN | iəRiN’ | ‘iron’ | |
| d. | səLəs | səLiʃ | ‘light’ | |
| e. | æx | eç | ‘horse’ | B40:87-88 |

The vowel that precedes the palatalized consonant often changes its quality as well. Below are three examples of [a] mutating into different vowels before palatalized consonants. The vocalic part of the mutation is unpredictable and must be lexically specified.

(146) Palatalization, Bernera dialect

| | <u>singular</u> | <u>plural</u> | | |
|----|---------------------------------|--------------------|-----------|--------|
| a. | k ^h a t ^h | ke ^h t’ | ‘cat’ | |
| b. | ma ^h k | mi ^h k’ | ‘son’ | |
| c. | aLt | ul’t’ | ‘knuckle’ | B40:87 |

Labials, retroflexes and [h] can’t be palatalized in Scots Gaelic. When a word ends in one of these, the preceding vowel may mutate even though the consonant doesn’t change.

(147) Palatalization, Bernera dialect

| | <u>singular</u> | <u>plural</u> | | |
|----|-----------------|---------------|----------|--------|
| a. | Rā:v | Rē:v | ‘oar’ | |
| b. | k l’iəv | k l’e:v | ‘basket’ | |
| c. | t ə:b | t ε:b | ‘bay’ | B40:87 |

The reason that palatalization is a test for syllable structure is that it normally affects only rhymes. Onsets don’t palatalize, although they may be affected by other mutations, as in a) below. Furthermore, most mutations take place only in monosyllables. The main mutations that take place in unstressed syllables are ə → i (such as -əx → -iç, -əγ ~ -i) and -ak → -æk’ (B40:85). If a word like [tarav] ‘bull’ is monosyllabic, it is predicted to be eligible to undergo mutation, and furthermore, the entire rhyme ([arav]) should mutate. The vowels should both change together if they are one segment.

This is in fact the case. When a word with an intrusive vowel undergoes mutation, both the sonorant and the final consonant mutate, and the vowels both change together as well.

(148) Mutations with intrusive vowels, Bernera dialect

B40:87

| | <u>singular</u> | <u>plural</u> | |
|----|-----------------------------|------------------------------|----------------|
| a. | t ^h ar <u>av</u> | t ^h æð'æ <u>v</u> | 'bull' |
| b. | baL <u>ag</u> | bul'ug' | 'bellow' |
| c. | dər <u>ɔ</u> y | duð'uj | 'fishing line' |
| d. | skar <u>av</u> | skʏð'ɣ <u>v</u> | 'cormorant' |

Words with intrusive vowels thus pattern with monosyllables in the mutation paradigms. The entire VRVC sequence behaves as if it belongs to the final rhyme of the word, which is the normal location for mutations.

This argument for monosyllabicity is the weakest of those given here. As noted above, mutations involve unpredictable vowel changes: for example, [t^harav] and [skarav] have the same rhyme yet take different vowels in the plural. This unpredictability means that at least some aspects of the mutated form must be lexically listed. It is possible that the whole pattern is a complex system of allomorphy, involving multiple lexically specified phonological forms for each word. The palatalized forms of intrusive vowels could be seen under this view as a historical artifact, left over from the time before the vowel intrusion occurred, rather than an indication that they synchronically have monosyllabic status. Moreover, a similar mutation pattern is found in Irish Gaelic with CVRəC words, where the [ə]s historically were intrusive, but now are certainly separate, syllabic segments.

Nevertheless, when added to the other phonological patterns here, the mutation paradigm provides another reason for speakers to classify vowel intrusion sequences pattern with monosyllables.

4.2.6. Syncope

The final phonological argument that intrusive vowel groups are monosyllabic concerns syncope. Vowel-initial inflectional suffixes trigger syncope when they attach to a disyllabic stem, provided that the syncope would not bring together two obstruents.

(149) Syncope, Leurbost dialect

| | | | | | |
|----|--------------|---|---------|---------------------|------|
| a. | fɪəkɪL' + ən | → | fɪəkLən | 'teeth' | O194 |
| b. | obəð + əx | → | obrəx | 'work (gen.sg.)' | O189 |
| c. | taxəR + i | → | taxri | 'happen (ind. fut)' | O239 |
| d. | darəs + ən | → | daRsən | 'door (pl.)' | O194 |

Syncope and vowel intrusion show an interesting interaction. If the consonants flanking the syncopated vowel are a pair that triggers vowel intrusion, for example [r] and [g], then an intrusive vowel appears in the same place that the underlying vowel deletes from. In a derivational framework, the pattern would be analyzed with ordered rules of Syncope and Vowel Intrusion.

(150) Syncope

$V \rightarrow 0 / C_1 _ C_2]_{\text{stem}} [V \dots]_{\text{inflectional suffix}}$

where the stem has 2 syllables, and at least one of C_1 and C_2 is non-obstruent.

Vowel intrusion

$V_i RC \rightarrow V_i R V_i C$ (for certain RC clusters)

Syncope feeds Vowel Intrusion, so that one vowel is deleted and another inserted in the same location.

(151)

Syncope

Vowel intrusion

- a. /taRig' + i/ → /taRg'i/ → taRag'i 'pull (ind. fut.)' O239
- b. /taRæg + ən/ → /taRgən/ → taRag'ən 'nail (pl.)'
- c. /baLəx + u/ → /baLxu/ → vaLaxu 'boy (voc. pl.)'
- d. /k'āNix' + əs → /k'āNx'əs/ → x'āNax'əs 'buy (rel.)'
- e. /kaL'əx + ən/ → /kaL'xən/ → kaL'axən 'wife (pl.)' O194

Under the view that intrusive vowel sequences are disyllabic, this phenomenon is problematic for Optimality Theory. It cannot be analyzed using only markedness and faithfulness constraints, as Smith 1999 and Bosch 1993 point out¹⁶. To demonstrate why not, let us assume that syncope is triggered by the constraint LAPSE.

(152) LAPSE

A sequence of two unstressed syllables is prohibited.

LAPSE, or any similar constraint, cannot interact with MAX and DEP in any way that will produce deletion and insertion in the same place, as shown in the tableau below. The intrusive vowel candidate (c) is harmonically bounded by the faithful candidate (a), because (a) has a subset of (c)'s violation marks. No ranking can cause (c) to win.

(153)

| /taRig' + /i/ | LAPSE | CONSTRAINTS CAUSING VOWEL INTRUSION | DEP | MAX |
|-------------------------------|-------|---|-----|-----|
| a. 'taR.ig'.i | * | | | |
| b. 'taR.g'i | | * | | |
| c. 'ta.Rag'.i (actual winner) | * | | * | * |

¹⁶ An alternative, not explored here, is that the system could also be simply irregular and memorized. There are instances of the phenomenon discussed here, vowel intrusion combined with syncope, that happen in cases where there is no synchronic trigger for the vowel intrusion: [māLə] 'eyebrow' pluralizes to [māLǣ.ən], with vowel intrusion, although no consonant cluster would be formed otherwise. Oftedal gives other examples where unpredictable changes such as metathesis or depalatalization accompany the syncope (194).

Such a mapping, with gratuitous deletion and insertion, is a challenge to the OT premise that phonological patterns can be explained purely through markedness constraints on outputs and faithfulness constraints on input – output mappings.

Under the view that intrusive vowel sequences are monosyllabic, this problem disappears, because the nature of the phenomenon is quite different. What happens is not simultaneous deletion and insertion, but deletion accompanied by vowel intrusion. The intrusive vowel candidate (d) wins under the ranking shown below, because it does not violate LAPSE.

(154)

| /taRig' + /i/ | LAPSE | CONSTRAINTS CAUSING VOWEL INTRUSION | DEP | MAX |
|-----------------|-------|---|-----|-----|
| a. 'taR.ig'.i | *! | | | |
| b. 'taR.g'i | | *! | | * |
| c. 'taR.ag'.i | *! | | * | |
| d. → 'ta.Rag'.i | | | | * |

Thus, the monosyllabicity hypothesis makes the phenomenon analyzable in Optimality Theory, and captures the insight that intrusive vowel sequences are patterning with monosyllables rather than disyllables for syncope.

This problem illustrates how gestural representations can deal with part of the problem of opacity, which is generally one of the most difficult patterns for non-serial frameworks like Optimality Theory to handle. In many of the textbook cases of opacity, the rule that counter-feeds or counter-bleeds previous rules has the hallmarks of a gestural phenomenon: for example, it applies optionally, or only at certain speech rates. Treating intrusive vowel sequences as monosyllabic eliminates quite a broad swath of apparent cases of opacity; it is possible that extending gestural representations will eliminate others.

4.3. Evidence for subsyllabic structure

Scots Gaelic intrusive vowels are similar to those of Dutch, Finnish, etc. in that they are non-syllabic. As Bosch (n.d.) has proposed, these sequences appear to involve gestural overlap: a vowel gesture fully overlaps a sonorant and is heard in two parts. Yet in other ways, Scots Gaelic intrusive vowels stand apart from all others discussed so far. I argue that vowel intrusion happens in Scots Gaelic for a different reason than in other languages.

Scots Gaelic intrusive vowels are phonetically longer than would be expected under the account presented in previous chapters. I have proposed that vowel intrusion in other languages results from two pressures: the pressure to keep a space between consonants in a cluster, preserving their perceptibility, and the pressure to have a vowel gesture fully span its syllable (including the period of release within the consonant

cluster). This spacing usually results in only a brief vocalic period. But in Scots Gaelic, the sonorant gesture appears to be more or less in the middle of the vowel gesture: an extremely wide spacing of the consonant cluster. Furthermore, vowel intrusion occurs in a peculiar set of circumstances: it only happens with a monomoraic vowel, and it can be lexically specified to happen or not happen, unlike the cases described in previous chapters.

Over the next two sections, I develop the theory that symmetrical vowel intrusion is a gestural organization triggered by a special type of subsyllabic structure, in which a vowel and sonorant are adjoined into a structure I will refer to as α . To be a member of α , a segment must be moraic. This section shows that positing α can account for how vowel intrusion is lexically specified, and for why intrusion interacts with vowel length. In section 4 I argue that α is similar to the traditional notion of a nucleus and that intrusive vowel sequences are structurally similar to diphthongs, or coalesced vowel sequences.

4.3.1. Lexical specification

Unlike all languages discussed up till now, Scots Gaelic has synchronically unpredictable vowel intrusion. At an earlier stage of the language's history, vowel intrusion apparently happened only and always in certain consonant clusters. Since then, diachronic changes have altered many of the original clusters, either by changing or deleting consonants. The intrusive vowels remained as the clusters underwent these changes, and now appear in contexts where they would not synchronically be triggered.

For example, vowel intrusion happens in the [aLp] sequence in a) below, but not in the same environment in b) or c).

| | | |
|-------|---|-------------------|
| (155) | Unpredictable vowel intrusion, Leurbost dialect | O140 |
| a. | kaLap(ə) | 'calf of the leg' |
| b. | sgaLpaj | island name |
| c. | sg'aLpiç | 'dandruff' |

The historical chain of events that led to this situation are as follows. Originally, vowel intrusion happened in [Lb] clusters but not [Lp] clusters. [kaLap] (*colbthae*) once contained a [b], which later devoiced to [p] due to the influence of a following [h] (B40:213). When the [b] devoiced, the intrusive vowel remained even though it now precedes a consonant that would not synchronically trigger vowel intrusion. In [Lp] clusters that do not derive from historic [Lb], no vowel intrusion occurs.

Intrusive vowels do not even have to occur in consonant clusters. In many words, one of the original triggering consonants has disappeared historically, and yet the intrusive vowel remains, now preceding a hiatus or a word boundary. The orthography reflects the original cluster. In some of the examples below, the intrusive vowel appears to have an imperfectly copied quality due to coarticulation with the sonorant (see section 4).

(156) Intrusive vowels before hiatus or word boundaries

Lewis dialects

| | | | | |
|----|------------------|------------------|-----------------|--------|
| a. | fa <u>L</u> a | <i>falbh</i> | ‘go away!’ (sg) | O140 |
| b. | fa <u>L</u> a-u | | ‘go away!’ (pl) | |
| c. | mãLã.ən | <i>mailghean</i> | ‘eyebrows’ | O143 |
| d. | mar <u>a</u> .əγ | <i>marbhadh</i> | ‘to kill’ | |
| e. | u <u>n</u> u.əs | <i>Oéngus</i> | name | B40:35 |

Barra dialect

| | | | | |
|----|---------------------------------|--------------------|------------------|---------|
| f. | ʃæ <u>r</u> a.ətær’ | <i>searbhadair</i> | ‘towel’ | B40:153 |
| g. | mar <u>a</u> .i | <i>marbhaidh</i> | ‘will kill’ | B40:212 |
| h. | sær’æ.əs | <i>soirbheas</i> | ‘fair wind’ | |
| i. | su <u>r</u> ’i.ð | <i>suirge</i> | ‘wooing’ | |
| j. | ar <u>a</u> .ur | * <i>arbor</i> | ‘corn’ | |
| k. | gεN’ε.ðx | <i>gainmheach</i> | ‘sand’ | |
| l. | εN’ε.i | <i>aithnichidh</i> | ‘will recognize’ | B37:140 |
| m. | t ^h a <u>L</u> a.ənð | | ‘of the earth’ | B37:78 |
| n. | f <u>r</u> ’i-i | <i>fuirchidh</i> | ‘will stay’ | B40:211 |
| o. | du <u>r</u> ’i | <i>duirgh</i> | ‘fishing lines’ | |

It is reasonable to wonder whether in words like [faLa], the intrusive vowel has simply been reanalyzed as an ordinary, segmental vowel. There is evidence that it has not. Words like [kaLa] and [faLa] have the special pitch pattern that is associated only with intrusive vowels; they pattern as monosyllables in the phonology in the ways described in section 2 (for example, note that [unu.əs] has a non-initial [u] sound) and Borgstrøm reports that his consultants intuitively treat such sequences as monosyllabic. The passage quoted early on syllable judgments actually involved one of these unpredictable intrusive vowels:

He declared that the word *ʃɪæraɪ-ətær* ‘towel’ (*ʃɪæraɪtær*) contained three syllables, which he wrote down in the following manner: seara-ad-air, in phonetic spelling *ʃɪæraɪ-ət-ær*; he said that the first “syllable” seara- is long and stressed. Miss Annie Johnston, unacquainted with Mr. Sinclair’s views, also divided the word into the same three syllables. (B153)

Sequences like [ʃæra] also show a type of sonorant-vowel coarticulation, attributable to gestural overlap, which happens only with vowel intrusion, as discussed in section 6. All evidence points to the conclusion that these sequences are monosyllabic and involve gestural overlap. In some way, it must be possible to lexically specify whether the overlap happens or not.

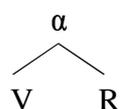
(157) Conjecture #1

Symmetrical vowel intrusion can be (directly or indirectly) lexically specified.

How should vowel intrusion be lexically specified? One possibility is that the phasing of two segments is lexically specified, and faithfulness constraints preserve this underlying phasing. However, I have argued in chapter 1 that faithfulness to phasing is an undesirable extension to the theory. It allows too many unattested types of contrasts. As a rule, vowel intrusion and other effects of inter-segmental phasing, such as release, are fully predictable. In dozens of languages, vowel intrusion is fully conditioned by phonological structure: it is always possible to predict whether intrusion is possible in a given cluster in a given word. Rather than throw away this generalization for one language, it is better to consider whether Scots Gaelic vowel intrusion could be conditioned by some “hidden” structure, more subtle than segmental ordering or syllable affiliation.

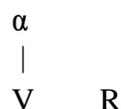
I propose that symmetrical vowel intrusion is conditioned by a type of structural adjunction between the vowel and sonorant. This adjunction structure can be lexically specified, and is preserved by faithfulness constraints. Segments which are adjoined are subject to special phasing constraints that do not apply to ordinary VR sequences. The unit produced by adjunction will be called α . In ordinary syllables, α dominates only vowels. Placing a sonorant under α in a sense incorporates it into the vowel.

(158) Vowel intrusion



Heard as [VRV]

No vowel intrusion



Heard as [VR]

Symmetrical phasing is the preferred realization [VR] $_{\alpha}$ in Scots Gaelic, for reasons discussed in section 4.

The phasing of V and R is not subject to faithfulness constraints, but the presence of α is. Thus, vowel intrusion is not directly lexically specified, but a structure producing vowel intrusion is lexically specified. This theory allows us to keep the generalization that inter-segmental phasing is not contrastive. The unit α will also help explain another characteristic unique to Scots Gaelic: that vowel intrusion cannot follow long vowels or diphthongs.

4.3.2. Interaction of vowel intrusion and vowel length

The second way in which intrusive vowels in Scots Gaelic are unusual is that they appear only in syllables with (underlyingly) short vowels. Clusters like [rf], [rx], [mr], and [rb] normally have vowel intrusion, but appear without it when preceded by a long vowel or diphthong, as shown below. In each group, the final example shows vowel intrusion being blocked.

(159) Vowel intrusion blocked after long Vs, diphthongs, Leurbost dialect

| | | | | |
|----|----|------------------------------------|------------------|------|
| rf | a. | bar <u>a</u> fas | village name | O140 |
| | b. | mī <u>ǝ</u> rfal' | 'miracle' | |
| rx | c. | m <u>ə</u> r <u>ə</u> x <u>ə</u> y | Murdoch (name) | O140 |
| | d. | d <u>ə</u> r <u>ə</u> x | 'dark' | O142 |
| | e. | u <u>r</u> u <u>x</u> ər | 'a shot' | |
| | f. | mo:rxuʃ | 'proud, haughty' | O140 |
| mr | g. | im <u>i</u> r <u>ə</u> y | 'to mention' | O143 |
| | h. | e:mr <u>i</u> ç | 'lowing of cow' | O52 |
| rb | i. | kar <u>a</u> b <u>a</u> d | 'wagon' | O142 |
| | j. | u <u>r</u> u <u>b</u> əL | 'tail' | |
| | k. | L'u:rb <u>ə</u> sd | village name | O51 |

This restriction is not typical of languages with vowel intrusion: generally vowel intrusion happens after long vowels just as easily as after short vowels, as shown by words like Saami [a:j:əpmu:] 'air', or Dutch [horən] 'horn', where [o] is bimoraic.

It is not likely, incidentally, that the location of the syllable boundary is a factor in this pattern. Clusters like [mr] should be heterosyllabic regardless of whether they follow a short or long vowel, since [mr] is not a possible onset in Scots Gaelic, never being attested in initial position (O48-49). Borgstrøm states that all intervocalic CC clusters are heterosyllabic after both long and short vowels (B37:77). Thus, phasing constraints that refer to syllable affiliation, like those proposed in chapter 2, cannot explain why vowel length matters in conditioning vowel intrusion.

A more plausible interpretation of these facts is that vowel intrusion happens in a VRC sequence only if the sonorant is moraic. In most theories, syllables are limited to bearing two moras; a short vowel is monomoraic while a long vowel or diphthong is bimoraic. Postvocalic consonants bear moras in some languages. When the vowel bears only one mora, as in a CVC syllable, it is possible for a following consonant to also bear a mora. But if the syllable contains a long vowel or diphthong, both moras are borne by the vowel(s) and none is available for the consonant.

I propose, therefore, that symmetrical vowel intrusion is connected with the moraicity of the sonorant involved. The situations where intrusion is blocked are precisely those where the sonorant could not be moraic.

| | | |
|-------|--|--|
| (160) | V intrusion possible | V intrusion not possible |
| | $\begin{array}{ccc} \mu & \mu & \\ & & \\ V & R & C \end{array}$ | $\begin{array}{ccc} \mu & \mu & \\ \swarrow & \searrow & \\ V & R & C \end{array}$ |
| | $\begin{array}{ccc} \mu & \mu & \\ & & \\ V & V & R & C \end{array}$ | |
| | Heard as: [VRVC] / [VRC] | [V:RC] |
| | | [VVRC] |

(161) Conjecture #2
 In symmetrical vowel intrusion, the sonorant is moraic.

Several facts support the above conjecture. First, a minimal word augmentation pattern indicates that postvocalic consonants can in fact be moraic in Scots Gaelic. Scots Gaelic does not permit (C)V words, although CVC, CV: and CVV are acceptable. This type of restriction is usually attributed to a requirement that lexical words be bimoraic (i.e., large enough to be a stress foot). Languages typically repair such words by adding a segment that can make the CV word bimoraic (McCarthy & Prince 1993). In Scots Gaelic, the repair chosen is to epenthesize an [h] after the vowel (B40:74). Since consonant epenthesis is sufficient to satisfy the bimoraicity criterion, postvocalic consonants in Scots Gaelic must be capable of being moraic.

Secondly, the proposal in (161) predicts that a VRV sequence should behave like a bimoraic group. This prediction holds true; Borgstrøm and Oftedal both note that svarabhakti groups pattern with long vowels and diphthongs. For example, in the Leurbost dialect, only long vowels and diphthongs occur before word-final or pre-consonantal [m]; short vowels cannot (O38). Yet an intrusive vowel group can precede [m]:

| | | | | |
|------------------------|----|---------|----------------|------|
| (162) Leurbost dialect | a. | bəð'ə̃m | ‘yeast’ | O38 |
| | b. | ãñã̃m | ‘name’ | O143 |
| | c. | kuð'ɯ̃m | ‘to celebrate’ | |

This fact supports the theory that a VRV sequence is bimoraic, and also that it is different from a sequence of two short vowels. CVCV[m] words do not exist, but CVCV[m] do.

The [ʔ]-epenthesis pattern of the Argyllshire dialect, discussed above, also indicates that VRV is bimoraic. [ʔ] is epenthesized after every monomoraic stressed syllable, presumably to make the stressed syllable heavy (due to STRESS TO WEIGHT). Since no epenthesis occurs after a stressed VRV syllable, the syllable must be heavy already. In a similar way, when an intrusive vowel group appears without a coda, as in

[fɑLɑ] “go away!”, no [h] is epenthesized as would happen in a monomoraic syllable. Oftedal notes that “svarabhakti groups behave in this respect like long vowels” (117).

Other evidence for the bimoraicity of the sequences comes from metrics and speaker intuitions. According to O’Rahilly 1932, in poetry intrusive vowel groups rhyme with similar groups or with long vowels. Also, speakers consciously identify such groups as long syllables. Borgstrøm quotes his consultant as saying that the syllable [ʃæra] is “long and stressed” (153). (Stress, incidentally, provides no information about syllable weight since it always falls initially).

Vowel intrusion happens only with moraic sonorants, but it does not happen to all moraic sonorants. Presumably in all CVR(C) words the sonorant bears a mora, but there are many CVR(C) words without vowel intrusion. For example, [sgaLpaj] has no vowel intrusion while the similar [kaLap(ə)] does. Some other underlying distinction must account for the difference between these cases; I propose that this underlying distinction is the presence or absence of α . Only a moraic sonorant dominated by α is subject to the timing constraints (elaborated below) that produce vowel intrusion.

| | | |
|-------|---|--|
| (163) | Vowel intrusion | No vowel intrusion |
| | α \wedge μ μ V R C | α μ μ V R C |
| | Heard as: [VRVC] | [VRC] |

The evidence in this section shows that α must be a type of unit that organizes only moraic segments. In this way, α is similar to the traditional notion of the syllable nucleus. The three basic claims about the structure involved in vowel intrusion are as follows:

(164) Proposal

1. Symmetrical vowel intrusion is conditioned by a structure α .
2. α adjoins moraic segments.
3. α can be underlyingly specified, and is preserved by faithfulness constraints.

The purpose of positing α is twofold. First, it is the structure responsible for requiring the sonorant to be moraic. Second, it provides a way to *indirectly* specify which words have vowel intrusion. There are no faithfulness constraints that preserve underlying phasing relations between gestures, but there is faithfulness to the presence or absence of α . Phasing is completely predictable from the structural organization of segments, but the structural organization of a string of segments is not predictable just from their linear order.

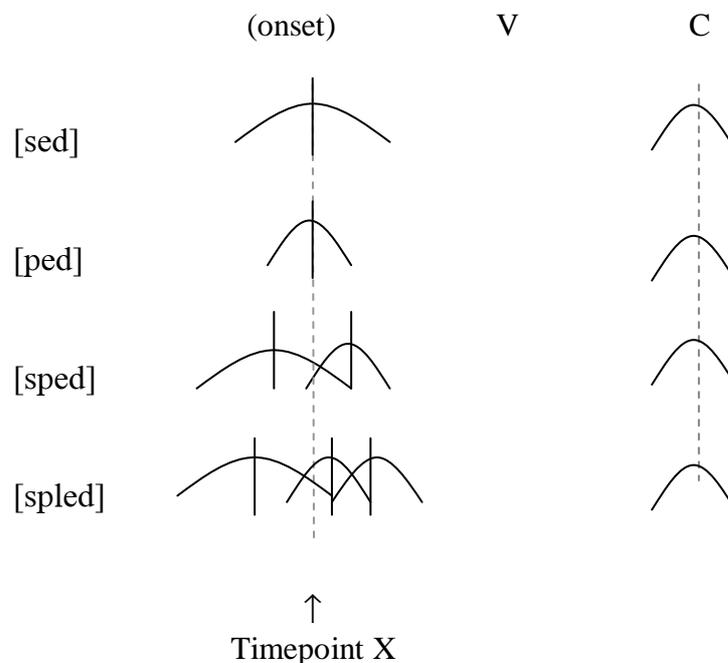
4.4. Structure α and timing

4.4.1. Subsyllabic structure and symmetrical timing: the C-center effect

In this section, I propose an explanation for why “adjunction” of a vowel and sonorant into the unit α should produce symmetrical timing. In recent literature on gestural timing, linguists have suggested that multiple segments which occupy similar structural positions (namely, consonants within a single onset) actually compete to occupy the same time period. I claim that the same is true of two segments within an α structure. They want to have their centers aligned at the same point- and in fact they achieve this, because placing a sonorant in the middle of a vowel is less marked than placing one consonant in the middle of another. For background, I will first discuss the centering phenomenon found in onset clusters.

Browman & Goldstein 2001 argue that all the consonants within an English onset cluster try to achieve the same phasing with respect to the following vowel. They base this claim on a timing phenomenon known as the C-center effect (Browman & Goldstein 1988, Honorof & Browman 1995, Byrd 1995). Roughly, the C-center effect is the tendency of all onset consonants to gravitate towards a certain timepoint. In syllables like [sed] and [ped], there is a consistent relation between the center of the onset gesture and the point of maximal constriction of the coda gesture. Although [s] and [p] have different durations, each of their centers falls at a timepoint (call it X) that is the same distance from the coda, as shown below.

(165) Alignments of onset Cs (approximated from Browman & Goldstein 2001)



Presumably the onset is actually phased primarily with respect to the vowel, but the coda is used as a reference point in instrumental studies because it is easier to measure. The C-center effect is support, of course, for the idea that gestures are phased with respect to landmarks such as the center.

When an onset contains both an [s] and a [p] as in [sped], neither of their centers falls on timepoint X. Rather, their centers deviate equally, in opposite directions, from X. In other words, if the timepoints of the [s]'s and [p]'s centers are averaged, the result is the same timepoint that the center of the [s] in [sed] falls on. This average is called the C-center. The same effect occurs if there are three onset consonants, as in [spled]. When the timepoints for the centers of [s], [p], and [l] are averaged, the result is X.

Browman & Goldstein 2001 propose that the C-center effect derives from the fact that each onset consonant wants to have the same phasing relation with respect to the vowel. Each wants to be phased as if it were the only consonant in the onset. The grammar cannot achieve this ideal phasing for both consonants, so instead it gives a slightly imperfect phasing to each consonant. This strategy minimizes the distance of any one consonant's center from timepoint X.

Within Optimality Theory, this insight can be formalized simply by assuming that constraints on C-V phasing do not distinguish between the first and second consonants in an onset.

- (166) ALIGN (C, LANDMARK¹, V, LANDMARK²)
 If C and V belong to the same syllable, and C precedes V (not necessarily directly), landmark¹ of C is simultaneous with the landmark² of V.

In a C₁C₂V sequence, this constraint applies both to C₁ and C₂. The only way to fully satisfy the constraint would be to make landmark¹ of the two consonants simultaneous, which would in effect make the two consonants simultaneous. But this is a very marked phasing of two consonants. In the universal hierarchy of constraints on overlap, *C IN C ("a consonant does not fully surround another consonant") is high-ranked. English chooses a repair in which each consonant has a somewhat sub-optimal phasing with the following vowel.

The importance of the C-center effect is that it suggests that two segments, despite being linearly ordered in the segmental string, may in effect try to occupy the same position in time. In the case of two consonants, it's unlikely that this complete simultaneity will ever happen, since it requires a very marked C-C phasing. However, if two segments that are more capable of overlap, such as a vowel and sonorant, were to compete for simultaneous timing, it is possible that some languages would allow them to be simultaneous. I claim that this is precisely what constitutes symmetrical vowel intrusion: the centering of a vowel and sonorant on the same timepoint due to a phasing constraint that does not distinguish between them.

4.4.2. Symmetrical vowel intrusion as vowel / sonorant centering

I propose that segments dominated by α are subject to identical phasing constraints with respect to preceding and following segments, and hence want to be centered at the same point. Since vowels are able to fully overlap sonorants under some

constraint rankings, this centering actually happens in some languages, causing the vowel to be heard in two approximately equal pieces.

Such a phasing can be derived through adjustment of the constraint in (166). As proposed in chapter 1, phasing constraints prefer that each vowel fully span its syllable. These need to be changed to refer to all segments dominated by α , rather than only vowels.

(167) ALIGN ([SEG] $_{\alpha}$, OFFSET, SYLL, OFFSET)

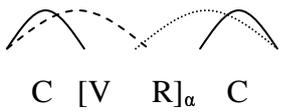
The offset of every segment dominated by an α node is aligned with the offset of the rightmost segment that belongs to the same syllable as that segment.

(168) ALIGN ([SEG] $_{\alpha}$, ONSET, SYLL, ONSET)

The onset of every segment dominated by an α node is aligned with the onset of the leftmost segment that belongs to the same syllable as that segment.

When there are two segments under α , these constraints prefer that both segments fully span the syllable, and in effect be simultaneous. Constraint ranking determines whether this happens, as shown below. If the constraints in (167) and (168) are ranked above *R IN V (“a vowel does not fully overlap a sonorant”), simultaneous phasing of V and R is chosen, as in candidate b). *R IN V would prefer an output with sequential phasing of V and R, as in candidate a).

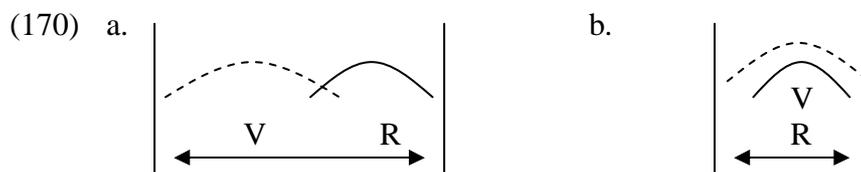
(169) Symmetrical vowel intrusion (preliminary)

| /CVRC/ | ALIGN [SEG] $_{\alpha}$, OFFSET, SYLL, OFFSET) | ALIGN ([SEG] $_{\alpha}$, ONSET, SYLL, ONSET) | *R in V |
|--|---|--|---------|
| a.  C [V R] $_{\alpha}$ C | *! | * | |
| b.  C [V R] $_{\alpha}$ C | | | * |

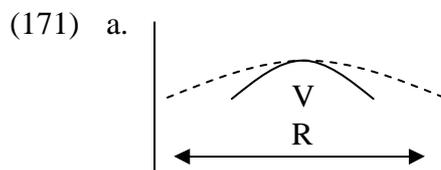
This ranking selects symmetrical phasing of the two segments in a [VR] $_{\alpha}$ structure. The V and R are centered on the same point.

4.4.3. Timing within α : duration

Centering the vowel and sonorant gestures on the same point is part of the desired result, but there are still several problems concerning the timing of segments within the α structure. In the tableau above, the winning candidate b) would be heard as a single short blend of a sonorant and vowel. The phonetic VRV heard in Scots Gaelic differs from this in two ways. First, it is apparently longer. If symmetrical vowel intrusion simply involved two gestures overlapping while each maintained its usual duration, then a [VR] $_{\alpha}$ structure would have the duration of a single short vowel or sonorant, as in b) below. It would be shorter than a VR sequence without overlap, as in a).



From the descriptions and phonetic evidence available, it appears that intrusive vowel groups have a longer duration than a single short vowel. Apparently the vowel articulation lengthens to compensate for the overlap with the sonorant, so that the total duration of the group remains is the same as it would be without overlap.



The overall timing of the syllable seems to reflect a requirement that the whole α unit maintain a certain duration.

I assume that this is a type of compensatory lengthening phenomenon. The segments within α appear to pool their moras, so that the structure maintains an overall length reflecting the number of moras within it. This is stated as a general principle below; I do not develop a more specific theory of the mechanisms involved. (The relation between moras and gestural timing is yet not well understood.)

(172) Principle of α timing

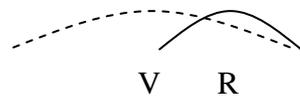
The duration of an α structure reflects the number of moras associated with segments within α .

As for why the vowel gesture but not the sonorant gesture lengthens to stretch the full distance, this is probably related to the fact that Scots Gaelic has long vowels but not geminate (long) consonants. Constraints limit consonant gestures to a one-mora length.

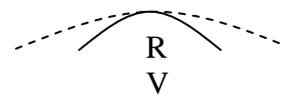
4.4.4. Timing within α : symmetry

The different lengths of the vowel and sonorant gestures create a problem for satisfying the phasing constraints. The alignment constraints in (167)-(168) would prefer the two gestures to have simultaneous offsets and onsets, but this isn't possible when the vowel gesture is longer than the sonorant. In a $[\text{VR}]_\alpha$ structure it is not possible to satisfy both $\text{ALIGN}([\text{SEG}]_\alpha, \text{ONSET}, \text{SYLL}, \text{ONSET})$ and $\text{ALIGN}([\text{SEG}]_\alpha, \text{OFFSET}, \text{SYLL}, \text{OFFSET})$ for both the V and R. One option would be to have R achieve one of these alignments while missing the other dramatically, as in a) below. But in Scots Gaelic, it appears that R is placed in the center of the vowel, so that it misses both desired alignments by the same margin, as in b).

(173) a.



b.



This pattern is in one way reminiscent of the C-center effect in CC onsets, in that two smaller violations of alignment are preferred to one larger violation. In a CC onset cluster, English chooses to move each C's center slightly off the desired timepoint X, instead of giving one C an ideal phasing with respect to the vowel and the other a very marked phasing. In symmetrical vowel intrusion, R's offset and onset both miss the syllable edges, rather than one edge having ideal alignment and the other edge a very marked alignment.

This pattern can be captured by allowing not only constraints that penalize deviation from the preferred alignment, but also constraints on the degree of non-alignment. Gafos 2002:316-322, in his analysis of the C-center effect, introduces the idea that a constraint may penalize more than a certain level of "displacement" from a certain alignment. He formalizes such constraints as self-conjoined constraints (CONSTRAINT^2), a mechanism introduced by Smolensky 1993 to capture the fact that grammars often prefer two non-local violations of a constraint over two local violations. A constraint of the form CONSTRAINT^2 penalizes a large violation in alignment of a single landmark.

(174) $\text{ALIGN}([\text{SEG}]_\alpha, \text{ONSET}, \text{SYLL}, \text{ONSET})^2$

If C and V belong to the same syllable, and C precedes V, the onset of V is not more than one "displacement" from the onset of C.

(175) $\text{ALIGN}([\text{SEG}]_\alpha, \text{OFFSET}, \text{SYLL}, \text{OFFSET})^2$

If V and C belong to the same syllable, and V precedes C, the offset of V is not more than one "displacement" from the offset of C.

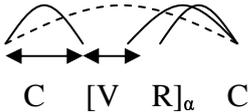
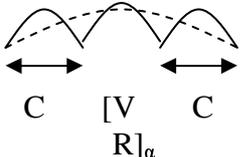
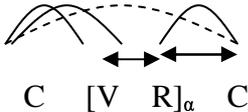
These constraints presuppose that there is some abstract size of displacement that can be counted. In the tableau below, units of displacement are shown with \longleftrightarrow .

Candidates a) and c) place the sonorant gesture all the way to one side or the other. This allows a) to satisfy $\text{ALIGN}([\text{SEG}]_\alpha, \text{OFFSET}, \text{SYLL}, \text{OFFSET})$, and c) to satisfy $\text{ALIGN}(\text{SYLL}, \text{ONSET}, [\text{SEG}]_\alpha, \text{ONSET})$. However, perfectly satisfying alignment for one edge of R requires moving the other edge more than one displacement from its ideal

alignment. This is penalized by the higher ranked ALIGN ([SEG]_α, ONSET, SYLL, ONSET)² and ALIGN ([SEG]_α, OFFSET, SYLL, OFFSET)².

Candidate b) places the sonorant gesture halfway between the two syllable edges. It misses both edges, but not by more than one displacement. Although this entails violations of both ALIGN ([SEG]_α, OFFSET, SYLL, OFFSET) and ALIGN (SYLL, ONSET, [SEG]_α, ONSET), these constraints are lower ranked and candidate b) wins. Hence, when the conjoined constraints are ranked higher than the non-conjoined ones, the grammar prefers two small violations of alignment rather than one large violation.

(176) Symmetrical vowel intrusion

| /CVRC/ | ALIGN (SYLL, ONSET, [SEG] _α , ONSET) ² | ALIGN ([SEG] _α , OFFSET, SYLL, OFFSET) ² | ALIGN (SYLL, ONSET, [SEG] _α , ONSET) | ALIGN ([SEG] _α , OFFSET, SYLL, OFFSET) | *R in V |
|--|--|--|---|---|---------|
| <p>a.</p>  <p>C [V R]_α C</p> | *! | | * | | |
| <p>b.</p>  <p>→ C [V R]_α C</p> | | | * | * | * |
| <p>c.</p>  <p>C [V R]_α C</p> | | *! | | * | |

In this way, the constraints are capable of choosing symmetrical phasing for all and only those VR sequences that are adjoined into structure α. Other rankings of the same constraints, of course, would produce α structures without symmetrical phasing.

4.4.5. Motivating vowel intrusion synchronically

In this section I show how α structures and the resulting vowel intrusion are currently enforced in the grammar. The structure α can arise in two ways. It may be specified in the input and preserved by faithfulness constraints, or it may not be specified in the input, but be added to the output to satisfy markedness constraints.

The faithfulness constraint MAX- α demands that underlying α structures be preserved.

(177) MAX- α

If two segments are adjoined into an α structure in the input, they are adjoined into an α structure in the output.

MAX- α competes with a constraint against the adjunction of segments into α . There may actually be a set of $*\alpha$ constraints regulating the adjunction of different segment types, but I will use only one constraint for the present.

(178) $*\alpha$

Segments are not dominated by α .

In Scots Gaelic, MAX- α outranks $*\alpha$, so underlying α structures are preserved. This ranking allows α , and the resulting vowel intrusion, to occur unpredictably in Scots Gaelic, as shown below. Any word that underlying has a sonorant dominated by α will have vowel intrusion.

(179) Preservation of underlying α

| α / f a L / | MAX- α | $*\alpha$ |
|--|---------------|-----------|
| a. → α / f a L / [faL α] (in Sc.G.) | | * |
| b. α faL [faL] | *! | |

Faithfulness to underlying α structures causes vowel intrusion to occur unpredictably in some segment strings. But there are also segment strings in which vowel intrusion does happen predictably. Intrusive vowels are always present in certain clusters when they follow short vowels, and intrusion is apparently productive in loans, like [taragad'] from *target* (O55) (I say only “apparently” because the ages of the loans are not clear from the sources.)

To explain why vowel intrusion occurs in loanwords, we must assume that some markedness constraints force the construction of α structures in these cases. I suggest that these are simply constraints against the overlap of certain types of overlapping consonant

sequences, which take the form of $*C^1C^2$ OVERLAP. Notice that these constraints refer to linear order:

(180) $*C_xC_y$ OVERLAP

In a C_1C_2 sequence, C_1 belonging to the class C_x and C_2 belonging to the class C_y , there is no overlap between the gestures of C_1 and C_2 .

The high ranking of constraints like these in Scots Gaelic is likely connected to the unusually large number of phonological contrasts it maintains among sonorants. Borgstrøm points out the relation between phasing and contrast maintenance:

...we must look for a special condition within the Gaelic sound-system which caused this tendency to be realized. That was the complicated system of lenited and non-lenited, palatal and non-palatal forms of l, n, r, m. The distinction of these four qualities necessitated a particularly clear and accurate articulation; this led to an increase of the interval between the consonants... and determined the insertion of a vowel. (B37:130)

Although not all 16 sonorants still exist, Borgstrøm still found three coronal nasals, three laterals, and three rhotics. Keeping them physically distant from following consonants gives them clearer formant offsets and likely helps to maintain the contrast among them.

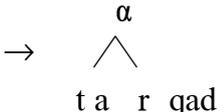
When a word like *target*, which contains an [rg] sequence, is encountered, there are several options for repairing it. [r] or [g] could be deleted, or a vowel could be epenthesized between them. It is also possible to remove the overlap by creating a $[VR]_\alpha$ structure, since such a structure has symmetrical phasing in Scots Gaelic. This repair violates the constraint DEP- α , which penalizes the construction of a non-underlying α structure.

(181) DEP- α

A segment that is dominated by α in the output is dominated by α in the input.

If a constraint like $*rg$ OVERLAP is ranked above at least one faithfulness constraint, it can be repaired through violation of that constraint. In the tableau below, candidates b), c) and d) show different possible repairs of [rg]. The epenthesis in b) and the deletion in c) are ruled out by high-ranked DEP and MAX. The faithful candidate a) is ruled out by $*rg$ OVERLAP. Candidate d), with vowel intrusion, wins because it violates only the lowest ranked faithfulness constraint, that against adding segments under α nodes.

(182) Adaptation of English *target*

| /targət/ | DEP | MAX | *rg OVERLAP | DEP- α |
|--|-----|-----|-------------|---------------|
| a. targad | | | *! | |
| b. taragad | *! | | | |
| c. tagad | | *! | | |
| d. <div style="text-align: center;"> α  t a r gad </div> [<u>tar</u> agad] | | | | * |

When a prohibited cluster follows a bimoraic vowel, the VR adjunction repair is not available. An α structure must organize moraic segments and a syllable is limited to two moras. In this case, the cluster surfaces with overlap, as in (159).

There are some indications that the creation of α is not only used in the clusters that historically triggered vowel intrusion. Borgstrøm 1941:90 reports that in some non-Hebridean dialects, a svarabhakti vowel also occurs in *initial* [dl] and [tl] clusters, as in [dul'iox] 'lawful' (*dligheach*) and [dorɔhət'] 'bridge' (*drochaid*). Once the option of creating α is available, it is predicted that the grammar may use this repair for breaking any marked cluster to which it is applicable, not only the clusters that originally triggered vowel intrusion.

This analysis crucially relies on the idea that constraints on gestural phasing and constraints on other types of structure exist in the same level of the grammar. α nodes are not added in order to remove a marked non-gestural structural configuration; rather, adding α nodes is a strategy for avoiding overlap of certain gesture types. The α structure is chosen because it produces the best possible gestural phasing. The phasing is not merely an automatic interpretation of a structure that is determined at an earlier stage of the derivation; it is a factor influencing the choice of structures. The part of the grammar that decides on the α structure has to know that in this particular language, such a structure will result in symmetrical vowel intrusion.

4.5. What is α ? Parallels to vocalic structures

In this section I argue that vocalic diphthongs also consist of two segments dominated by α , and that this is what distinguishes diphthongs from sequences of short vowels (with which they contrast in Scots Gaelic). α defines the gestural anchor of the syllable, the gesture or group of gestures with respect to which the preceding and following gestures, and perhaps the preceding and following syllable nuclei, are phased. When two vowels are under the same α node, they comprise one syllable. α is essentially equivalent to the traditional nucleus.

The idea that VRV sequences are similar to diphthongs or long vowels has never to my knowledge been formally fleshed out, but it is much hinted in early descriptive

work. Oftedal comments, for example, that “In svarabhakti groups, both vowels are always short, but it is convenient to regard the whole svarabhakti group as equivalent to a long vowel.” (38) Borgstrøm 1940 uses the same notation, square brackets, for both intrusive vowel groups and diphthongs. He notes that “The same stress and intonation as that of the diphthongs is characteristic of the complex [ara]” (15). In his classification of syllable types, “the type *m[ara]v* is united with the unquestionably monosyllabic diphthongs (type *d[ua]n* “poem”) to form the class of “double accented vowels.” (153)

4.5.1. Lexical specification of diphthongs

Diphthongs in Scots Gaelic are similar to vowel intrusion groups in two ways: they consist of two moraic segments, and they can be lexically specified. We can capture these similarities between the two types of segment groups by analyzing both as dominated by α .

In Scots Gaelic, diphthongs and monophthong- monophthong sequences are contrastive, as shown by the following examples.

(183) Contrastive VV sequences

| | Monosyllabic | Disyllabic | | |
|----|--------------|------------|----------------------------|---------|
| a. | fi.əx | fi.əx | ‘debt’, ‘raven’ | O25 |
| b. | ian | N’i.an | ‘bird’, ‘girl’ | C319 |
| c. | Ruəy | Ru.əy | ‘red’, ‘flush in the face’ | B37:149 |
| d. | biəy | bi.əy | ‘food’, let (him) be’ | |
| e. | duan | du.an | ‘song, hook’ | B40:56 |
| f. | yaiv | ga.i | ‘to them, will take’ | B40:129 |

The syllabification of a VV sequence is not predictable simply from the segmental string. In the words above, it must be underlyingly specified which VV strings surface as diphthongs and which don’t.

I propose that diphthongs are lexically specified in the same way that unpredictable vowel intrusion is: by the presence of an α node in the underlying representation. A sequence of two vowels normally becomes two syllables on the surface in Scots Gaelic, as in a) below; but two vowels that are underlyingly dominated by the same α node form the nucleus of a single syllable, as in b). In the same way, a sonorant is ordinarily phased to be only partially overlapped by neighboring vowels. But when a sonorant is united with a vowel under an α node, it is subject to the same phasing constraints as the vowel. The two segments together form the gestural nucleus of one syllable, as in d).

| (184) | Input | → | Output | |
|-------|-------------------|---|----------|---------------|
| a. | / f i ə x / | | fi.əx | ‘raven’ |
| | α \wedge | | | |
| b. | / f i ə x / | | fiəx | ‘debt’ |
| c. | / s g a L p i ç / | | sgaL.piç | ‘dandruff’ |
| | α \wedge | | | |
| d. | / k a L p / | | kaLap | ‘calf of leg’ |

Under this account, the presence of both unpredictable vowel intrusion and unpredictable diphthongs in Scots Gaelic is not coincidental: both are preserved by the same faithfulness constraint, MAX- α , repeated here.

- (185) MAX- α
 If two segments are adjoined into an α structure in the input, they are adjoined into an α structure in the output.

Diphthongs and intrusive vowel groups are not similar, of course, in their phasing. $[\text{VR}]_\alpha$ structures have symmetrical phasing, while the two vowels in a $[\text{VV}]_\alpha$ diphthong are phased sequentially, with little overlap. In the following section I show how this difference can be analyzed as resulting from the ranking of the different constraints on V-V overlap and V-R overlap.

4.5.2. Typology of α : coalescence, “VR diphthongs”

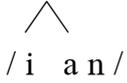
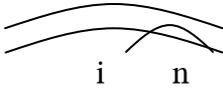
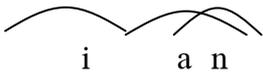
The different phasings of $[\text{VR}]_\alpha$ and $[\text{VV}]_\alpha$ (intrusive vowel groups and diphthongs) result from the fact that different phasing constraints apply to vowels and sonorants. However, it is also possible for $[\text{VR}]_\alpha$ to be phased non-symmetrically, or $[\text{VV}]_\alpha$ to be phased symmetrically, in other languages. Such phasing results in “VR diphthongs” and vowel coalescence, respectively.

As argued in chapter 1, there are different constraints on heavy gestural overlap, depending on the segment types involved. While *R IN V prohibits a vowel from fully overlapping a sonorant, *V IN V prohibits a vowel from fully overlapping another vowel.

- (186) *V IN V
 A vowel gesture does not fully surround another vowel gesture

In Scots Gaelic, *V IN V is ranked above the alignment constraints that prefer symmetrical phasing within α . Hence, symmetrical phasing does not happen in $[\text{VV}]_\alpha$ structures. The gestures remain side by side.

(187) [ian] ‘bird’

| α  / i a n / | *V IN V | ALIGN ([SEG] $_\alpha$, OFFSET, SYLL, OFFSET) | ALIGN ([SEG] $_\alpha$, ONSET, SYLL, ONSET) | *R IN V |
|--|---------|--|--|---------|
| a.  [e:n] a | *! | | | |
| b. →  [ian] | | * | * | |

*R IN V, on the other hand, is ranked below the alignment constraints, and hence is violated to produce symmetrical phasing in $[\text{VR}]_\alpha$, as shown in (169).

In Optimality Theory, every ranking of the constraints should be a possible grammar. Other rankings of the constraints above would have other results, and I claim that these results are attested. If *V IN V were ranked below the alignment constraints, $[\text{VV}]_\alpha$ would be phased symmetrically, with full overlap between the vowels, as in candidate a) above. In the task dynamic model, when two gestures overlap, any contradictory gestural specifications are “blended”, which means their parameter values are averaged. Thus, two coextensive vowels should be heard as a single vowel that is articulatorily between the two component vowel segments. For example, if the parameter values of [a] and [i] were averaged throughout, this would result in a sound between [a] and [i], such as [e].

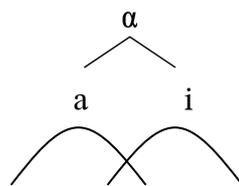
Furthermore, it is predicted that the two gestures should be heard as a single *long* vowel. I have proposed above, in (172), that an α structure maintains a length reflecting the number of moras in it. Therefore, a $[\text{VV}]_\alpha$ structure, even if the vowels are symmetrically phased, should have a the duration of a bimoraic vowel. If [a] and [i] are dominated by α , they will be heard as [e:].

This is, in fact, a good description of what happens in vowel coalescence. In many languages, adjacent vowels may merge into one long vowel that combines features of the two. For example, in Tokyo Japanese the word ‘red’ can be pronounced [akai] or [ake:] (Kawahara 2000). According to de Haas 1988:169, coalescence preserves mora counts: “the quantity of the output is identical to the sum of the input vowels.” In the present theory, coalescence is almost identical to symmetrical vowel intrusion, in being the symmetrical phasing of two vowels within an α structure. Diphthongs and coalesced

vowel sequences are structurally identical, both consisting of $[VV]_{\alpha}$. They differ only in the phasing of the gestures involved.

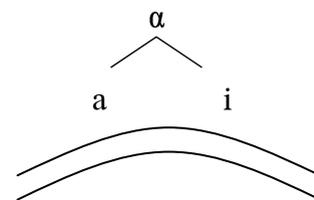
(188)

Diphthongs



Heard as [ai]

Coalescence



Heard as [e:]

The tableau in (187) demonstrates how constraint ranking chooses between the phasing possibilities in (188).

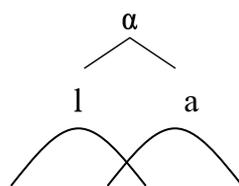
Just as there are two possible phasings of $[VV]_{\alpha}$, it is predicted that there should be a second possible phasing of $[VR]_{\alpha}$. If $*R \text{ IN } V$ were ranked above the alignment constraints on α structures, this would produce $[VR]_{\alpha}$ without symmetrical phasing. In effect, these would be VR or RV diphthongs.

Kaye 1985 has proposed that such structures exist in certain African languages. Some sonorants appear to be structurally linked to the syllable nucleus rather than to the onset or coda. For example, in the Kru language Vata, $C[l]V$ syllables occur, but only with short vowels: [ple] is a possible word but *[ple:] or *[plra] is not. Kaye argues that this is because [l] is not structurally part of the onset, but part of the nucleus, which is limited to containing two moras: a long vowel, two short vowels (a diphthong), or a short vowel and consonant. Furthermore, there are no cooccurrence restrictions between C_1 and [l] in a $C_1[l]$ sequence. Languages typically have restrictions on what consonants may combine in an onset, but rarely have restrictions on which nuclei can follow a particular onset. In this way as well, [l] behaves like part of the nucleus.

I propose that Kaye's "RV diphthongs" are $[RV]_{\alpha}$ structures without symmetrical phasing. They are structurally identical to intrusive vowel groups in Scots Gaelic, except in the linear order of vowel and sonorant. The segments are only phased differently.

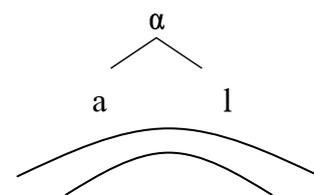
(189)

"RV diphthongs"



Heard as [la]

Symmetrical vowel intrusion



Heard as [al̩]

Under this view, there are four basic types of bisegmental, bimoraic syllable nuclei: VV diphthongs, RV or VR diphthongs, coalesced vowel sequences, and symmetrical vowel intrusion groups. All are dominated by α nodes, and the differences in their phasing result from the conflict between constraints on gestural alignment and constraints against gestural overlap.

(190) Typology of bisegmental syllable nuclei

| Constraint ranking | Result |
|--|-----------------------------|
| *V IN V >> CONSTRAINTS ON PHASING α | VV diphthongs |
| CONSTRAINTS ON PHASING α >> *V IN V | Coalescence |
| *R IN V >> CONSTRAINTS ON PHASING α | RV or VR “diphthongs” |
| CONSTRAINTS ON PHASING α >> *R IN V | Symmetrical vowel intrusion |

If all of these phenomena involve α structures, it is predicted that there should be some typological correlation between them. I have proposed a single faithfulness constraint preserving α , MAX- α . If MAX- α is ranked highly in a language, it will preserve both [VV] $_{\alpha}$ and [VR] $_{\alpha}$ structures (although some other constraint may rule one of them out). While only a few cases of symmetrical vowel intrusion and VR / RV diphthongs are known to me, they do seem to exhibit this correlation. Scots Gaelic and Hocank, the two languages I claim to have symmetrical vowel intrusion (Hocank is discussed in the following chapter), both have unusually large numbers of vocalic diphthongs as well. Oftedal lists sixteen contrastive diphthongs for the Lewis dialect of Scots Gaelic (O87-98). Hocank has twenty-three diphthongs (Susman 1943:27). Vata, one of the languages for which Kaye 1985 proposed RV diphthongs, also has ten VV diphthongs (Kaye 1981). This tendency of languages with [VR] $_{\alpha}$ or [RV] $_{\alpha}$ structures to license vocalic diphthongs supports the theory that these nucleus types are structurally similar.

4.5.3. Licensing of gestures within α : the case of nasality

The Barra dialect shows another similarity between intrusive vowel groups and diphthongs, involving the licensing of nasality. Rules for the distribution of nasality can be stated most simply if it is assumed that intrusive vowel groups and diphthongs involve the same structure.

Most vowels in the Barra dialect are contextually nasal before or after nasal consonants, and can also be independently nasal. For example, mutations are a source of independent vowel nasality. Words that begin with [m] change the [m] to [v] in initial mutations, which are used to realize morphemes such as the definite article or vocative case. The vowel following the [m] is nasalized due to its environment, as in (a), but the nasality is also present in the mutated form in b) where the [m] is absent.

| | | | |
|----------|--------|-----------|--------|
| (191) a. | mũxk | ‘pig’ | |
| b. | ə vũxk | ‘the pig’ | B37:79 |

This independent nasality shows that nasalization cannot result only from overlap of a consonant's velum lowering gesture onto the vowel. Rather, a nasal vowel must be associated with an independent velum lowering gesture, at least in cases like b) above.

Intrusive vowel sequences never contain independently nasal vowels. When a nasal-initial word has vowel intrusion, as in a) below, it may have the purely contextual nasalization expected after nasals (it is not clear, because Borgstrøm never transcribes nasalization next to nasal consonants). But when a word like [mara.əɣ] undergoes the [m~v] mutation, the nasality does not show up in the [v]-initial form, contrary to the pattern in (191).¹⁷

| | | | | |
|-------|----|------------------|-----------|--------|
| (192) | a. | mar <u>a</u> .əɣ | 'to kill' | |
| | b. | var <u>a</u> v | 'killed' | B37:79 |

For some reason, intrusive vowel groups are not compatible with independent nasality on vowels. (An intrusive vowel group involving a nasal sonorant will presumably be nasal in the context above, but in this case it is impossible to tell whether the nasality is independent or contextual, since vowels are nasal before and after nasal consonants anyway. Only VRV groups with non-nasal sonorants concern us here).

Certain vocalic diphthongs also cannot be nasal in Barra, namely those that contain a mid vowel, such as [ɣi], [iə] (= [iɣ]), or [uə] (= [uɣ]). There is a simple generalization about licensing nasality that encompasses both intrusive vowel groups and diphthongs.

(193) Licensing of nasality (Barra)

Complex α structures do not license independent nasality unless both of their constituent segments are segments that can be independently nasal.

The mid-vowels [o], [ɣ], and [e] cannot be independently nasal in Barra (B40:129); nor can the sonorants [l' L L' r r' R]. The diphthongs and vowel intrusion groups that cannot be independently nasal are precisely those that contain one of these segments. This suggests that there are licensing constraints that prohibit one segment in α from being associated with a nasal gesture if such a gesture is not compatible with the other segment in α .

The generalization in 193) would also predict that nasal consonants do not occur in vowel intrusion with vowels that cannot license nasality; i.e. mid vowels. Among the data in Borgstrøm 1940, this is true except for one function word, [ɣnɣ] 'one'. All other examples of VNV contain high or low vowels: /an/, /aN'/, /æɳ/, /æm/, /im/, /in/, /tun/, and /uN/. This generalization has not to my knowledge been noted before.

A full analysis of these restrictions is beyond my scope here, but I note this as one more way in which diphthongs and vowel intrusion groups pattern together.

¹⁷ The Lewis dialect is different: Oftedal 42 states that svarabhakti "seems to have counteracted the development of nasal vowels to a certain degree... But this is only a tendency, not a strict rule; there are many instances of nasal vowels... in svarabhakti."

4.5.4. Cooccurrence restrictions

As a final note, Scots Gaelic VRVC sequences do not fully meet one of the diagnostics Kaye 1985 suggested for recognizing RV nuclei. This could be seen as a challenge to the view that both involve [RV]_α or [VR]_α structures, but it can be explained as an artifact of the way the structures historically developed in the two languages.

In the West African languages that Kaye proposes to have RV diphthongs, there are no cooccurrence restrictions at all between the C and R of a CRV sequence. Cooccurrence constraints are frequent within onsets but rare between an onset and nucleus, so this freedom of CR combinations supports the theory that the R is in the nucleus. In Scots Gaelic, on the other hand, [VR]_α structures do not exist before all types of consonants. They mostly precede consonants that historically triggered vowel intrusion. However, this difference is likely a historical artifact. In at least some West African languages, CRV derives from earlier CVRV (Mensah & Tchagbale 1983, quoted in Leben & Fujimura 2000). A great variety of CR sequences developed when the intervening vowel disappeared, because there are typically no cooccurrence restrictions on onsets of adjacent syllables. In Scots Gaelic, the development of the [VR]_α structures was apparently mediated by a stage of more conventional vowel intrusion, which took place only in certain heterorganic RC clusters. For this reason, [VR]_α structures now tend to precede only a limited number of consonants.

Nevertheless, subsequent changes to codas in Scots Gaelic have greatly increased the number of environments that [VR]_α structures now occur in. They now occur in clusters with voiceless stops, which do not require vowel intrusion, and even before hiatus or word boundaries. It appears that in principle they could precede any coda. I conclude that, as in Kaye's African examples, there are actually no synchronic cooccurrence restrictions between Scots Gaelic [VR]_α nuclei and following or preceding consonants (aside from the general restrictions on C-V and V-C sequences in this language).

4.6. Intrusive vowel quality: sonorant-vowel blending

The final section of this chapter concerns cases where an intrusive vowel is transcribed with a different quality than the preceding vowel portion. I argue that this difference results from coarticulation with the sonorant, due to the overlap of their gestures. Although this phenomenon has been treated before, I show that the data are more complicated than usually assumed. Analyses which treat the intrusive vowel as a separate segment, and claim that it shares some features with the sonorant, do not account for all of the data.

4.6.1. Vowel backing after [r], [n] in Barra

Scots Gaelic intrusive vowels, especially in the Barra dialect, do not always have exactly the quality of the preceding vowel: they strongly coarticulate with the sonorant that is phased in the middle of the vowel gesture. This coarticulation is stronger than that which occurs in normal CV sequences, supporting the theory that a greater degree of gestural overlap is involved.

The vowel inventory is given below.

(194) Stressed syllable short vowel inventory, Barra dialect

B37:79-89

| front | back | |
|-------|--------|---------|
| | -round | + round |
| i | ɯ | u |
| e | ɤ | o |
| æ (ɛ) | a | ɔ |

In Barra, when certain combinations of vowel and sonorant form an intrusive vowel group, the intrusive vowel does not have the same quality as the non-intrusive portion of the vowel. After [r] or [n], the intrusive front vowels [æ] and [i] back and / or lower, as shown below ([ɛ] is an allophone of [æ]).

(195) Barra Gaelic non-identical vowel qualities

| | | | |
|--------------|---------------------------|---------------------|---------|
| æ <u>r</u> a | ʃæ <u>r</u> av | ‘bitter’ | B40:134 |
| | dʒæ <u>r</u> amət | ‘omission, mistake’ | B40:134 |
| | ʃæ <u>r</u> a.ətær’ | ‘towel’ | B40:153 |
| | ʃæ <u>r</u> ak | ‘to fade’ | B37:149 |
| | fæ <u>r</u> ak | ‘anger’ | B37:162 |
| | ʃæ <u>r</u> avanǝ | ‘female servant’ | B37:234 |
| | fæ <u>r</u> amət | ‘envy’ | B37:121 |
| | ena | m <u>e</u> nav | ‘small’ |
| | ʃ <u>e</u> na <u>x</u> əs | ‘conversation’ | B37:127 |
| | ʃ <u>e</u> na <u>v</u> ar | ‘grandmother’ gen. | B37:171 |
| in <u>y</u> | in <u>y</u> xiN’ǝ | ‘brain’ | B37:116 |

We can generalize that backing and lowering occur in combinations of non-palatal sonorants with front vowels. There are no other examples attested in Borgstrøm 1940 where non-palatalized sonorants ([n], [r], [l], [R], [N], and [L]) follow front vowels in a vowel intrusion sequence¹⁸. This is not surprising, given that the non-palatalized sonorants tend to occur with back vowels throughout the language.

The reason that the sonorant affects the intrusive vowel appears to be that the gestures of [r] and [n] involve a slightly more retracted position of the tongue than the front vowels. The articulations of [r] and [n] are described by Borgstrøm as relatively neutral; neither strongly palatalized nor strongly velarized. According to Borgstrøm 1940:132-3, the Barra [a] is not strongly backed, but “a kind of “flat front” articulation, during which the tongue is not much retracted,” so that “before non-palatal consonants it is sometimes difficult to distinguish *æ* from *a*.” Thus, probably does not take a very large influence on [æ]’s articulation to make it sound like [a].

This type of coarticulation (as I will analyze it) happens only with intrusive vowels; non-intrusive vowels are not affected in the same way by preceding sonorants. The sequences [ræ], [nɛ], and [ni] are attested, where the vowels are not intrusive.

¹⁸ The Bernera dialect does have some combinations of /i/ with /r/ in vowel intrusion, and these undergo coarticulation as well, as in [i^oruxəð] ‘a shot’ and [i^orubəL] ‘tail’, where [i^o] means a slightly rounded [i] (B40:209).

(196) Non-coarticulation with non-intrusive vowels, Barra dialect

| | | | |
|----|------------------------|--------------------|---------|
| ræ | k ^h ræçk'əN | 'skin' | B40:164 |
| | dræx | 'appearance, look' | B37:136 |
| nɛ | bəkan də nɛxkɔ̃ | 'a little snow' | B37:115 |
| ni | fɔ:ni | 'is of use' | B37:86 |

Bosch & de Jong 1998 confirm instrumentally that sonorants have a stronger effect on intrusive vowels than on regular vowels. They compare CVC₂V₂C words and CVC₂V₂C words for the effect of C₂ on V₂ in each. Palatalization or velarization on C₂ affects both the F2 value (corresponding to backness) and also the F1 value (corresponding to height) of following intrusive vowels more than that of following non-intrusive vowels.

Within articulatory phonology, consonant-vowel assimilation has been analyzed as a result of overlap between their gestures (see, for example, studies on palatalization by Zsiga 1995 and Cho 1998). The gestural theory straightforwardly explains why an intrusive vowel coarticulates more than a normal vowel with the preceding consonant: there is more gestural overlap involved. The intrusive vowel is actually part of a gesture that fully overlaps the sonorant, and hence the sonorant has a greater effect on the vowel's trajectory than it would on a vowel that overlapped with it less.

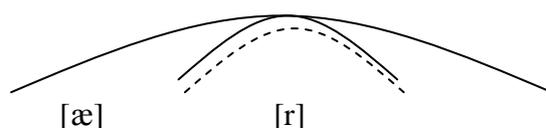
There is phonetic evidence from other languages that secondary articulations on consonants disrupt vowel articulations. Ohman 1966 shows that there is vowel-to-vowel coarticulation in VCV sequences in Swedish and English, but this coarticulation is blocked in Russian (see also Purcell 1979). The reason appears to be that Russian, like Scots Gaelic but unlike Swedish or English, has secondary articulations of palatalization or velarization on consonants. The palatalization or velarization is a vowel-like gesture itself, and interferes with any overlapping vowel gestures.

The same effect seems to happen in Barra Gaelic. To see how this happens, let us take the case of [færa_̣k] 'anger'. This word contains an [æ], which consists of the gesture [tongue body wide pharyngeal]. It also contains an [r], which consists of two gestures: [tongue tip narrow alveolar] and [tongue body mid pharyngeal]. Since [r] is phased in the middle of [æ], there is a period when the tongue body is being instructed to assume both a mid pharyngeal and narrow pharyngeal constriction.

(197) færak ‘anger’

Gestures

- [r] : Tongue tip narrow alveolar (———)
Tongue body mid pharyngeal (- - - - -)
[æ]: Tongue body wide pharyngeal



I suggest that the middle of the [æ] gesture undergoes blending with the tongue body gesture of the [r]. Blending is the averaging of conflicting parameter values that occurs when gestures involving the same articulators overlap. The realization of the [r]’s tongue body backing disrupts the trajectory of [æ], and it does not recover its original target constriction value, so that the portion heard after [r]’s release sounds like a more back vowel, [a]. The phonetic [æ] and [a] are really one gesture, which is influenced by a competing gesture during only part of its duration.

4.6.2. Vowel fronting: mutations, verb forms in Barra

There are also a number of cases where intrusive vowels are fronted or raised after [r’] or [l’]. However, this does not happen consistently. Most of the examples of raising and fronting are either forms that have undergone the palatalization mutation, or certain verb forms. I propose that in these forms, the intrusive vowel is affected not only by the sonorant but by an additional gesture that is overlaid on the whole end of the syllable.

As shown in section 2.5, certain inflections cause a final consonant cluster to become palatalized, and the preceding vowel changes as well. Palatalization affects both the intrusive and non-intrusive portions of the vowel, supporting the theory that they are one gesture. Yet palatalization does not affect the two vowel portions in exactly the same way: in the Barra dialect, intrusive vowels that undergo palatalization are always heard as higher or fronter than the preceding vowel portion (B40:176). Examples are given below.

(198) Intrusive vowels in mutation, Barra

| | Basic form | Mutated form | | |
|------|---------------------|----------------------|----------------------|------------|
| ur'i | dɔrɔxɔ̃ | nas dɔur'içə | 'dark / comp.' | B40:211, 2 |
| | dɔrɔy | dɔur'i | 'fishing line / pl.' | B40:211 |
| ul'i | dɔr'ev | duul'i-ɔ̃ | 'difficult / comp.' | B37:175 |
| er'i | færak | fer'ik' | 'anger / gen.sg.' | B40:178 |
| ul'i | baLak | bul'ik' | 'bellows/ gen.sg.' | B37:161 |
| ur'i | Luruk-ɔ̃ | Lur'ik'N'ən | 'leg / pl.' | B37:154 |
| ør'e | t ^h arav | t ^h ɔr'ev | 'bull / pl.' | B40:141 |
| | skarav | skɔr'ev | 'cormorant / pl.' | |
| | marav | nə mɔr'ev | 'the dead / pl.' | |
| | garav | gɔr'evɔ̃ | 'rough / comp.' | B37:175 |

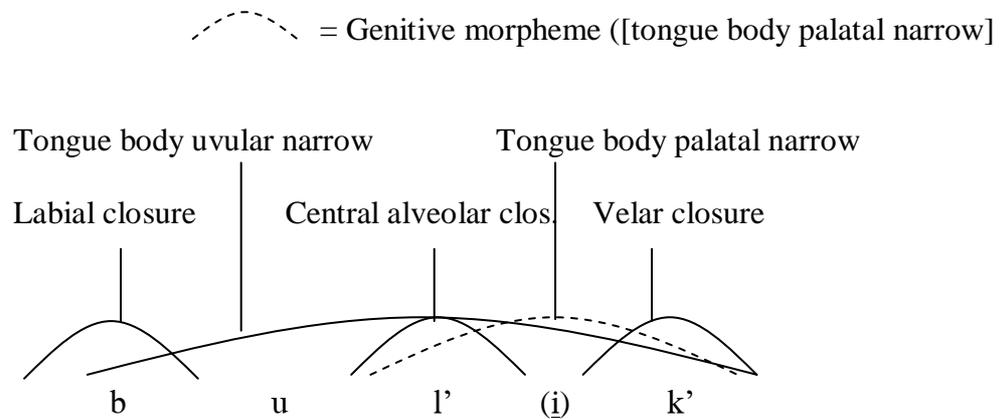
In many of these cases, the non-identical vowel qualities could simply be attributed to coarticulation of the vowel with the sonorant, but in a few cases this explanation cannot hold. Near-minimal pairs show that in forms like singular nouns, where mutation is not involved, intrusive vowels do not sound raised or fronted in similar environments.

| | | | |
|---------------------------|-------------|----------------|---------|
| (199) Mutated (see above) | Non-mutated | | |
| fer'ik' | vs. mer'ek' | 'rust' | B37:82 |
| t ^h ɔr'ev | vs. gɔr'ɔm | 'to crow, cry' | B40:141 |
| duul'i-ɔ̃ | vs. fɔl'ɔm | 'helm' | B40:212 |

This suggests that the palatalization mutation itself contributes to the raising or fronting of the intrusive vowel, and the fact that *all* intrusive vowel groups in mutated forms have non-identical vowels supports this conclusion.

I propose that the mutation-causing morpheme is a single gesture, such as [tongue body narrow palatal], which spans the final two consonants. Since spanning these consonants requires it to span the intrusive portion of the vowel as well, that part of the vowel undergoes blending. Hence, it sounds more like a [narrow palatal] vowel.

(200) Gestural score of a ‘mutated’ word ([bul’ik’] ‘bellows- gen. sg.’)



This approach to mutations explains why the intrusive vowels in palatalized words always sound higher or fronter than the preceding vowel portion, and why there is a difference between intrusive vowels in mutated and non-mutated words.

Similar cases of raising or fronting occur in certain verbal forms, as below.

| | | | | |
|-------|------|-----------------------------|-------------|---------|
| (201) | ur'i | sur'i-š | ‘wooing’ | B40:212 |
| | er'i | t ^h er'ik'əxkiN' | ‘to end’ | B40:195 |
| | | t ^h er'ik'i | ‘will end’ | B40:211 |
| | | her'ik' | ‘ended’ | B40:195 |
| | | (cf. [mer'ek'] ‘rust’) | | |
| | ur'i | fur'iči / fur'i-i | ‘will stay’ | B40:211 |

These words are problematic. Borgstrøm and Oftedal do not analyze them as palatalized, so they should not involve a single [narrow palatal] gesture spanning two consonants and the intrusive vowel. Yet they do have an intrusive vowel that sounds raised, unlike the morphologically simple examples in 199).

However, while linguists do not analyze these forms as involving palatalization, it is possible that speakers do. Verb paradigms often do include palatality-related alternations. In particular, a verb’s infinitive may have non-palatal consonants where the finite forms have palatals. Oftedal analyzes this as a “depalatalization” mutation occurring in the infinitive (together with another mutation affecting the initial consonant).

(202) “Depalatalization”, Leurbost dialect

| Infinitive | Past | |
|------------|--------|---------------------|
| faLəx | ɣaLiç | ‘hide’ |
| fuLəg | ɣulig’ | ‘suffer’ |
| fu.aL | ɣu.al | ‘sew’ |
| kur | kuð | ‘put’ ¹⁹ |

I suggest that speakers may analyze these forms differently: rather than viewing the infinitive as a depalatalized form, they may choose to regard the finite forms as palatalized, a mutation type familiar to them from so many nouns and adjectives. The forms in 201) certainly look at a glance like palatalized words, since the consonants flanking the intrusive vowel are palatalized.

Indeed, from the data given in Oftedal, it is not clear to me why he identifies the infinitives as depalatalized rather than analyzing the finite forms as palatalized (unless perhaps for etymological reasons). In either case, the mutation would have to be seen as irregular, since not all infinitives with a final non-palatalized consonant correspond to palatalized finite forms, and not all palatalized finite forms correspond to non-palatalized infinitives. It seems quite plausible that speakers would analyze these alternations as an irregular application of a mutation type (palatalization) that occurs frequently in other parts of speech. In other words, I propose that the examples in 201) have a representation like that in (200).

I also propose that there is one adjective that involves an exceptional palatalization mutation: [dʁr’ev] ‘difficult’. This word is not expected to be palatalized, since it is a simple adjective and palatalization normally happens only in the comparative. However, [dʁr’ev] is also unusual in that it is formed from a different stem than its comparative, as shown below.

| | | | | |
|-------|----|----------|--------------------|---------|
| (203) | a. | dʁr’ev | ‘difficult’ | B40:141 |
| | b. | dʁul’i-ð | ‘difficult- comp.’ | B37:175 |

I suggest that speakers analyze [dʁr’ev] as an irregular adjective involving the palatalization mutation in the non-comparative. (Some languages have non-comparative adjectives that are etymologically comparatives, like English *near* from *nigher*; I do not know if [dʁr’ev] has such a history).

4.6.3. Exceptions

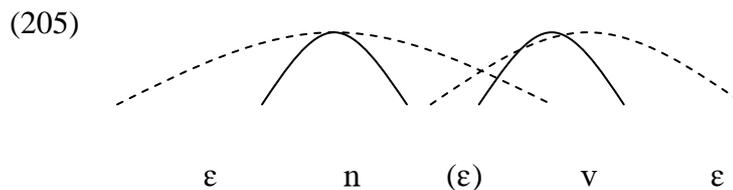
The analysis above accounts for almost all cases where intrusive vowels are not identical to the preceding vowel, but there are still three exceptional words²⁰.

¹⁹ [ð] acts as the palatalized version of [r] in Leurbost.

In one word, the intrusive vowel's quality appears to be influenced by the quality of the following vowel. [ʃɛn_ɪavar] shows the normal backing of intrusive [æ / ɛ] after [n], but in [ʃɛn_ɛvɛr'] the expected backing fails.

- (204) a. ʃɛn_ɪavar 'grandmother' gen. B37:171
 vs. b. ʃɛn_ɛvɛr' 'grandmother'

Clements 1995 suggests that [ʃɛn_ɛvɛr'] is affected by analogy to [ʃɛnɛr'] 'grandfather' (which does not involve vowel intrusion). I propose instead that there is an influence of the following vowel. If the intrusive vowel has some slight level of overlap with the following vowel, this should help it recover from the disruption to its trajectory caused by the [n]. The [ɛ] gesture is weakened in the middle by blending with [n], but the intrusive portion of the vowel gesture includes the beginning of the following [ɛ] gesture as well. (Note that none of the cases 195) where [æ] is backed after [n] have a following front vowel).



A more precise modeling of this effect will require adjustment of the phasing constraints, which currently do not allow a vowel gesture to extend beyond its own syllable, but the important point is that vowel-to-vowel coarticulation can be modeled in gestural phonology. The sporadic vowel harmony attested in Scots Gaelic (as in [tʉrʉɣ] / [tʉrɔɣ] 'drought' and [tʉrʉs] / [tʉrəs] 'journey, time' (O147)) supports the idea that adjacent vowels do affect one another.

While [ʃɛn_ɛvɛr'] has less sonorant-vowel coarticulation than expected, there are two function words that have more. The words below show exceptional levels of raising or fronting of the intrusive vowel, when compared to [mɛr'ɛk'] "rust".

- (206) a. ɣr'ɪN' 'on us' B37:18
 b. ɣr'ɛv 'on you (pl)' B37:183

I suggest that there are two factors at work in these cases. First, function words are often prosodically reduced compared to lexical words. Prosodic reduction may lead to a greater level of overlap between gestures, and hence to more coarticulation. Secondly, the fact

²⁰ Ní Chiosáin 1994 gives two more exceptional words besides those below: [karæt'] 'friend' and [dul'ix'] 'sorry'. However, Borgstrom does not transcribe these vowels as svarabhakti vowels, so I assume they are not intrusive (B37:97,226).

that the intrusive vowels is only fronted in [ʎr'ev] but fronted and raised in [ʎr'iN'] is probably due to the influence of the following [N'], which is very strongly palatal. Borgstrøm 40:161 reports that “For *N'*... the middle part of the tongue is energetically raised towards the palate, so that *N'* is strongly palatal, and often seems to be followed by a very short *j* before back and mixed vowels.” [N']’s influence on the intrusive vowel is especially strong because it involves a more extreme position of the tongue body than other palatalized consonants.

To summarize, the combinations of vowels and sonorants attested for Barra Gaelic vowel intrusion in Borgstrøm 1940’s data are the following.

(207) VCV groups, Barra

| | i | e | æ/ε | u | u | ʎ | ɔ | a |
|----|------|------|------|------|-------------|------|-----|-----|
| l' | il'i | | | ul'i | ul'i | ʎl'ʎ | | |
| L | | | | | | | | aLa |
| l | | | | | | | | |
| m | imi | æmæ | | | | | | |
| n | inø | εnɔ | | | un <u>u</u> | ʎnʎ | | ana |
| N | | | | uNu | | | | aNa |
| N' | | εN'ε | | | | | | |
| r | | ærɔ | | uru | | | ɔrɔ | ara |
| r' | ir'i | er'e | ær'æ | ur'i | ur'i | ʎr'ʎ | | |
| | | er'i | | | | ʎr'e | | |
| | | | | | | ʎr'i | | |
| R | | | | | | | | aRa |

The analysis presented above differs from previous approaches to this problem in that I do *not* attribute raising or fronting of the intrusive vowel to the influence of the sonorant alone—at least not in Barra, where the words [mer'ek'], [gʎr'ʎm], and [fʎl'ʎm] show that in morphologically simple environments, intrusive vowels are not affected by palatalized sonorants. Fronting or raising of intrusive vowels after [r'] and [l'] is a result of an additional gesture being overlaid on the end of the word, as part of the palatalization mutation. Only the backing of front vowels after [n] and [r] is a result purely of coarticulation of the vowel and sonorant.

4.6.4. Coarticulation or feature spreading?

Non-identical intrusive vowel qualities have been analyzed by Clements 1986 and Ní Chiosáin 1994 as involving feature-spreading. A feature-spreading analysis is, of course, incompatible with the theory that the intrusive vowel and previous vowel are together one segment: a single vowel cannot bear two different sets of features. I will

argue that a coarticulation analysis accounts for more of the data than the feature-spreading approach.

Clements 1986:331 claims that “the epenthetic vowel is a copy of the preceding vowel in all respects, except that...if the intervening consonant is specified for backness, the epenthetic vowel copies this feature specification from the consonant.” In Clements’ analysis, the intrusive vowel is a separate, epenthetic segment. It copies its [±back] feature from the preceding sonorant and all other features from the preceding vowel. This process is unusual because it appears to be an example of ‘non-constituent spreading’: only [±back] is spreading, without the other features that are dominated by the Place node, [±round] and [±high] (Halle 1995, Ní Chiosáin 1994).

The first difficulty with this analysis is that it does not describe all the data. There are many cases where the intrusive vowel does not share the [±back] feature of the preceding sonorant, and also cases where the vowel shares the [±high] feature of the sonorant. Examples are repeated below.

(208) Vowels differ in height

- | | | | |
|----|------------------------|------------|---------|
| a. | t ^h er’ik’i | ‘will end’ | B40:211 |
| b. | ʁr’iN’ | ‘on us’ | B37:183 |
| c. | inʁxiN’ð | ‘brain’ | B37:116 |

Vowel and sonorant differ in backness

- | | | | |
|----|----------|------------------|---------|
| a. | fʁl’ʁm | ‘helm of a boat’ | B37:227 |
| b. | ʃenɛvɛr’ | ‘grandmother’ | B37:171 |
| c. | gʁr’ʁm | ‘to crow, cry’ | B40:141 |

It seems difficult for any approach to account for all these cases without acknowledging the role of the palatalization mutation, and other factors such as following consonants and vowels, in determining intrusive vowel quality. However, these factors could undoubtedly be built into the feature-sharing analysis in a similar way to the gestural analysis.

The area where the gestural approach and the featural approach really differ is in their ability to take into account the physical magnitude of a gesture as a factor. Features have only two settings, [+] and [-]. But physically, a given feature may or may not have a strong phonetic realization. For example, [r’] in Barra Gaelic is featurally [+palatal], and phonetically “the sound of *r*’ is strongly palatal” (B40:165). The cognate sound in the Lewis dialects, transcribed [ð] or [ð’], is also featurally [+palatal] in the sense that it alternates with [r] in the palatalization mutation, but phonetically “the front of the tongue is raised towards the palate, but apparently not so much... as for *r*’ in the southern dialects, so that ð’ has not a very strongly palatal sound.” (B40:72)

Since Lewis [ð’] does not involve a strong tongue-raising movement, the palatalization mutation in Lewis must work differently than in Barra: there must not be a [narrow palatal] gesture overlaid on the end of the word. Either there is a less extreme gesture such as [mid palatal], or else speakers simply substitute [+palatal] phonemes in

the mutated words, without actually adding a gesture. In either case, we expect the palatalization mutation to have less effect on intrusive vowels. This is in fact the case. The following is a list of the vowel-sonorant combinations found in Borgstrøm 1940's Bernera data.

(209) Intrusive vowel groups, Bernera dialect

| | i | e | æ/ε | u | u | o | ɣ | ɔ | a |
|----|------|--------------|------------|------|------|-----|------|-----|-----|
| l' | il'ə | | | ul'u | | | ɣl'ɣ | | |
| L | | | | | | | | | aLa |
| l | | | | | | | | | |
| m | imi | | | | | | | | |
| n | inə | | ænæ ænä | | unuu | | ɣnɣ | ɔnɔ | ana |
| N | | | | UNU | | | | | aNa |
| N' | | | | | | | | | |
| r | i'ru | | ærä | UrU | | oro | ɣrɣ | ɔrɔ | ara |
| ð' | | eð'e eð'i | | uð'u | | | ɣð'ɣ | | |
| R | | | | | | | | | aRa |

In Bernera, intrusive vowels are not raised or fronted after [ð'] in mutated forms, as shown below.

| (210) | Lewis | Barra & southern dialects | | |
|-------|----------------------|---------------------------|-----------------|---------|
| a. | nəs duð'uç(ə) | nas dɯr'içə | 'darker' | B40:211 |
| b. | duð'uj | dɯr'i | 'fishing lines' | |
| c. | fuð'uçi | fur'içi / fur'i.i | 'will stay' | |
| d. | skɣð'ɣv | skɣr'ev | 'cormorants' | |
| e. | t ^h æð'æv | t ^h ɣr'ev | 'bulls' | |

The featural account cannot explain the correlation between the strength of the phonetic realization of the sonorant's features, and the spreading of these features to the intrusive vowel. Features are only present or absent; they do not have degrees of strength. So it is not clear from the featural analysis why there is less feature-spreading in dialects where the features have less extreme phonetic realizations.

4.6.5. An alternate strategy: removal of secondary articulations

Some dialects deal with conflicts between the vowel and sonorant in vowel intrusion differently: instead of allowing the vowel articulation to be disrupted, they alter the consonant. Borgstrøm 1941 reports that in the non-Hebridean dialect of Ross-shire,

words that have vowel intrusion with a palatal [r'] and a back vowel tend to depalatalize the /r'/. For the words below, he gives two pronunciations: one in which /r'/ is depalatalized to [r] and the intrusive vowel has the same quality as the preceding vowel, and one in which /r'/ is realized as [r'] and the intrusive vowel is raised. (Note that /ar'/ combinations do not occur in vowel intrusion in Borgstrøm 1940's Barra data; the Barra cognates of the words below are [æɾ'ækət] 'silver' and [tʁr'ɛv] 'bulls').

- (211) Ross-shire depalatalization B41:140
- | | | |
|----|---|-----------------|
| a. | ar <u>a</u> kət / ar'i:kət | 'silver' |
| b. | t ^h ar <u>a</u> j / t ^h ar'i: | 'bulls' |
| c. | dur <u>u</u> j / dur'i: | 'fishing-lines' |

This optional depalatalization does not occur in normal combinations of a back vowel and [r'], where vowel intrusion is not concerned. In that situation, there is instead an allophone of /r'/ that Borgstrøm describes as “a sound which can resemble a ž ... or a j modified by an apical articulation.” (99) He transcribes this sound differently than the [r] in the words above.

This depalatalization is simply another response to the conflict between the articulatory specifications of the sonorant and surrounding vowel gesture. Either the trajectory of the vowel must change, producing a raised intrusive vowel, or the trajectory of the consonant must change, losing its secondary articulation. In Ross-shire, the two strategies are evidently both present, in variation.

4.6.6. Intrusive [ə]

There is one more circumstance in a vowel that is historically intrusive does not have the same quality as the previous vowel. The intrusive vowel in Barra is transcribed as [ə] between [m] and [l'] or [r]. Borgstrøm normally transcribes [ə] only in unstressed, reduced, syllables, suggesting that this intrusive vowel has an unusually short duration.

- (212) Barra intrusive [ə] B37:128
- | | | |
|----|---------|-----------|
| a. | iməl'ak | 'naval' |
| b. | iməl'iç | 'to lick' |
| c. | iməɾay | 'mention' |

Bosch (n.d.) states that “the epenthetic schwa does not exhibit the atypical stress and pitch pattern of the full epenthetic vowel—instead, the inserted schwa is unstressed.” Borgstrøm 1937, who treats intrusive vowels as involving special syllabification, also comments that “the syllabic division is not so clear as otherwise” (128). I assume that this vowel intrusion does not involve a [VR]_α structure. Either the vowel has been reanalyzed a segment, and hence is no longer intrusive, or else it is the type of intrusion resulting from C-C phasing constraints. There are also a few cases of intrusive schwa in the

Bernera dialect: [ʃinɔvadə] ‘old stick’, [sk’il’əb] ‘chisel’ (B40:212, 83); I do not know whether these are of the same type as in Barra.

4.7. Conclusion

Scots Gaelic vowel intrusion illustrates how gestural phasing can interact with aspects of phonological structure different than segmental ordering, or syllable affiliation. I have argued that symmetrical vowel intrusion depends on the existence of a particular subsyllabic constituent, α , which is equivalent to the traditional notion of a nucleus. Two segments joined under an α node are subject to identical phasing constraints, which pressures them to be simultaneous. A similar pressure for simultaneity has been argued to exist in onsets, by Browman and Goldstein 2001. These patterns suggest that the traditional constituents of the syllable- onset, nucleus, and coda- may be definable in gestural terms, as segments that are subject to particular types of phasing constraints.

I have proposed a place for symmetrical vowel intrusion groups within the typology of heavy nuclei. When the constraints that cause symmetrical vowel intrusion are reranked, they produce α structures with the characteristics of vocalic diphthongs, “RV diphthongs”, or vowel coalescence. All of these are ways in which two segments join to form a single bimoraic syllable nucleus. In the theory presented here, they are structurally very similar. The difference between RV diphthongs and symmetrical vowel intrusion is only one of phasing, as is the difference between vocalic diphthongs and vowel coalescence.

The next chapter will show that Hocank has symmetrical vowel intrusion similar to that of Scots Gaelic, but involving a different linear order of segments: Hocank has symmetrical vowel intrusion in $[RV]_{\alpha}$ structures rather than $[VR]_{\alpha}$.

4.8. Appendix: consonant cluster charts

The chart below summarizes Oftedal’s lists of clusters that occur postvocally in the Leurbost dialect, and clusters that trigger vowel intrusion. He cautions that “the following list cannot be regarded as complete. Many of the gaps in the list are purely accidental” (O47). Clusters that trigger vowel intrusion are shaded; clusters that surface intact are unshaded. Some clusters trigger vowel intrusion only in certain circumstances. These clusters are written twice, once with and once without shading. A dash ‘-’ after a cluster indicates that it is found only word-medially; the absence of a dash indicates that the cluster is found only word-finally; a dash in parentheses indicates that the cluster is found both word-medially and word-finally.

(213) Scots Gaelic C₁C₂(C₃) clusters, Leurbost dialect(a) Clusters where C₂ is a stop

| | p | b | t | d | t' | d' | k | g | k' | g' |
|------------------------------|-----------|------------|----------------|-------|---------|---------|-------------|----------------|--------|---------|
| p,b,t,d,t ,d',k,k' ,g' | | | | | | | | | | |
| g | | | | gd- | | | | | | |
| f | | | | fd | | | | | | |
| v | | | | | | | | | | |
| ç | | | | | | çd'(-) | | | | |
| ǰ | | | | | | | | | | |
| x | | | | | | | | xg(-) | | |
| ʏ | | | | | | | | | | |
| s | | sb- | | sd(-) | | | | sg(-), sgL- | | |
| ʃ | | | | | | ʃd'(-) | | | ʃg'(-) | |
| h | | | | | | | | | | |
| m | mp - | mb | | | | | | | | |
| N | | | Nt(-), Ntr- | Nd(-) | | | Nk(-) Nk | Ng(-) | | |
| N' | | | | | N't'(-) | N'd'(-) | | | | N'g'(-) |
| n | np | | | | | | | | | |
| L | Lp- Lp | L-b | Lt(-) | | | | Lk | Lg | | |
| L' | | | | | L't'(-) | | | | | |
| l | | | | | | | | | lk' | lg' |
| R | | | Rt | Rd(-) | | | Rk | | | Rg' |
| r | rp(-) | rb-, rb | | | | | rk(-) | rg | | |
| ř (r') | | | | | řt'(-) | | řkn- | | řk'(-) | řg' |
| j | jp | | | | | | | | | |

(b) Clusters where C₂ is a fricative or affricate

| | f | v | ç | ǰ | x | ɣ | s | ʃ | h | j |
|------------------------|-----------|-----|----|---|-----------|----|-------------------------------|--------|-----|----|
| p,b,t,d | | | | | | | | | | |
| t' | | | | | | | | t'ʃ(-) | | |
| d' | | | | | | | | d'ʃ(-) | | |
| k | | | | | | | | | | |
| g | | gv- | | | | | | g'ʃ(-) | | |
| k', g' | | | | | | | | | | |
| f | | | | | | | | | | |
| v | | | | | | | | | vh- | |
| ç, ǰ, x, ɣ, s, ʃ, h | | | | | | | | | | |
| m | | | mç | | | | | mʃ | | |
| N | | | Nç | | Nx | | Ns- | | | |
| N' | | | | | N'x | | | N'ʃ- | | |
| n | | nv | nç | | nx | | | | | |
| L | | Lv | | | Lx | | | | Lh- | |
| L' | | | | | L'x | | | | | |
| l | lf- | lv | | | | | | | lh- | lj |
| R | | | | | | | Rs(-), Rsb-, Rsd(-) | | Rh- | |
| r | rf- rf | rv | | | rx- rx | rɣ | | | rh- | |
| ð (r') | | ðv | ðç | | ðx | | | | ðh- | ðj |
| j | | | | | | | | | jh- | |

(c) Clusters where C₂ is a sonorant

| | m | N | N' | n | L | L' | l | R | r | ð |
|--------|----|-----|------|-------|-----|------|-----|---|-----------|------|
| p | | | | | | | | | br- | bð- |
| b | | | | | | | | | | |
| t | | | | | | | | | tr- | |
| d | | | | | | | | | dr- | |
| t' | | | | | | | | | | t'ð- |
| d' | | | | | | | | | | d'ð- |
| k | | | | | kL- | | | | kr- | |
| g | | | | | gL- | | | | gr- | |
| k' | | | | | | | | | | |
| g' | | | | | | | | | | g'ð- |
| f | | | | | | | | | fr- | |
| v | | | | | | | | | vr-(?) | |
| ç | | | | çn- | | | | | | |
| ǰ | | | | | | | | | | |
| x | | | | xn- | xL- | | | | xr- | |
| ɣ | | | | ɣn- | | | | | | |
| s | | sN- | | | | | sl- | | sr- | |
| ʃ | | | ʃN'- | | | ʃL'- | | | | ʃð- |
| h | | | | | | | | | | |
| m | | | | mn | | | | | mr- mr | |
| N | | | | | | | | | | |
| N' | | | | | | | | | | |
| n | nm | | | | | | | | nr- | |
| L | Lm | | | | | | | | | |
| L' | | | | | | | | | | |
| l | lm | | | | | | | | | |
| R | | | | Rn(-) | | | RI- | | | |
| r | rm | | | | | | | | | |
| ð (r') | ðm | | | | | | | | | |
| j | | | | | | | | | | |

CHAPTER 5. HOCANK (WINNEBAGO)

5.1. Introduction

In chapter 4, it was argued that Scots Gaelic vowel intrusion results from the creation of a [VR]_α nucleus. The Siouan language Hocank (also known as Winnebago) has a very similar structure, except that it involves [RV]_α nuclei. This view of intrusive vowels turns out to have interesting consequences for the well-known problem of Hocank accent. The accentual pattern, which is usually analyzed with rule ordering, can be analyzed in a non-serial framework if CVRV is treated as monosyllabic.

5.1.1. Conditioning environment for vowel intrusion

Symmetrical vowel intrusion, traditionally known as “Dorsey’s Law”, is triggered by all the CR cluster types that exist in the language. Below are examples of each. Data is taken from Miner 1979, Miner 1992, Miner 1992b, Miner’s undated Grammar, Hale & White Eagle 1980, White Eagle 1982, and Susman 1943, abbreviated as M79, M92, M92b, M(n.d.), HWE, WE, and S.

| | | | | |
|-------|-----|------------|-------------------------------|---------|
| (214) | kr | karáire | ‘they departed returning’ | M79:29 |
| | kn | kānák | ‘put s.th. not having length’ | M79:26 |
| | kw | hokewé | ‘enter’ | M79:30 |
| | pr | parás | ‘flat’ | M79:27 |
| | pn | bo:púnūs | ‘hit at random’ | M92:30 |
| | sr | serétʃ | ‘long, tall’ | M79:27 |
| | sn | wasúnú | ‘spit, roast’ | M79:27 |
| | sw | gisewé | ‘calm down’ | M92:30 |
| | ʃr | ʃuruʃgé | ‘you (sg.) untie it’ | M79:30 |
| | ʃn | ʃíní | ‘cold’ | M92:30 |
| | ʃw | ʃawaʒók | ‘mash’ | HWE 124 |
| | tʃw | tʃiwítʃiwĩ | ‘reverberating’ | M79:26 |
| | xr | ʃuruxúruk | ‘you (sg.) are able’ | M79:30 |
| | xn | ũ:xĩní | ‘ashes’ | M92b |
| | xw | xuwuxúwu | ‘brittle’ | M79:29 |

These clusters all consist of voiceless obstruents and sonorants. Homorganic combinations involving plosives ([pw, tʃn, tʃr]) are absent, but the homorganic fricative – sonorant combinations [sn, sr] do occur. Susman 1943:15 describes [r] as a single-flap tongue tip alveolar trill.

In the following chart, clusters that trigger vowel intrusion are shaded, and clusters that surface at the beginning of a phrase are unshaded²¹. (S20)

(215)

| | p | t | k | g | tʃ | dʒ | s | ʃ | x | m | n | r | w | j | h | ʔ |
|----|---|----|---|-----|----|-----|----|----|---|---|----|----|-----|---|---|----|
| p | | | | | | | ps | pʃ | | | pn | pr | | | | pʔ |
| t | | | | | | | | | | | | | | | | tʔ |
| k | | | | | | kdʒ | ks | kʃ | | | kn | kr | kw | | | kʔ |
| tʃ | | | | tʃg | | | | | | | | | tʃw | | | |
| s | | st | | sg | | | | | | | sn | sr | sw | | | sʔ |
| ʃ | | | | ʃg | | ʃdʒ | | | | | ʃn | ʃr | ʃw | | | ʃʔ |
| x | | | | xg | | xdʒ | | | | | xn | xr | xw | | | xʔ |

In native words, CR clusters predictably undergo vowel intrusion. Borrowings, however, like [črá:k] *truck* and [sná:p] *snuff* (M92b), sometimes lack intrusive vowels where they would be expected, as pointed out by John Koontz (p.c.). This may be a case of incomplete nativization of loanwords, but even so, it shows something important about Hocank vowel intrusion: that it is unlike the highly automatic and unconscious timing patterns that produce vowel intrusion in most languages. For example, Wiik 1965:28 reports that Finns who have vowel intrusion don't perceive the difference between English *scalloping* and *scalping*, so presumably these speakers couldn't refrain from adding intrusive vowels to borrowings even if they wanted to.

I have argued in chapter 4 that symmetrical vowel intrusion in Scots Gaelic can be indirectly lexically specified. Timing itself is not contrastive, but vowel intrusion is caused by a structure “α” whose presence is contrastive. The loanwords above suggest that lexical specification might play a role in Hocank vowel intrusion as well, and this would be fully consistent the theory of symmetrical vowel intrusion developed in chapter 4. However, two loans are limited data. Lacking more extensive evidence that vowel intrusion requires lexical specification, I will assume in the analysis below that intrusion is synchronically motivated and enforced in Hocank.

5.2. Evidence for monosyllabicity, monosegmentality

In Hocank, there is less of a tradition of describing intrusive vowel sequences as monosyllabic than there is in Scots Gaelic. The fieldworkers Susman and Miner describe them as disyllabic, although Susman 1943:13 notes that they may be the “functional

²¹ Miner's Lexicon contains one root that may involve vowel intrusion in a different cluster: [kʔorokʔoros] ‘be hollow’. This root behaves like a vowel intrusion sequence in that it reduplicates in its entirety; I do not know whether it has the “fast” phonetic realization of vowel intrusion sequences. There are apparently no other examples of underlying /kʔr/ in the language. The Lexicon also contains one word, [tʃwe:k] ‘snipe’, which lacks vowel intrusion in a cluster that usually produces it (tʃw/). Miner writes ‘sic’ after this entry, perhaps indicating uncertainty about its accuracy.

equivalent” of one long syllable or “be regarded...as playing the part of one long syllable”. Only Alderete 1995 and Clements 1991 (who follows Steriade 1990’s gestural analysis) explicitly claim that Hocank intrusive vowel sequences are monosyllabic.

Fieldworkers do not report having tried to discern speakers’ intuitions about syllabification with segmentation tasks or direct questions the way Borgstrøm 1940 and Oftedal 1956 did for Scots Gaelic. White Eagle, who is a native speaker, has published a study of Hocank accent (Hale and White Eagle 1980), but she does not explicitly discuss her own intuitions about syllable structure. Hale & White Eagle treat intrusive vowel sequences as disyllabic, but they also treat what others describe as long vowels and diphthongs as disyllabic, so by “syllable” they apparently mean what others call a mora.

However, intrusive vowel syllables phonologically pattern like single syllables, and the two vowels together act like a single segment. Miner 1992 points out three ways in which CVRV does not behave like an ordinary disyllable: reduplication, contextual nasalization, and ablaut. Restrictions on root size may be added to this list. As in Scots Gaelic, linguists report that intrusive vowel sequences sound different than normal CV.CV sequences, although instrumental confirmation is lacking for Hocank.

5.2.1. Reduplication

Hocank reduplicants are normally monosyllabic, taking the form of an infix when the root is CV:C, or a suffix otherwise. The reduplicants are in bold below.

(216) Reduplication

| | | | | |
|--------|---------------|------------|-------------------------------------|--------|
| gihú | ‘swing’ | gihuhú | ‘wag tail’ | M92:29 |
| hit’ é | ‘speak, talk’ | hit’et’ é | also ‘speak, talk’ | M92:29 |
| ratʃgǎ | ‘drink’ | ratʃgǎtʃgǎ | ‘drink repeatedly’ | M92:29 |
| mā:nǐ | ‘walk’ | mā:nǐnǐ | ‘walk a little’ | S33 |
| wafǐ | ‘dance’ | wafǐfǐ | ‘dance a little, stop, dance again’ | S33 |
| wa:zǐ | ‘to suckle’ | wa:zǐzǐ | ‘to suckle a little at a time’ | S34 |
| | | sga:sgáp | ‘sticky’ | M79:29 |
| | | ʒo:ʒók | ‘slippery’ | M79:29 |

In intrusive vowel sequences, however, not only the final CV but the entire sequence is copied. They are the only sequences longer than C(C)V that may reduplicate.

| | | | | |
|-------|--|-----------------|------------|------------------------|
| (217) | Reduplication of intrusive vowel syllables | | | |
| | -kereʃ | ‘make designs’ | kerekéreʃ | ‘spotted’ / ‘colorful’ |
| | tʃiwi | ‘reverberating’ | tʃiwitʃiwi | also ‘reverberating’ |
| | ʃará | ‘bald’ / ‘bare’ | ʃaraʃára | ‘bald in spots’ M92:29 |
| | parás | ‘flat’ | parapáras | ‘wide’ M79:29 |
| | (root glosses not given for rest) | | kirikiris | ‘striped’ S33 |
| | | | poropóro | ‘spherical’ M79:26 |
| | | | xaraxára | ‘in slices or leaves’ |
| | | | xuwuxúwu | ‘brittle’ |
| | | | kūnūkúnūs | ‘cartilaginous’ M79:29 |

If intrusive vowel sequences are monosyllabic, we can maintain the generalization that the reduplicant is maximally one syllable, without exceptions.

(218) /ʃra + REDUPLICANT/ → ʃara.ʃára

Non-intrusive CV₁CV₁ sequences do not show this special reduplication pattern. Words like [howó] ‘swollen’, [xeté] ‘big’, and [heré] ‘to be’ reduplicate only their final CV, like other disyllables. Therefore, the reduplication pattern cannot be analyzed as simply having a special provision for identical vowels.

5.2.2. Root Size

Another way in which Hocank morphology counts syllables is in its restriction on root size. According to Miner (n.d.:37), “Verb roots in Winnebago are normally (in those cases where analysis is possible) monosyllables or Dorsey’s Law sequences. Typical roots are *xée* ‘buy’; *šgáac* ‘play’; *keré* ‘return’.” Dorsey’s Law is the traditional term for vowel intrusion. In other words, an ordinary two syllable sequence cannot be a root, but a vowel intrusion sequence can. If intrusive vowel sequences are regarded as monosyllabic, then the pattern is simply that all roots are one syllable.

5.2.3. Nasalization

Contextual nasalization provides evidence that the intrusive vowel and following vowel are actually the same segment and same gesture. When one of the two vowel portions in an intrusive vowel sequence undergoes contextual nasalization, the other must also. [i, a, u] nasalize after a nasal consonant, as in the following words.

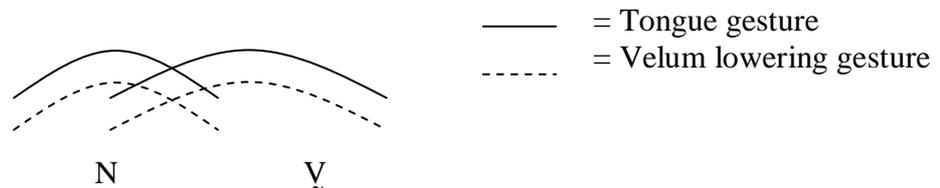
| | | | |
|-------|-------------------------|-----------------|--------|
| (219) | Contextual nasalization | | M92:30 |
| a. | mǎ: | ‘earth, ground’ | |
| b. | nǐ: | ‘water’ | |
| c. | wamǎnúke | ‘thief’ | |

Nasalization is also contrastive in Hocank, as in the following words.

- (220) Contrastive nasalization M92:29
- | | | | | |
|----|------|-----|------|--------------------------|
| a. | ha:k | vs. | hã:k | ‘rear part’, ‘woodchuck’ |
| b. | gisú | vs. | gisũ | ‘(de)husk’, ‘upset’ |

These contrasts show that the language allows a vowel to be associated with its own velum lowering gesture. I will assume that even contextually nasalized vowels have a separate velum lowering gesture; contextual nasalization is not merely an extension of the consonant’s velum gesture over the vowel.

- (221) Contextual nasalization



When vowel intrusion is triggered by a C[n] sequence, both vowel portions surface as nasal, even though the first one is not after a nasal segment on the surface.

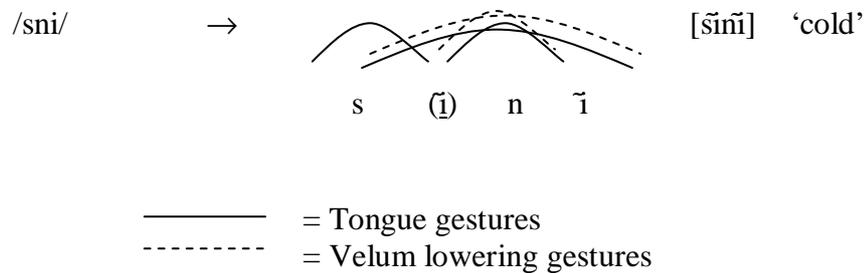
- (222) Nasalization with vowel intrusion M92:30
- | | | | | |
|----|----------|-----|------|-----------------|
| a. | kãnãk | vs. | krãk | ‘marry’ |
| b. | šĩnĩ | | | ‘cold’ |
| c. | bo:pũnũs | | | ‘hit at random’ |

Under the theory that the two vocalic sections are the same segment, it is natural that both have the same nasality in the output. The segmental string is /CnV/. Since the vowel’s velum lowering gesture (dotted below) is attached to the entire vowel segment, the part of the vowel that is phonetically realized before the [n] is nasalized as well.²²

²² John Koontz points out (p.c.) that historically, the nasality may originate with the vowel in some cases. For example, the word [kãnãk] ‘marry’ has been reconstructed as historical *krãk. [r] changed to [n] before nasal vowels. If the synchronic grammar also treats [kãnãk] as underlyingly /krak/, this would mean that the vowels are underlyingly, not contextually, nasal. If so, their featural identity is unremarkable under any account.

However, this historical explanation does not seem to apply to all C[n] clusters. According to Wolff 1950, Proto-Siouan *[sn] is realized as sV₁nV₁ in Hocank, so presumably a word like [šĩnĩ] ‘cold’ comes from an original *[sn] cluster with a vowel that could have been underlyingly oral or nasal. In this case, the predictable nasality of the intrusive vowel must be contextual, not underlying.

(223) Nasalization with vowel intrusion



Contextual nasalization shows that the intrusive vowel cannot have different gestural specifications than the following vowel, as predicted if they are in fact one gesture and one segment. A similar pattern occurs with ablaut, discussed below.

5.2.4. Ablaut

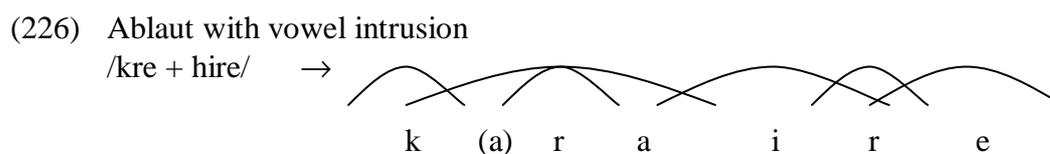
Many Hocank stems change their final [e] to [a] before certain suffixes. Below, the segments that have undergone ablaut are shown in bold in the second column.

| | | |
|--------------|-----------|-------------------------------|
| (224) Ablaut | | M92:30, Miner n.d.:42 |
| waré | wararé | ‘work / imperative’ |
| mā:tjé | mā:tjaire | ‘cut a piece off / 3pl.’ |
| té: | tá:nā | ‘I go / I could go’ |
| hīxé | hīxawi | ‘he buries me / he buries us’ |

In the words above, only the final vowel of a stem undergoes ablaut. But if a stem ends in an intrusive vowel sequence involving the vowel [e], both [e] portions change to [a].

| | | |
|-----------------------------------|-----------|---------------------------------|
| (225) Ablaut with vowel intrusion | | M92:30 |
| keré | karáire | ‘leave returning / 3pl.’ |
| mā:pére | mā:páranā | ‘slice thin / could slice thin’ |
| gisewé | gisawánák | ‘calm down / calm down sitting’ |

Under the hypothesis that the vowels are really one segment and one gesture, the ablaut actually affects only the final stem vowel as usual.



Ablaut and contextual nasalization are alike in that they are segmental changes that affect both vowels in an intrusive vowel sequence, although only the second appears to be in the correct position.

In non-Optimality Theoretic frameworks, all of the patterns described above (reduplication, root size restrictions, ablaut, nasalization) must be analyzed with rule ordering. Miner 1992 analyzes vowel intrusion as a rule of Epenthesis, which applies after Nasalization, Reduplication and Ablaut. This type of analysis is successful in modeling the interaction of these processes, but as argued in chapter 2, it is not necessarily explanatory from a cross-linguistic perspective. A rule ordering analysis doesn't explain why this particular kind of "epenthesis" (insertion of a copy vowel into CR or RC clusters) is, across languages, virtually always ordered last, while other types of epenthesis and even copy vowel epenthesis are not. Rule ordering also does not explain why such sequences have different phonetic characteristics than ordinary CVCV sequences, as discussed in the next section.

5.2.5. Phonetics

Only impressionistic phonetic descriptions are available for Hocank, but they are consistent with the claim that intrusive vowel groups are heavy monosyllables. Miner 1979:26 calls them "fast sequences", because "the sequences are spoken (and apparently, sung) faster than other CVCV sequences." Susman 1943:10, who refers to such sequences as "CVCV morphemes" (although vowel intrusion can also happen between morphemes), comments that "in most surroundings, CVCV is intermediate in length between one long and two short syllables." She also observes: "In a "CVCV" morpheme which constitutes a phrase, the first vowel is shorter than normal. After a short unstressed syllable and before a stressed syllable, CVCV takes about the time of one long syllable" (S8). Thus, CVRV apparently has a shorter duration than a disyllable.

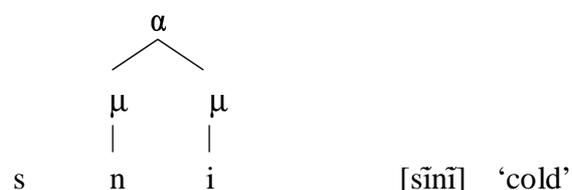
There is also evidence, discussed further in section 4, that CVRV syllables have different pitch patterns than disyllables. Susman 1943:13 claims that "secondary stress seems to attach equally to both syllables" of CVRV. This is strikingly similar to Borgström's and Oftedal's descriptions of stress being "shared" among the vowels of CVRV in Scots Gaelic.

5.3. Vowel intrusion as [RV]_α

5.3.1. Bimoraicity

I propose that Hocank vowel intrusion results from the same subsyllabic structure as Scots Gaelic vowel intrusion, discussed in chapter 4. A moraic sonorant and a vowel are united under an "α node", creating a bimoraic structure that is similar to the traditional notion of a nucleus. The only difference from Scots Gaelic is that V and R are in a different order in the input.

(227)



The symmetrical phasing of segments within the α structure is caused by the same constraint ranking as in Scots Gaelic. I do not repeat this part of the analysis here.

Like Scots Gaelic, Hocank syllables with symmetrical vowel intrusion are bimoraic. Evidence for their bimoracity comes primarily from the accentual system, which is analyzed in section 4. Also, as noted in section 2.1, the intrusive vowel sequence reduplicates as an infix, which bimoraic but not monomoraic syllables do. In addition, a minimal word pattern treats these syllables as heavy. Hocank does not allow monomoraic words. Only the nucleus determines syllable weight: CV(C) is light and CV:(C) or CVV(C) heavy. Therefore, monosyllables always have a long vowel (HWE130, M92:39).

| | | | |
|-------|---------------------------------|---------|--------------------------------|
| (228) | Predictable V: in monosyllables | | HWE 130 |
| | tʃi: | ‘house’ | ra:p ‘beaver’ |
| | na: | ‘wood’ | zi:k ‘squirrel’ |
| | wā:k | ‘man’ | sḍʒa:k ‘be warm’ (Miner 1992b) |

Intrusive vowel sequences can stand alone as words without lengthening of the vowel, as in [s̃iṁí] ‘cold’. This indicates that they are bimoraic, with the \underline{VRV} sequence equivalent to a long vowel in weight. If the sonorant were not moraic, we would expect lengthening to *[s̃iṁí:].

5.3.2. Nasality restrictions

In chapter 4, I pointed out that intrusive vowel sequences in one dialect of Scots Gaelic show restrictions on the distribution of nasal vowels that are unique within the language. An intrusive vowel sequence containing a non-nasal sonorant cannot have a nasal vowel, although in ordinary syllables nasal vowels can follow or precede non-nasal consonants. I proposed that constraints limit the licensing of nasality within $[VR]_{\alpha}$.

- (229) Licensing of nasality (Barra Gaelic)
 Complex α structures do not license independent nasality unless both of their constituent segments are segments that can be independently nasal.

Hocank $[VR]_{\alpha}$ show evidence of a similar restriction. Susman 1043:26 observes that “Only the nasal vowels may follow m and n, and e and o, which have no nasal equivalents, may follow these nasal consonants in ordinary syllables, but not CVCV.” (CVCV is her term for intrusive vowel sequences). In other words, a nasal consonant may not co-occur with a vowel that is incapable of being nasal. Hocank thus provides additional evidence that segments within $[VR]_{\alpha}$ structures are subject to special co-occurrence restrictions that do not apply to ordinary adjacent consonants and vowels.

5.3.3. Motivating vowel intrusion

The motivation for creating α structures appears to be different in Hocank than in Scots Gaelic. I have argued that in Scots Gaelic, creating α is a way of avoiding overlap

between certain kinds of consonants, whether they are tautosyllabic or heterosyllabic. Minimizing overlap in RC clusters helps to make contrasts among the nine coronal sonorants more acoustically salient. The creation of $[VR]_{\alpha}$ does not seem to be conditioned by syllable structure in Gaelic. In Hocank, however, I will argue that syllable structure does matter. Only tautosyllabic clusters have intrusion, and the motivation for creating $[RV]_{\alpha}$ structures is to avoid complex onsets. Preserving contrasts is less of a problem in Hocank, which has only five sonorants in total.

An onset segment can be defined as a segment preceding an α structure within a syllable. The prohibition on complex onsets is actually inherent in some of the C-V phasing constraints already proposed. As discussed in chapter 4, Browman & Goldstein 2001 propose that, within a syllable, every consonant before the vowel wants to have the same phasing relation with respect to the vowel. This was captured with the following constraint:

- (230) ALIGN (C, LANDMARK¹, V, LANDMARK²)
 If C and V belong to the same syllable, and C precedes V (not necessarily directly), landmark¹ of C is simultaneous with the landmark² of V.

In a C_1C_2V sequence, this constraint applies to both C_1 and C_2 . It is impossible to give both consonants the desired phasing, without having them fully overlap. Hence, the constraint above automatically penalizes complex onsets: it can only be fully satisfied when there is no more than one prevocalic consonant in the syllable.

I propose that incorporating the R of a CRV sequence into α is a way of eliminating the complex onset and better satisfying the constraint above. To capture this formally, it will be necessary to adjust the constraint to refer to α structures.

- (231) ALIGN (C, LANDMARK¹, α , LANDMARK²)
 If C and α belong to the same syllable, and C precedes α (not necessarily directly), landmark¹ of C is simultaneous with the landmark² of α .

This constraint assumes that the entire α structure has gestural landmarks that can be referred to for phasing, and that flanking consonants are phased with respect to the α complex as a whole.

As stated in chapter 4, I assume that all vowels are dominated by α . For simplicity, vowels are shown as underlyingly dominated by α . The constraint DEP- α prohibits placing additional segments under α .

- (232) DEP- α
 A segment that is dominated by α in the output is dominated by α in the input.

The following tableau shows the options for realizing a CRV sequence. If the C and R fully overlap, as in a), this satisfies the alignment constraints but violates the higher-ranked *C IN C. If C and R are left in the onset but do not fully overlap, as in b), then at least one of the onset consonants must violate ALIGN (C, ONSET, α , ONSET). If R is incorporated into the nucleus α , as in c), this allows full satisfaction of the phasing constraints, but violates faithfulness. The ranking *C IN C >> ALIGN (C, ONSET, α , ONSET)

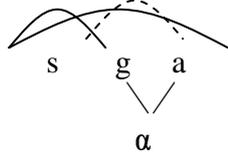
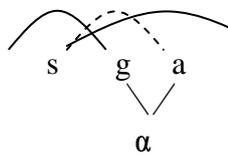
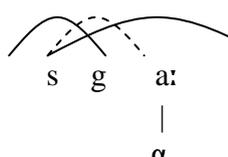
>> DEP- α produces chooses candidate c), where R is under α . Other phasing constraints, given in chapter 4, will cause candidate c) to have symmetrical vowel intrusion.

(233) [kere] ‘leave returning’

| /kre/ α | *C IN C | ALIGN (C, ONSET, α , ONSET) | DEP- α |
|------------------------|---------|---------------------------------------|---------------|
| a. | *! | | |
| b. | | *! | |
| c. → | | | * |

This repair for complex onsets is not available when the onset consists of two obstruents. Putting an obstruent into an α structure would require it to have heavy overlap with the vowel. As established in chapter 1, such overlap is more marked for obstruents than sonorants: *OBSTRUENT IN V is universally higher ranked than *SONORANT IN V. The tableau below shows how *OBSTRUENT IN V blocks vowel intrusion in /sga:/ ‘white’. Candidate a) adopts the repair of placing [g] under α . It is eliminated because this requires heavy overlap between [g] and [a], violating *OBSTRUENT IN V.

(234) [sga:] ‘white’

| /sga/ α | *OBSTRUENT IN V | CONSTRAINTS CAUSING CENTERING WITHIN α | ALIGN (C, ONSET, α , ONSET) | DEP- α |
|--|--------------------|---|--|------------------|
| a.  [saga] | *! | | | * |
| b.  [sga] | | *! | * | * |
| c. →  [sga:] | | | * | |

In short, the creation of α structures is a strategy for removing complex onsets in Hocank. This strategy can only be used for CR clusters, because non-sonorant consonants can't be in α structures in Hocank. Hence, CC clusters consisting of two obstruents surface intact.

5.3.4. Syllable structure effects, and a second type of vowel intrusion

In the analysis above, vowel intrusion is conditioned directly by syllable structure. Many descriptions, however, claim that vowel intrusion is conditioned by morphological factors. There are, in fact, generalizations about where vowel intrusion occurs that can be stated in terms of morphological boundaries. In most cases, an intervocalic CR cluster triggers symmetrical vowel intrusion if the consonants are tautomorphemic, but a different, short intrusive vowel appears if the consonants are heteromorphemic. There is evidence, however, that morphology plays a role only in so far as it determines syllable boundaries.

If an intervocalic CR cluster is tautomorphemic, it always has symmetrical vowel intrusion. Tautomorphemic CR clusters occur in many roots and in at least two suffixes--the declarative [-ʃānā], and [-ʃūnū] meaning ‘customarily’ (M92:43)²³. But if an

²³ Miner's Grammar also contains the suffixes [ʃāwāk] ‘you (sg)’ and [aʃāwāk] ‘you (pl)’, which appear to contain vowel intrusion.

intervocalic CR cluster is heteromorphemic, it has a different intrusive vowel: a schwa that Miner 1979 describes as having “more or less the quality of a short version of the following full vowel” (i.e. the vowel adjacent to the sonorant, as is typical in vowel intrusion.) It is usually not transcribed. Examples of this schwa at different morpheme boundaries are given below.

| | | | |
|-------|------------------------------|--|-------------------|
| (235) | [ə] intrusion | | M92:31 |
| | Before suffixes: | | |
| | a. | wańík | ‘bird’ |
| | b. | wańig ^ə ńík | ‘little bird’ |
| | c. | wańig ^ə ńig ^ə ra | ‘the little bird’ |
| | Between roots in a compound: | | |
| | d. | pe:tʃ | ‘fire’ |
| | e. | wa:tʃ | ‘boat’ |
| | f. | pé:dʒ ^ə wá:tʃ | ‘locomotive’ |

This intrusive schwa appears to consist of just a short, variable release between consonants. Like the cases discussed in chapters 1 and 2, it can be produced by C-C phasing constraints. It does not involve an [RV]_α structure. Syllables containing intrusive schwa do not count as bimoraic in the accentual system, the way syllables with long intrusive vowels do. Another difference between the two intrusive vowels is that obstruents that precede an intrusive [ə] are always voiced, while obstruents that precede a long intrusive vowel are not.

I propose that the reason symmetrical vowel intrusion does not occur in heteromorphemic CR is that these clusters are also heterosyllabic. There is no complex onset, so there is no reason to build a [RV]_α structure. Evidence for syllabification comes from pausing. In describing the pre-sonorant voicing pattern, Susman 1943:18 notes that “if the slightest pause occurs, the sonant and glide vowel is replaced by the corresponding surd (hã:brá ‘the day’, resolves into hã:p-ra).” Speakers generally prefer to pause between syllables, not within onset clusters, so the placement of the pause between the C and the R suggests they are heterosyllabic²⁴. Incidentally, speakers do not need to pronounce the [p] with the preceding syllable in order to make that syllable a minimal word, a consideration which has been proposed to affect pausing patterns in English. CV: words are well-formed in Hocank.

The following constraint prefers to align syllable and morpheme boundaries.

²⁴ Susman draws the opposite conclusion from the same data. She apparently reasons that the pre-sonorant voicing seen in [hã:bra] happens only in onsets, and hence is disrupted when the two consonants are separately syllabified as speakers pause. I assume that pausing is ordinarily determined by, and respects, syllable affiliation. Voicing is conditioned by gestural overlap between consonants, and for this reason is blocked by pausing.

(236) ALIGN (MORPHEME, SYLLABLE)

Every morpheme edge coincides with a syllable edge.

In Hocank, ALIGN (MORPHEME, SYLLABLE) is ranked above DEP- α . Therefore, the grammar prefers to remove complex onsets by creating [RV] $_{\alpha}$ rather than by misaligning morpheme and syllable boundaries. In the tableau, candidates a) and c) show two possible repairs for a [kr] onset: a) splits [k] and [r] between different syllables, while c) puts [r] into the nucleus under α . Candidate a) does not have a syllable boundary between [i] and [k], where there is a morpheme boundary. Therefore, a) violates ALIGN (MORPHEME, SYLLABLE) and is eliminated.

(237)

| /hi + kre/ | ALIGN (MORPHEME, SYLLABLE) | ALIGN (C, ONSET, α , ONSET) | DEP- α |
|---|----------------------------|------------------------------------|---------------|
| a. hik.re [higre] | *! | | |
| b. hi.kre [higre] | | *! | |
| c. → α / \ hi. kr e [hikere] | | | * |

Under this ranking, heteromorphemic C and R are heterosyllabic and there is no complex onset to be removed. Hence, there is no symmetrical vowel intrusion.

There are several advantages to the theory that vowel intrusion is conditioned by syllable structure, rather than by morphological structure directly. First, it explains why there is exactly one type of heteromorphemic cluster that does have symmetrical vowel intrusion: a CR cluster where the C is a prefix. There are two prefixes consisting of a single obstruent, which trigger vowel intrusion when they attach to a sonorant-initial root.

(238) /ʃ/ prefixation

guu

ʃguu

M92:31, S45

‘leave returning here / 2nd p.’

But: waʃĩ

ʃawaʃĩ

‘dance / 2nd p.’

rugás

ʃurugás

‘tear’ / 2nd p.’

ruʃíp

ʃuruʃíp

‘pull down’ / 2nd p.’

| | | | | |
|-------|-----------------|--------------------|--------------------------|--------|
| (239) | /k/ prefixation | | | M92:31 |
| | uu | k'uu | 'make, wear / one's own' | |
| But: | ruʃíp | ku <u>ru</u> ʃíp | 'pull down / one's own' | |
| | ratʃgǎ́ | ka <u>rat</u> ʃgǎ́ | 'drink one's / own' | |
| | | ka <u>ra</u> péres | 'one's-own-know' | S138 |

These word-initial clusters are the only situation where it is not possible to make a heteromorphemic C and R heterosyllabic. From the morphological-conditioning view, they are an exception, but from the syllable-conditioning view, they are unsurprising.

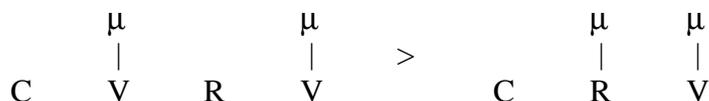
Relating Hocank vowel intrusion to syllable structure is also more consistent with the general typological characteristics of vowel intrusion, which are discussed in chapter 2. There are definitely cases where syllabification affects phasing, but none where it is clear that morphemic affiliation matters—for example, I have not found any non-derived environment blocking (NDEB) effects involving vowel intrusion. Pending such evidence, it is better to keep the more restrictive hypothesis that morphemic boundaries affect phasing only insofar as they affect syllable boundaries. No constraints refer directly to the phasing of segments belonging to different morphemes.²⁵

5.3.5. Historical source of moraic sonorants

While synchronically, Hocank [RV]_α structures and the resulting vowel intrusion can be analyzed as a way of avoiding complex onsets, this is probably not how they arose historically. The sonorant likely became moraic in order to preserve the mora of an elided syllable.

Miner 1979 suggests that CR clusters result from an earlier syncope, adding that “there may be a bit of evidence for this in Mandan”. An ancient syncope could explain why [RV]_α arose in the first place in this language family: as a strategy for preserving a mora originally associated with a deleted vowel.

(240) Hypothetical historical mora transfer



Thus, [RV]_α could historically be the outcome of a type of compensatory weight phenomenon. In this it would be like the “RV diphthongs” that Kaye 1995 proposes for some African languages: they also arose historically from CVRV. However, it does not

²⁵ It is possible, of course, that syllable structure and phasing relations are redundant structures: that the definition of being an onset, for example, is having a particular kind of phasing relationship to a following vowel. In a theory like this, morphological structure could be seen as directly affecting phasing, rather than determining syllable boundaries which in turn determine phasing. The important point remains the same: that there are not two separate factors, morphemic boundaries and syllable boundaries, that affect phasing.

seem necessary or illuminating to give a synchronic analysis that recapitulates this history.

The closely related language Chiwere may have bimoraic [RV]_α without the gestural timing that produces vowel intrusion. Chiwere words that are cognate to Hocank words with symmetrical vowel intrusion have a special accentual pattern. Normally, accent can fall either on the first or second syllable. But Miner notes that if a word contains a CRV syllable that is cognate to Hocank CVRV, accent falls predictably on that syllable, as shown by the examples below.

| | | | |
|-------|---------|----------|--------------------------|
| (241) | | | Whitman 1947, Miner 1979 |
| | Chiwere | Hocank | |
| a. | ugwé | hoikéwe | ‘enter’ |
| b. | waθlú | wasūnú | ‘spit, roast’ |
| c. | d̄ʒiglé | d̄ʒikeré | ‘become’ |
| d. | labláðe | raparás | ‘tear with the mouth’ |
| e. | lublíye | rupiríʃ | ‘curl’ |
| f. | gléblā | kerepána | ‘ten’ |
| g. | bláθge | parás | ‘flat’ |
| h. | θléd̄ʒe | serétʃ | ‘long, tall’ |

The Chiwere pattern can be explained if these CRV syllables are counted as heavy, and thus attract accent. Since the vowel is short, the second mora in a syllable like [gwe] or [θlu] could only be associated with the sonorant. This suggests that Chiwere, too, has [RV]_α, but without the symmetrical phasing of Hocank (and Scots Gaelic) ones. Instead, these would be like the “RV diphthongs” discussed in chapter 4.

5.4. Accent

The accentual system of Hocank is consistent with the view that intrusive vowel syllables are a kind of heavy syllable, as Hayes 1995:362 has also noted. In several ways, a CVRV sequence doesn’t behave like a sequence of light syllables: it can form the head of an iamb, and it cannot be split between two feet. However, CVRV does not behave exactly like other heavy syllables. Hocank associates a high tone with each foot head, and this tone is realized later after CVRV than after other heavy syllables. I will link this difference to the fact that such syllables have RV nuclei, and R doesn’t license tone.

A basic Optimality Theoretic analysis of Hocank accent is laid out in section 5.4.1–5.4.4, while 5.4.5 shows how intrusive vowels fit into the pattern. The following abbreviations are used throughout this section: L = light syllable, H = heavy syllable, H = a syllable with an intrusive vowel (which is a kind of heavy syllable), T or an acute accent = high tone, μ = mora, **μ** = prominent mora.

5.4.1. Late realization of tone

My analysis of Hocank accent assumes the basic iambic foot structure proposed by Hayes 1995. Hayes' analysis, made in the context of a typological survey of stress systems, is guided partly by the goal of describing Hocank in terms of theoretical apparatus whose existence is supported by other languages. Other studies have concluded that Hocank has patterns that are unknown elsewhere, such as initial extrametrical syllables, or foot boundaries that fall within syllables. I will not review here all the arguments against alternative analyses of Hocank footing, but refer the reader to Hayes 1995 for discussion.

Hayes proposes that Hocank is a pitch accent language that has iambic feet, and that often realizes accent on the syllable after the head of a foot. The following rules (simplified) apply:

- (242) Foot Construction: Form iambs left to right, optionally skipping a single light syllable between feet.
Tone Assignment: Assign high tone to the sonority peak of a syllable that is the head of its foot.
Tone Shift: From an initial or light syllable, shift tone one syllable to the right.

Below is an example of how this system places accent on [hokiwároké] 'swing' (M79:28).

- | | |
|-------------------|--------------------|
| (243) | /hokiwaroke/ |
| Foot Construction | (ho.ki).(wa.ro).ke |
| Tone Assignment | (ho.kí).(wa.ró).ke |
| Tone Shift | (ho.ki).(wá.ro).ké |

A shifting operation requires multiple stages of derivation, as in the ordered rules above. However, the insight that tone falls after the foot head can also be captured by aligning the beginning of the tone to the end of the prominent mora, and this does not require serial derivation.

It is cross-linguistically common for tones to be realized late. In Greek, for example, the F0 peak that is associated with a prominent syllable falls outside of the syllable altogether. It is consistently aligned just after the beginning of the following vowel (Arvaniti et al. 1998). In Japanese, there is also a tendency to realize the F0 peak in the following syllable, although less consistently (Sugito 1968, Hasegawa & Hata 1988). Other languages that realize tone late in or after the prominent syllable include Navajo (De Jong & McDonough 1993) and Mandarin (Xu 1997, 1998, 1999).

There is evidence that tones may be aligned with respect to moraic segments. For Dutch, Ladd et al. 2000 show that the high tone of a Low-High sequence is realized during the second half of a long vowel, but on the consonant following a short vowel. This difference holds even when a phonologically bimoraic vowel and a phonologically monomoraic vowel have the same physical duration. This is consistent with an analysis in which the high tone falls one mora after the low tone. Plausibly, a consonant following a

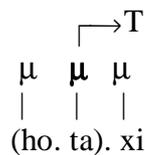
short stressed vowel is syllabified as a coda (perhaps ambisyllabic) in Dutch. Hence, it bears a mora, since coda consonants contribute to syllable weight in Dutch.

(244) Dutch *Low High* tone realization



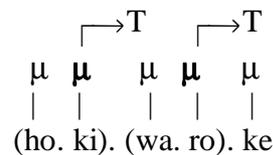
I suggest that Hocank, like Dutch, places high tone one mora after the first mora of the syllable that licenses it. Below, a tone is horizontally positioned over the mora that it is realized on. Iambic footing is shown with parentheses.

(245) a.



hotaxí ‘expose to smoke’

b.



hokiwároké ‘swing (n.)’

The reason Hocank, unlike Dutch, realizes tone as late as on the vowel of the next syllable is linked to the fact that in Hocank, only vowels are moraic. Hocank coda consonants never contribute to syllable weight: CV and CVC are light, while CV: and CV:C are heavy. If an accented syllable is monomoraic, and tone is to be realized one mora late, it must be realized on the following vowel.

5.4.2. Constraints on accent

A few markedness constraints suffice to regulate the introduction of tone. First, there is a constraint demanding that the right edge of each prominent position (defined below) be aligned with the left edge of a high tone.

(246) ALIGN (PROMINENCE, RIGHT; TONE, LEFT)

Every prominent position P licenses a single high tone T, and the left edge of T is aligned with the right edge of P.

Prominent positions are themselves determined by prosodic constraints which are not discussed here. In Hocank, I propose that prominent positions include the head syllable of the head foot (the main stressed syllable), and the first mora of the head of a non-head foot (a secondarily stressed syllable). The first foot is the head foot. Data discussed below will demonstrate that these are the positions that tone seems to associate with.

- (247) Prosodically prominent positions, Hocank (preliminary, revised in (260))
- a. The whole head syllable of the head foot of a word. Head feet are initial.
 - b. The first mora of the head syllable of a non-head foot.

ALIGN (PROMINENCE, RIGHT; TONE, LEFT) competes with a constraint that wants to align a tone to the beginning of every prominent position.

- (248) ALIGN (PROMINENCE, LEFT; TONE, LEFT)
 Every prominent position P licenses a single high tone T, such that the left edge of T is aligned with the left edge of P.

Note that it is not possible to satisfy both (PROMINENCE, RIGHT; TONE, LEFT) and (PROMINENCE, LEFT; TONE, LEFT), because each refers to a *single* tone. If two tones are introduced for a single prominent mora, one in each position, then neither constraint is satisfied. Both constraints want there to be only one tone; the ranking of the two constraints determines the first and second choices of where to place this tone.

The tonal alignment constraints compete with a faithfulness constraint against tonal epenthesis:

- (249) DEP-TONE
 A tone in the output has a correspondent in the input.

The following tableau shows a constraint ranking that produces late realization of tone in a string of light syllables. For this and following tableaux, candidates are shown in moraic structure, with prominent moras in bold.

Candidate a) has a tone on the mora after each prominent position, satisfying ALIGN (PROMINENCE, R; TONE, L). Candidate b) has a tone directly on each prominent mora, satisfying ALIGN (PROMINENCE, L; TONE, L). Candidate c) has no tone, which violates both the alignment constraints but satisfies faithfulness. Since ALIGN (PROMINENCE, R; TONE, L) is highest ranked, candidate a) wins.

(250) [hokiwároké] ‘swing (n.)’

| /hokiwaroke/ | ALIGN (PROMINENCE, R; TONE, L) | ALIGN (PROMINENCE, L; TONE, L) | DEP-TONE |
|--|--------------------------------|--------------------------------|----------|
| a. → ┌→T ┌→T (μ μ) (μ μ) μ [hokiwároké] | | ** | ** |
| b. T T (μ μ)(μ μ) μ [hokíwaróke] | *!* | | ** |
| c. (μ μ)(μ μ) μ [hokiwaroke] | *!* | ** | |

ALIGN (PROMINENCE, L; TONE, L) does play a role in determining the output in cases when the higher-ranked ALIGN (PROMINENCE, R; TONE, L) cannot be satisfied for some other reason. For example, late realization of tone is not possible when the prominent syllable is word-final: there is no following mora for tone to fall on.

As shown in the tableau below, the options for a word-final foot are to not realize the tone at all, as in candidate b), or to realize it on the prominent mora, as in candidate a). The choice between these two options is determined by the ranking of ALIGN (PROMINENCE, L; TONE, L) and DEP-TONE. In Hocank, the first is higher-ranked, so candidate a) wins.

(251) [wasgé] ‘dish, plate’

| /wasge/ | ALIGN (PROMINENCE, R; TONE, L) | ALIGN (PROMINENCE, L; TONE, L) | DEP-TONE |
|---|--------------------------------|--------------------------------|----------|
| a. → T (μ μ) [was.gé] | * | | * |
| b. (μ μ) [was.ge] | * | *! | |

Hence, a word-final (LL) foot has tone on the last syllable.

5.4.3. Initial feet

As stated in (247), the main stressed syllable is considered one prominent position. This captures the fact that tone is never realized on an initial, non-final sequence of (LL), (H), or (LH), but is always realized on the syllable immediately following one of these. In other words, the tone licensed by an initial foot is always realized late, when possible.

(252) Tone after initial feet

Initial LL

| | | | | |
|----|-------------------|------------------|-------------------|--------|
| a. | (LL) \acute{L} | ho. ta. xí | ‘expose to smoke’ | M79:28 |
| b. | (LL) $\acute{L}L$ | ha. ra. tʃáb. ra | ‘the taste’ | M79:28 |

Initial H

| | | | | |
|----|-----------------|----------|---------------------------|--------|
| c. | (H) \acute{H} | nā: wá:k | ‘he (moving) was singing’ | S10 |
| d. | (H) \acute{L} | ho: tʃák | ‘Hocank’ | M79:27 |

Initial LH

| | | | | |
|----|-------------------|------------------|----------------------|-----|
| e. | (LH) $\acute{H}L$ | xe. tea. rái. re | ‘they got big’ | S29 |
| f. | (LH) \acute{L} | hi. nā:. nák | ‘we (sitting) slept’ | S11 |

This pattern is fully parallel to that demonstrated in tableau (250); the only difference is that some of the prominent positions are whole bimoraic syllables.

Incidentally, the words in (257)e-f) differ from the description of the data in Alderete 1995:29 and Hayes 1995. Both claim that an LHL word is accented $L\acute{H}L$, both citing the same example, [kírí:nā] ‘returned’. But this word appears to be part of a pattern of exceptional accent before certain suffixes. According to S47 and M92:52, the declarative suffix [nā] regularly causes the preceding vowel to become long and accented regardless of its position in the word, as shown below.

(253) [nā] causing preceding V:

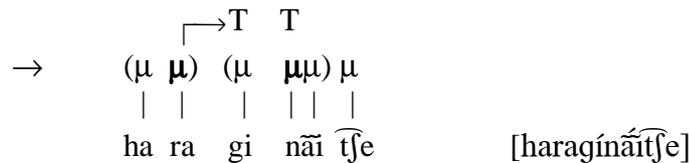
| | | |
|---------------------------------------|----------------------|-----|
| ha. pé:. nā | ‘he waited for him’ | S12 |
| pí:. nā | ‘it is good’ | S47 |
| nĩ. gi. gí:. nā | ‘I did to you’ | S47 |
| hā:ké k̄iri. ní:. nā | ‘he did not go back’ | S47 |
| (hā:ke...nĩ ‘not’; k̄irí ‘to return’) | | |

I assume that some morphological factor independent of the basic accentual system is at work in [kírí:nā]. Examples (252) e)–f) suggest that $L\acute{H}L$ is the normal pattern.

5.4.4. Heavy syllables (without intrusion)

In non-initial feet, heavy syllables appear with falling accent unless they contain opening diphthongs. Falling pitch presumably reflects tone on the first mora, rather than the second.

(254)



This is not expected according to the constraints proposed so far: we would expect tone to fall on the second mora, since the first mora of each foot head is considered a prominent position. However, rising tone within a syllable is avoided in many languages, including Hocank.

The constraint NORISE, which Gussenhoven 1997:15 proposes based on Roermond Dutch, penalizes a rise in pitch within a single syllable.

(255) NORISE * T (adapted from Gussenhoven 1997)
(μ μ)_σ

The effects of this constraint are seen in other languages, according to Gussenhoven. For example, Hausa allows falling but not rising tones within single syllables (Leben 1978:206). Toura allows four level tones and six falling tone patterns within syllables, but no rising tones (Bearth 1971). Possible phonetic grounding for NORISE is the fact that F0 rises take longer to produce than F0 falls (Ohala 1978). The durational confines of a single syllable may be small enough to make the realization of a rise difficult. Thus, this deviation from the usual tonal alignment in Hocank can be attributed to an independently motivated pressure.

The tableau below demonstrates how the constraints choose this pattern. Heavy syllables are shown as “**μμ**”, with the first mora bold to show its prominence. The location of tone within the syllable is indicated by placing T above the first or second mora. All the candidates realize tone late from the first foot, but differ on the treatment of the heavy syllable. Candidate b) realizes tone one mora after the prominent mora, according to the usual pattern. This results in rising tone in the syllable, violating high-ranked NORISE. Candidate c) avoids rising tone by realizing tone on the following syllable, but this makes the tone two moras late and fails to satisfy either alignment constraint. Candidate a) avoids rising tone by realizing the tone directly on the prominent element. This satisfies ALIGN (PROMINENCE, L; TONE, L), so candidate a) wins.

(256) [haragínáitʃe]

| /haragínáitʃe/ | NORISE | ALIGN (PROMINENCE, R; TONE, L) | ALIGN (PROMINENCE, L; TONE, L) |
|---|--------|--------------------------------------|--------------------------------------|
| a. $\rightarrow (\mu \mu) \begin{array}{c} \lrcorner \rightarrow T \\ (\mu \mu\mu) \mu \end{array} T$ haragínáitʃe | | * | * |
| b. $(\mu \mu) \begin{array}{c} \lrcorner \rightarrow T \\ (\mu \mu\mu) \mu \end{array} \rightarrow T$ haragínáitʃe | *! | | ** |
| c. $(\mu \mu) \begin{array}{c} \lrcorner \rightarrow T \\ (\mu \mu\mu) \mu \end{array} \begin{array}{c} \lrcorner \rightarrow T \\ (\mu \mu\mu) \mu \end{array}$ haragínáitʃé | | * | **! |

In this way, heavy syllables in non-initial feet are assigned tone on their first mora, which is heard as falling tone. There is one further detail to the pattern, not treated here: opening diphthongs do have rising tone rather than falling tone. This can be produced by a higher-ranked constraint demanding that the tonal profile match the sonority profile, but it is tangential to the main point here.

In summary, the normal accentual pattern in Hocank is to place tone one mora after initial feet and after light syllables that are heads of feet. Heavy syllables realize their own tone, normally on their first mora. The following section discusses the patterning of intrusive vowel syllables within this system.

5.4.5. Intrusive vowel syllables

As argued in section 3, syllables with symmetrical vowel intrusion are bimoraic, but contain an unusual type of nucleus: RV rather than VV or V:. In the accentual system, intrusive vowel syllables (H) behave like heavy syllables in that they always license a tone, but unlike normal heavy syllables, they realize this tone late. I attribute this to the fact that the first mora of (H) is associated with a consonant, which does not license tone. Tone is licensed by the second mora of (H), and hence realized later.

5.4.5.1. Initial feet

Word-initial feet provide evidence that an intrusive vowel syllable is not a sequence of two light syllables (S43:13). An initial (LL)L has tone on its third mora, while initial (LH) places its tone on the following mora. Thus, if a word like [hakaraxe] is (LL)LL, we expect tone on [ra]; if the structure is (LH)L, we expect tone on [xe]. The latter is what happens, as seen below.

(257) High tone after initial (LH) feet

| | | | |
|---------------------------|---|---------------------|---------|
| (LH) \acute{L} | ha. <u>ka</u> . ra. xé | ‘I buried my own’ | S13 |
| (LH) \acute{L} | hi. <u>ko</u> ro. hó | ‘prepare, dress’ | M79:30 |
| (LH) \acute{L} | gi. <u>sa</u> wa. nák | ‘calm down sitting’ | M92:30 |
| (LH) \acute{H} | wi. <u>ki</u> ri. páras | ‘cockroach’, | M79:30 |
| (LH) $\acute{H}\acute{H}$ | gi. <u>ka</u> nā. <u>ka</u> nāp. <u>ʃ</u> ānā | ‘it is shiny’ | M89:170 |
| (LH) $\acute{H}\acute{H}$ | wa. <u>ki</u> ri. <u>po</u> ro. <u>po</u> ro | ‘spherical bug’ | HWE 131 |

This pattern is expected under the theory developed so far: an intrusive vowel syllable is a single heavy syllable, and like other heavy syllables it realizes its tone late when it is the head of the initial foot. If intrusive vowel sequences were LL sequences, then their behavior in the above words would be exceptional. This is shown by the comparison between an LHL word and a LLL word below.

(258) Hypothetical LL interpretation of intrusive vowel words

| | | |
|-----|-------------------------------|------------------------|
| | (LL) $\underline{L}\acute{L}$ | ha. <u>ka</u> . ra. xé |
| vs. | (LL) $\acute{L}L$ | ha. ra. tʃáb. ra |

Unaccented initial LLL sequences are unknown. If intrusive vowel sequences were two syllables, they would break the generalization about accentual patterns at the beginnings of words.

5.4.5.2. Non-initial feet

In non-initial feet, both normal heavy syllables and intrusive vowel syllables always license tone—but while tone is realized on the first mora of a normal heavy syllable, it is realized on the mora following an intrusive vowel syllable.

A heavy syllable outside the initial foot always has a tone, since it is always a foot head and does not realize its tone late. The mora following it never carries tone. (Non-initial HH does not occur in the reported data). Some examples of heavy syllables in various contexts are given below.

| | | | |
|-------|---|-----------------------------------|----------------------|
| (259) | Heavy syllables outside the initial foot always bear accent | | |
| | (L L) (H́) L | hit. ʔet. ʔéi. re | M79:29 |
| | (H) (H́) L | mā:. tʃái. re | M79:29 |
| | (L L) (H́) (L L) (H́) (L Ĺ) | hi. zã. kí. tʃãf. gu. nã́. nã. gá | M79:25 ²⁶ |
| | (L L) Ĺ (L L) (H́) (L H́) (L Ĺ) | wa. ỹi. ỹí. giʃ. gap. ʔúí. ze. ré | M79:25 |
| | (L L) (Ĺ H́) L | ha. ra. gí. nãí. tʃe | S49 |

glosses:

‘they speak’, ‘they cut a piece off’, ‘nine and’, ‘baseball player’, ‘you will suffer for it’

An intrusive vowel sequence is also a heavy syllable, hence always the head of a foot, and always licenses tone. But unlike H, it prefers to realize its tone late. A non-final (H) is always followed by a tone. In this way, heavy CRV differs from heavy CVV.

To explain this, I propose that consonants, even if moraic, do not license tone in Hocank. Gordon 1999 shows that this to be a common situation. Many languages permit a CVV but not a CVC syllable to carry a contour tone (i.e. two tones), even if CVC counts as a heavy syllable for other purposes. This suggests that in some languages only vocalic moras license tone.

Accordingly, I amend the definition of prominent moras in Hocank to exclude consonants. In a bimoraic syllable where the first mora is associated with a sonorant, the second mora counts as prominent.

(260) Prosodically prominent positions, Hocank (revised)

- a. The whole head syllable of the head foot of a word. Head feet are initial.
- b. The first *vocalic* mora of the head syllable of a non-head foot.

If R in CRV is not a prominent mora, it is predicted that tone should be realized late after (H). Tone is realized one mora after the prominent mora that licenses it, and in an intrusive vowel syllable, this prominent mora is the second one. In the tableau below, candidate a) wins because it places tone one mora after the prominent mora, as preferred by ALIGN (PROMINENCE, R; TONE, L). Candidate b) places tone directly on the prominent mora, while candidate c) places it early, so neither of these has the preferred alignment.

²⁶ The syllable [nã́] has accent on the second mora because of a general pattern, not analyzed here, in which T falls on the most sonorous vowel in a diphthong.

(261) [ra:. gá. kãnáʃ. gé]

| / ra:gaknaʃge/ | ALIGN (PROMINENCE, R; TONE, L) | ALIGN (PROMINENCE, L; TONE, L) |
|--|-----------------------------------|-----------------------------------|
| a. $\rightarrow \begin{array}{c} \lrcorner \rightarrow T \\ (\mu\mu) (\mu \mu\mu) \mu \end{array}$ ra:. gá. kãnáʃ. gé | | ** |
| b. $\begin{array}{c} \lrcorner \rightarrow T \quad T \\ (\mu\mu) (\mu \mu\mu) \mu \end{array}$ ra:. gá. kãnáʃ. ge | *! | * |
| c. $\begin{array}{c} \lrcorner \rightarrow T \quad T \\ (\mu\mu) (\mu \mu\mu) \mu \end{array}$ ra:. gá. kãnáʃ. ge | * | ** |

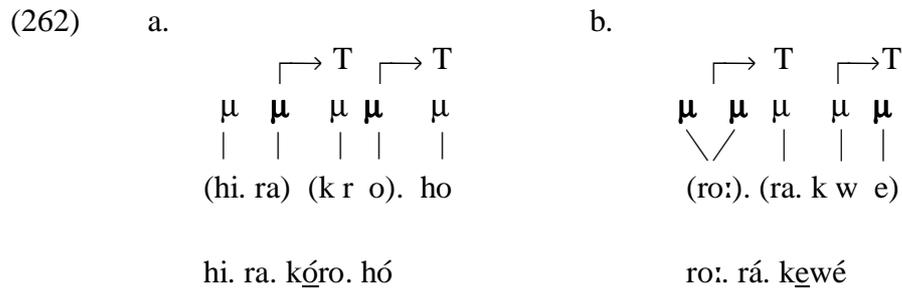
Thus, an intrusive vowel syllable will always realize its tone on the following syllable when possible. This is the basic difference in behavior between intrusive vowel syllables and other heavy syllables, and it results from the fact that the former contain moraic consonants.

5.4.5.3. First mora tone; second mora tone; no tone

In this section I describe the distributions of three types of intrusive vowel syllables: those heard with tone on the first mora, those heard with tone on the second mora, and those heard without tone. Each of these realizations corresponds to a particular environment, and is explained under the theory proposed here.

There are two circumstances under which tone is realized *on* an intrusive vowel syllable. First, the tone of a preceding foot can be realized late on the first mora of an intrusive vowel syllable. Not being a prominent position, the R of CRV doesn't license a tone, but a tone licensed by a preceding syllable can be realized on it. Secondly, a word-final intrusive vowel syllable realizes its own tone on its second mora, because there is no following syllable for tone to fall on.

The accents heard on intrusive vowel syllables are described as having two distinct phonetic realizations that correspond to the two environments described above. In the first situation, tone is heard on the first vowel as in a) below; in the second situation, tone is heard on the second vowel as in b) below. I assume that this reflects association with the first and second mora, respectively; a theory of the physical realization of tone on intrusive vowel syllables is presented in section 4.5.



The following examples demonstrate that intrusive vowel syllables have a first-mora accent only when they follow a foot of the kind that realizes its tone late—i.e., any initial foot, or a non-initial LL or H foot. The tone heard on the intrusive vowel syllable is licensed by the previous foot, not by the intrusive vowel syllable itself.

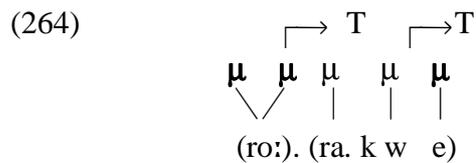
(263) Intrusive vowel sequences with first-mora accent

- a. Following an initial LL foot:
- | | | | |
|----------------------------------|---------------------------|--------------------------|-----------|
| (LL) (<u>H</u>) | ha. nĩp. ǰǎnǎ | ‘I swam (declar.)’ | WE 82:314 |
| (LL) (<u>H</u>) [́] L | hi. ra. k <u>ó</u> ro. hó | ‘prepare, dress (2 sg.)’ | HWE 128 |
- b. Following an initial H foot:
- | | | | |
|---------------------------------|-----------------------------------|--------------------------|---------|
| (H) (<u>H</u>) | ro:. k <u>e</u> wé | ‘dress, paint face’ | M79:30 |
| (H) (<u>H</u>) | mǎ:. ǰǎratǰ | ‘promise (2 sg.)’ | HWE 127 |
| (H) (<u>H</u>) (<u>H</u>) | wa:. p <u>ó</u> ro. p <u>ó</u> ro | ‘snowball’ | M79:30 |
| (H) (<u>H</u>) [́] L | ya:. k <u>ó</u> ro. hó | ‘prepare, dress (1 sg.)’ | HWE 128 |
- c. Following an initial H foot:
- | | | | |
|------------------|-------------------------------|-----------------|--------|
| (H) (<u>H</u>) | k <u>e</u> re. k <u>e</u> ref | ‘colorful’ | M30 |
| (H) (<u>H</u>) | ǰ <u>a</u> ra. ǰ <u>a</u> ra | ‘bald in spots’ | M92:29 |
- d. Following a non-initial LL foot:
- | | | | |
|-------------------------------------|------------------------|---|---------|
| (LL) ([́] L) (<u>H</u>) | ha. ki. rú. dǰik. ǰǎnǎ | ‘pull taut (3 rd sg- declar.)’ | HWE 126 |
|-------------------------------------|------------------------|---|---------|
- e. Following a non-initial H or LH foot:
- | | | | |
|--|---|-------------------|---------|
| (LL) ([́] L) (<u>H</u>) (<u>H</u>) | hi. rat. ʔát. ʔa. ǰǎnǎk. ǰǎnǎ | ‘you are talking’ | HWE130 |
| (LH) (<u>H</u>) (<u>H</u>) | wa. k <u>i</u> ri. p <u>ó</u> ro. p <u>ó</u> ro | ‘spherical bug’ | HWE 131 |

Intrusive vowel syllables realized with second mora accent are always word-final, meaning they have no place to realize their tone late. Also, they are always preceded by something that does not place a tone on following moras: by an L that is not a foot head; or by an (H) or (LH) foot, which realizes its own tone. (If a word-final (H) is preceded something that does realize tone late, (H) does not have two tones; instead, it does not

license its own tone. This is part of a system of tonal clash avoidance, which is not treated here.)

For example, in [ro:rákewé] the intrusive vowel is preceded by H L. The heavy syllable forms a foot by itself, and realizes its tone late on the following L. The L cannot form a foot, so it becomes the first syllable of an LH iamb. It does not license any tone. The vowel of the intrusive vowel syllable does license tone, and must realize its own tone since there is no following syllable to place it on.



ro: rá. kewé

The following examples show that the distribution of intrusive vowel syllables with second mora accent is that predicted by this analysis. They are always word-final and preceded by something that does not realize tone late: either a light syllable that is not a foot head, or a heavy syllable (which is not in the initial syllable), which realizes its own tone.

(265) Intrusive vowel syllables with second-mora accent

After L

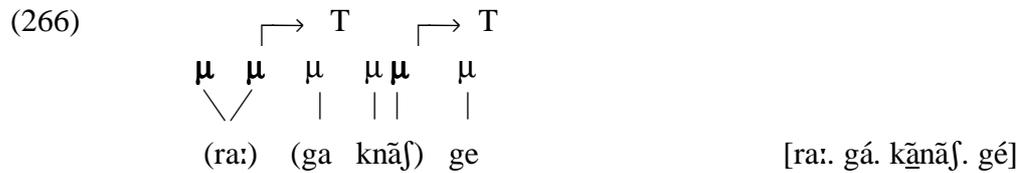
| | | |
|----------------------------------|---|--------------------------|
| (L L)(<u>L</u> H) (<u>L</u> H) | ha. ra. kí. <u>ʃ</u> uru. <u>ḍ</u> ʒík. <u>ʃ</u> ǎǎ | ‘pull taut- 2sg.’ HWE126 |
| (H) (<u>L</u> H) | ro: r <u>á</u> . k <u>ew</u> é | ‘you dressed him’ S13 |
| (H) <u>L</u> (L H) | wi: pá. m <u>ǎ</u> . k <u>er</u> é | ‘rainbow’ M81:342 |

After non-initial H

| | | |
|------------------------|------------------------------------|----------------------------------|
| (L L) (H) (<u>H</u>) | ha. ke. we <u>á</u> k. <u>ʃ</u> ǎǎ | ‘he is entering (moving)’ M79:29 |
|------------------------|------------------------------------|----------------------------------|

There are also cases where an intrusive vowel syllable is realized without any accent. These cases always fulfill two conditions. First, the intrusive vowel syllable is not preceded by anything that would place a tone on the following mora. Second, the intrusive vowel syllable is followed by at least one syllable so that its own tone has a place to be realized late.

In [ra:gákǎnǎʃgé], for example, the intrusive vowel syllable [kǎnǎʃ] places a tone on the following syllable [ge]. The single light syllable [ga] which precedes [kǎnǎʃ] cannot form a foot, so it does not license tone and [kǎnǎʃ] appears without any tone.



The penultimate (H) feet below are other examples of intrusive vowel syllables that don't realize any tone. It can be seen that all meet the two conditions given above.

- (267) Intrusive vowel syllables without accent
- | | | | |
|----|------------------------------------|-------------------------------|----------------------------------|
| a. | H (<u>H</u>) (L) L | tʃu:. giá. ʃãñãp. ké | ‘kingbird’, M81:342 |
| b. | (L L) L (L <u>H</u>) (<u>H</u>) | hi. rat. ʔát. ʔa. ʃãñãk. ʃãñã | ‘you are talking’, HWE130 |
| c. | (H) (L <u>H</u>) L | ra: . gá. kãñãʃ. gé | ‘ant’, M81:342 |
| d. | (L L) L (L <u>H</u>) L | hi. ro. kí. ya. porok. ʃé | ‘he rolled them up together’ S29 |

In short, distributional facts support the theory that an intrusive vowel syllable is a heavy syllable that realizes its accent late. Like other heavy syllables, it is always associated with a tone, but unlike other heavy syllables, this tone is normally realized to the right of the syllable.

5.4.5.4. Weak local parsing

In some respects, an (H) syllable outside of the initial foot acts like an (LL) sequence. Each places a tone on a following syllable, and each realizes a tone on its first mora only when it follows a foot. This similarity follows from the fact that in both (LL) and CRV, the tone is licensed by the second mora—in the case of LL, because the second mora is the head of the foot; in the case of CRV, because the first mora is non-prominent due to being consonantal.

But intrusive vowel sequences do not pattern like LL sequences in other respects. One difference between the two relates to the possibility of weak local parsing. Hocank can optionally leave one L syllable unparsed between two feet, as seen in (267) b) and d) and in the following examples.

- (268)
- | | | |
|-----------------|------------------------|----------------------------|
| (L L) L (L L) L | ho. ki. wá. ro. ro. ké | ‘swing (v. intr.)’ M81:342 |
| (H) L (L L) L | wi: rá. gũʃ. ge. rá | ‘the stars’ M79:28 |

Only one L in a row can be left unparsed. But if an intrusive CYRV sequence consisted of two light syllables, it would be necessary to posit cases in which more than one L in a row is left unparsed, as in the hypothetical alternative representations below.

(269) (L L) \acute{L} (L \underline{H}) (\acute{H}) hi. rat. $\text{?át. ?a. } \underline{\text{?ánāk. } \acute{\text{?ánā}}$ ‘you are talking’, HWE130
 Hypothetical: (L L) \acute{L} L (L L) \acute{L} L

(L L) \acute{L} (L \underline{H}) \acute{L} hi. ro. kí. ya. $\underline{\text{porok. } \acute{\text{?é}}$ ‘he rolled them up together’ S29
 Hypothetical: (L L) \acute{L} L (L L) \acute{L}

Treating (\underline{H}) as monosyllabic allows us to maintain a simple generalization about weak local parsing: only one light syllable is left between feet.

Also, weak local parsing cannot skip one of the putative “syllables” of $\text{CV}\underline{\text{R}}\text{V}$. This is seen in words like [hirakórohónirá] (“the fact that you do not dress”, Halle 1990:149). If the intrusive vowel syllable were a sequence of two light syllables, it would be possible to leave the first one unparsed. This would cause tone to fall on [ni], as shown below. Such a parse is possible in a word that really consists of a string of light syllables, like [hokiwároroké] “swing” (M81:342). If this kind of parse were possible, then it would not be predicted that (\underline{H}) should always be followed by a tone.

(270) Hypothetical weak parsing of /hirakronira/

| | |
|---|-------------------|
| $\begin{array}{ccccccc} & & \lceil \rightarrow T & & \lceil \rightarrow T & & \\ (\mu & \mu) & \mu & (\mu & \mu) & (\mu & \mu) \\ & & & & & & \\ \text{hi} & \text{ra} & \underline{\text{ko}} & \text{ro} & \text{ho} & \text{ni} & \text{ra} \end{array}$ | *[hirakórohóníra] |
|---|-------------------|

Cf. (ho ki) wa (ro ro) ke [hokiwároroké]

There are no examples of intrusive vowel syllables being parsed like this. $\text{CV}\underline{\text{R}}\text{V}$ is always treated like a foot, and hence always followed by a tone, as shown below.

(271) Real parsing of /hirakronira/

| | |
|---|------------------|
| $\begin{array}{ccccccc} & & \lceil \rightarrow T & \lceil \rightarrow T & & \lceil \rightarrow T & \\ (\mu & \mu) & (\mu\mu) & (\mu & \mu) & \mu & \\ & & & & & & \\ \text{hi} & \text{ra} & \text{kro} & \text{ho} & \text{ni} & \text{ra} \end{array}$ | [hirakórohónirá] |
|---|------------------|

In this respect, $\text{CV}\underline{\text{R}}\text{V}$ acts as a unit in a way that other CVCV sequences don’t. In the theory of Hayes 1995, this unity is captured by splitting / CRV / into two syllables after most of the accent rules have applied; in the $[\text{RV}]_\alpha$ theory, it is captured by representing $\text{CV}\underline{\text{R}}\text{V}$ as monosyllabic on the surface.

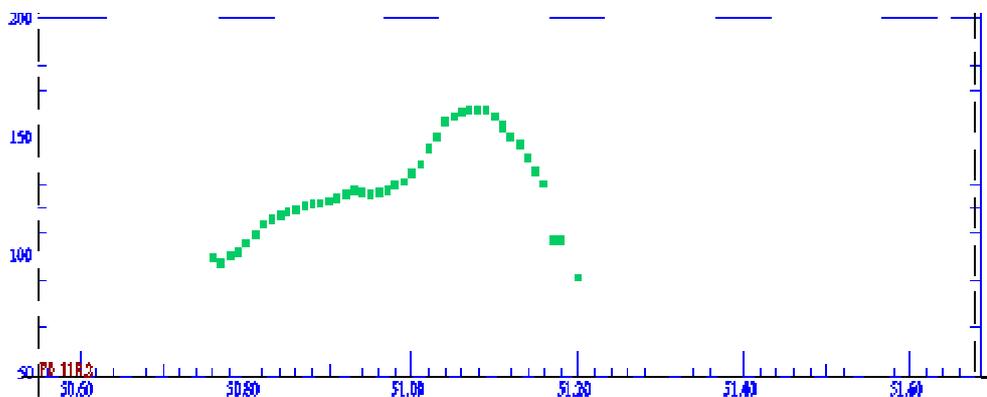
5.4.6. Physical realization of tone on intrusive vowels

I have been assuming that a word-final intrusive vowel syllable has a single tone associated with its second mora. In this way, it is like an LL foot, which also has tone on its second mora word-finally. But not all descriptive accounts agree that (LL) and (H) have an identical accentual structure.

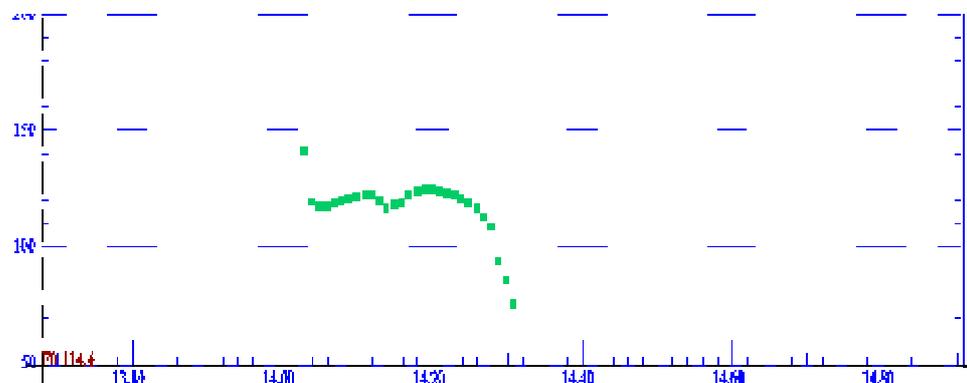
In early work, Miner transcribes intrusive vowel syllables with secondary accent on the first vowel and primary accent on the second, as in [kèré] ‘depart returning’. He transcribes ordinary disyllables, such as [wasgé] ‘dish, plate’, with only one accent. He notes, however, that others disagree: “perceptually, in the nonreduplicated fast sequences, it sometimes happens that the secondarily accented syllable has almost as much accent as, or even as much as (but never more than) the primarily accented one. It may be this that caused Lipkind to write stress only on the C₁V₁ portion of fast sequences, an error which persists through Wolff to Matthews and beyond” (M79: 26-7). In later studies, Miner omits the secondary accents on the intrusive vowels, changing the transcription of accent to [keré]. Thus, fieldworkers give at least three different transcriptions of accent on words like ‘depart returning’: [kére], [kèré], and [keré].

Using tapes of Gerd Fraenkel’s fieldwork on Hocank, stored in Indiana University’s Archives of the World’s Languages, I made pitch tracks of an intrusive vowel syllable, [sɛretʃ] ‘long’, and similar two-syllable words like [warutʃ] ‘eat’. These words were spoken in isolation in the context of a Swadesh word list. [sɛretʃ] is the only word in the list consisting of a single intrusive vowel syllable, so of course conclusions based on the two tokens of this word must be very tentative. However, the pitch contours do not support Miner’s later transcriptions of purely second-vowel accent. The disyllabic [warutʃ] has a clearly rising pitch, as seen in (272), while [sɛretʃ] has a fairly steady pitch, as seen in (273). A heavy monosyllable like [se:p], as in (274), has a clear fall. This supports Miner’s early transcription convention, in which these three foot types were distinguished accentually.

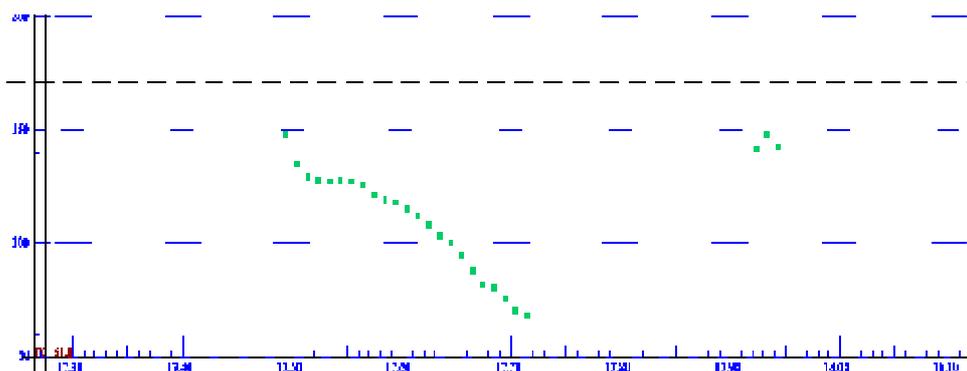
(272) Pitch track of [warutʃ]



(273) Pitch track of [sɛrɛtʃ]



(274) Pitch track of [sɛ:p]



I propose that [sɛrɛtʃ]'s unique pitch pattern results from the fact that the physical realization of tones is linked to that of segments. In a CRV sequence where tone is linked to the same mora as V, the high pitch is linked to the vowel gesture, which stretches across the syllable. If the vowel intrusion were perfectly symmetrical, with the sonorant exactly in the middle of the vowel, high pitch would be heard more or less evenly across the syllable. Some of Susman 1943:13's observations agree with this: she states that "secondary stress seems to attach equally to both syllables" in CVRV.

But Hocank vowel intrusion is not always perfectly symmetrical. Susman observes that "in a "CVCV" morpheme which constitutes a phrase, the first vowel is shorter than normal." This suggests a slightly skewed alignment as below. (Capturing the slight non-symmetricality of Hocank vowel intrusion is possible with modifications to the alignment constraints. I do not do so here, given the lack of evidence about what the exact alignment is.)

(275)



If a vertical line is imagined in the center of this sequence, more of the R is heard on the left side of the line and more of the V is heard on the right side. Therefore, tone realized on the R will be heard more on the beginning of the syllable, and tone realized on the V will be perceived more on the end. But since the V gesture does spread completely across the syllable, there will be some perception of high pitch in the beginning as well. This may explain why Miner transcribed a secondary accent in [kèré]. Lipkind's transcription [kére] may reflect a dialect or idiolect where the sonorant is timed later in the vowel, so that more of the vowel and its tone are heard near the beginning of the syllable. The mistaken assumption that [kere] has two syllables imposes an artificial choice on the fieldworker, to assign accent to the first or second, when in fact the two vocalic periods are a single segment, with a single accent.

5.4.7. Summary of accent

There are more details to the accentual system that are not treated here (such as deletion of tones in clash, the accenting of opening diphthongs, and the placement of tone when a syllable elides in “syllable merger”), but the essential point is that intrusive vowel syllables act like single heavy syllables rather than LL sequences, and that the differences between intrusive vowel syllables and other heavy syllables all derive from the fact that a consonantal mora cannot license tone in this language. Preliminary phonetic evidence also indicates differences in the realization of accent on LL, H, and H.

Furthermore, it is possible to give a principled analysis of the accentual pattern that depends only on output constraints, without rule ordering. The placement of pitch accents in Hocank is guided by constraints that are operative in many other languages, such as prohibiting consonants from licensing accent, and prohibiting rising tone within a syllable.

5.5. Conclusion

Hocank intrusive vowels share the unusual characteristics of those in Scots Gaelic. The overlap between vowel and sonorant is relatively dramatic compared to vowel intrusion in other languages, and the resulting syllable is bimoraic. In Hocank, this bimoraicity is proven primarily by the accentual system, but also by minimal word requirements and by the reduplication pattern, in which intrusive vowels are infixed like heavy syllables rather than suffixed like light syllables. Patterns of ablaut and contextual nasalization demonstrate that the intrusive vowel has no ability to take a different quality than the non-intrusive vowel, as expected if they are one gesture.

Such vowel intrusion cannot be analyzed as only an effect only of C-C phasing; rather, it reflects a particular structure within the syllable. I have proposed that the sonorant is adjoined to the vowel, and they together function as a single α unit. Hence, a CVRV sequence behaves like a heavy monosyllable. The accentual system supports the view that one of the moras of an intrusive vowel syllable is associated with the sonorant, because this mora shows an aversion to licensing tone, which is typical of consonants. Scots Gaelic and Hocank demonstrate that intrusive vowels- that is, vocalic periods that do not correspond to an independent segment- do not have to be short and fleeting. An intrusive vowel can be as long as an ordinary short vowel, and stable in quality and duration, yet not behave like a separate syllable for phonology or for speaker intuitions.

APPENDIX: LIST OF CONSTRAINTS

Markedness constraints

Constraints on total overlap

General form:

*GESTURE_x IN GESTURE_y

A gesture of type *x* does not fully surround a gesture of type *y* (extending on both sides of it).

Specific constraints:

*V IN V

A vowel gesture does not fully surround another vowel gesture.

*C IN V

A vowel articulation does not extend on both sides of a consonant articulation (fully surrounding it).

*OBSTRUENT IN V

A vowel gesture does not completely surround the gesture of an obstruent consonant (where gutturals are not considered obstruent).

Also: *NASAL IN V, *GLIDE IN V, *[r] IN V, *[l] IN V, *[ɹ] IN V, *[ʁ] IN V,

*GUTTURAL IN V

Constraints on CC phasing

*C_xC_y OVERLAP

In a C₁C₂ sequence, C₁ belonging to the class C_x and C₂ belonging to the class C_y, there is no overlap between the gestures of C₁ and C₂.

OCP- GESTURE

Overlapping identical oral gestures are prohibited.

General form:

ALIGN (G¹, LANDMARK¹, G², LANDMARK²) Gafos 2002:278, 292
Align landmark¹ of gesture¹ to landmark² of gesture².

Landmarkⁱ takes values from the set {onset, target, c-center, release, offset}

Specific constraints:

ALIGN (C₁, CENTER, C₂, ONSET)

In a C₁ C₂ sequence, the center of C₁ is aligned with the onset of C₂.

ALIGN (C₁, RELEASE, C₂, TARGET)

In a C₁ C₂ sequence, the release of C₁ is aligned with the target of C₂.

ALIGN (C:, CENTER, C, ONSET)

In a C₁ C₂ sequence, where C₁ is a geminate, the center of C₁ is aligned with the onset of C₂.

ALIGN (C, CENTER, C:, ONSET)

In a C₁ C₂ sequence, where C₂ is a geminate, the center of C₁ is aligned with the onset of C₂.

ALIGN (C, CENTER, R, ONSET)

In a C₁ C₂ sequence, where C₂ is a sonorant, the center of C₁ is aligned with the onset of C₂.

ALIGN (R, CENTER; C, ONSET)

In a C₁ C₂ sequence, where C₁ is a sonorant, the center of C₁ is aligned with the onset of C₂.

ALIGN (R, RELEASE, C, TARGET)

In a C₁ C₂ sequence, where C₁ is a sonorant, the release of C₁ is aligned with the target of C₂.

ALIGN (R, CENTER; C, ONSET) IN σ

In a C₁ C₂ sequence, where C₁ is a sonorant, and where C₁ and C₂ belong to the same syllable, the center of C₁ is aligned with the onset of C₂.

ALIGN (R, RELEASE; C, TARGET) IN σ

In a C₁ C₂ sequence, where C₁ is a sonorant, and where C₁ and C₂ belong to the same syllable, the release of C₁ is aligned with the target of C₂.

Alignment constraints referring to the nucleus

ALIGN (V, OFFSET, SYLL, OFFSET)

The offset of every vowel is aligned with the offset of the rightmost segment that belongs to the same syllable as that vowel.

superseded by ALIGN ([SEG]_α, OFFSET, SYLL, OFFSET)

ALIGN (V, ONSET, SYLL, ONSET)

The onset of every vowel is aligned with the onset of the rightmost segment that belongs to the same syllable as that vowel.

superseded by ALIGN ([SEG]_α, ONSET, SYLL, ONSET)

ALIGN ([SEG]_α, OFFSET, SYLL, OFFSET)

The offset of every segment dominated by an α node is aligned with the offset of the rightmost segment that belongs to the same syllable as that segment.

ALIGN ([SEG]_α, ONSET, SYLL, ONSET)

The onset of every segment dominated by an α node is aligned with the onset of the leftmost segment that belongs to the same syllable as that segment.

ALIGN ([SEG]_α, ONSET, SYLL, ONSET)²

If C and V belong to the same syllable, and C precedes V, the onset of V is not more than one “displacement” from the onset of C.

ALIGN ([SEG]_α, OFFSET, SYLL, OFFSET)²

If V and C belong to the same syllable, and V precedes C, the offset of V is not more than one “displacement” from the offset of C.

ALIGN (C, LANDMARK¹, V, LANDMARK²)

If C and V belong to the same syllable, and C precedes V (not necessarily directly), landmark¹ of C is simultaneous with the landmark² of V.
(**superseded** by ALIGN (C, LANDMARK¹, α, LANDMARK²))

ALIGN (C, LANDMARK¹, α, LANDMARK²)

If C and α belong to the same syllable, and C precedes α (not necessarily directly), landmark¹ of C is simultaneous with the landmark² of α.

Constraints on “gesture sharing”

*MULTIPLE LINKING

A single gesture is not associated with more than one segment.

*MULTIPLE LINKING: STOP-C

A single head gesture is not associated with a stop and a following consonant.

Other markedness constraints

*α α structures do not occur.

ALIGN (MORPHEME, SYLLABLE)

Every morpheme edge coincides with a syllable edge.

ALIGN (PROMINENCE, RIGHT; TONE, LEFT)

Every prominent position P licenses a single high tone T, and the left edge of T is aligned with the right edge of P.

ALIGN (PROMINENCE, LEFT; TONE, LEFT)

Every prominent position P licenses a single high tone T, and the left edge of T is aligned with the left edge of P.

NORISE * T (adapted from Gussenhoven 1997)
(μ μ) $_{\sigma}$ i.e., no rising tone within a syllable

*SEG

Segment S does not occur.

STRESS TO WEIGHT

Kager 1999

A stressed syllable is heavy.

Faithfulness constraints

BE-IDENT-F

Kitto & de Lacy 2000:3

An epenthetic segment E and its base have identical values for feature F.

DEP

A segment that is present in the output is present in the input.

DEP- α

A segment that is dominated by α in the output is dominated by α in the input.

DEP-TONE

A tone in the output has a correspondent in the input.

MAX

A segment that is present in the input is present in the output.

MAX- α

If two segments are adjoined into an α structure in the input, they are adjoined into an α structure in the output.

MAX-*Position*-SEGMENT

(adapted from Beckman 1998 :131)

A segment S in a prominent position in the input has a correspondent in the output.

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