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Coronalization as Assibilation

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Coronalization as Assibilation" submitted by Corey Stuart Telfer in partial fulfillment of the requirements for the degree of Master of Arts.

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ABSTRACT

The common phonological process of coronalization, where a velar stop *k* becomes a strident coronal affricate *ts* or *tʃ* before a high front vocoid, has yet to receive an adequate formal explanation. While this process is usually thought to result from articulatory assimilation, some linguists have claimed it to be primarily acoustic in nature (Flemming 2002, Guion 1996, 1998, Ohala 1992). This is analogous to assibilation, an acoustic process where a dental stop *t* becomes *ts* before a high front vocoid (Kim 2001). The striking similarities between coronalization and assibilation lead me to argue that they are closely related, and that a formal analysis of assibilation (Kim 2001) can be adapted to account for coronalization. After comparing the typology of coronalization (Bhat 1978) to the typology of assibilation (Hall and Hamann 2003) I provide a thorough formal analysis of coronalization that takes both acoustic and articulatory factors into account.

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This thesis is dedicated to my grandfather, Edmund S. Telfer, who encouraged me in my pursuit of academic study, and who shares my love of language.

Tapadh leibh

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LIST OF ABBREVIATIONS AND SYMBOLS

2ND	second person
[ant]	anterior
[bk]	back
[cont]	continuant
[cor]	coronal
[dist]	distributed
[dor]	dorsal
[fr]	front
GEN	genitive
[hi]	high
IPA	International Phonetic Alphabet
K	all velar stops
K͡S	all strident velar affricates
[lo]	low
LOC	locative
MASC	masculine
N	nucleus
NOM	nominative
O	onset
OT	Optimality Theory
PERF	perfective
Q	all uvulars
R	rhyme
S	all dental and alveolar consonants (stops, fricatives and affricates)
SG	singular
[strid]	strident
T.	tongue
T	all dental and alveolar stops (including affricates)
V	vowel (specifically the major class features [−consonantal, +sonorant])
VOT	voice onset time
σ	syllable

If something is true then anyone should be able to understand it.

Phil Lane, Jr., Hereditary Chief of the Yankton Dakota

CHAPTER 1: INTRODUCTION

The coronalization of velars is an exceedingly common phonological process among the diverse languages of the world. Typically a velar stop, such as *k*, becomes a coronal affricate *tʃ* or *ts* when followed by a high front vowel *i*. This process is usually considered to be a simple case of articulatory assimilation, perhaps because it occurs so frequently, and many phonologists presume that coronalization has already been adequately explained. In fact, the causes of coronalization have yet to be agreed upon. As many divergent theories have been put forward in an attempt to resolve this issue, strong contentions remain entrenched and a consensus has not yet been reached. Here are some examples of coronalization:

Table 1 Examples of coronalization

1. Acadian French: $k^{(j)}$ $g^{(j)}$ → ʧ ʤ						(Hume 1994)
kø	~	kʲø	~	ʧø	‘tail’	
kɥir	~	kʲɥir	~	ʧɥir	‘leather/to cook’	
okɛ̃	~	okʲɛ̃	~	oʧɛ̃	‘no, not any’	
ki	~	kʲi	~	ʧi	‘who’	
kœr	~	kʲœr	~	ʧœr	‘heart’	
gɛte	~	gʲɛte	~	ʤɛte	‘to watch for’	
gœl	~	gʲœl	~	ʤœl	‘mouth’	

2. Old French: k → ʦ				(Buckley in press, Walker 1981)
Proto-Romance	*Old French*			
kira	ʦirə	*cire*	‘wax’	
kɛntu	ʦɛnt	*cent*	‘hundred’	
kɛlu	ʦiɛl	*ciel*	‘sky’	

3. Kirundi: k g → ʦ ʥ					(Broselow and Niyondagara 1990)
a.	gu-teːk-a	‘to cook’	b.	kw-oːg-a	‘to swim’
	ja-teːʦ-e	‘he cooked’		j-oːʥ-e	‘he swam’

Assibilation is generally not associated with coronalization, though the two processes share some striking similarities. Like coronalization, assibilation is also typically caused by a following high front vowel *i* and generally results in a coronal affricate *ʦ* (although high back vowels such as *ɯ* can also cause this change).

Table 2 Examples of assibilation

1. Quebecois French: t d → ʦ ʥ / _ {j i ɪ ʏ y ɥ}				(Walker 1984)
tsjɛ̃	‘take!’	ʥjø	‘God’	
tsɥe	‘kill’	ʥɥɛl	‘duel’	
ptsi	‘small’	ʥine	‘dinner’	
tsy	‘you’	mɔrʥy	‘bitten’	
tsɪp	‘type’	ʥɪsk	‘record’ (noun)	
tsʏk	‘toque’	ʥʏk	‘duke’	

2. Blackfoot: t → ʦ / _i				(Howe 2005:57-8)
a.	/nit-iːtsiniki/	[niʦiːtsiniki]	‘I related (a story)’	
	/kit-iːtsiniki/	[kiʦiːtsiniki]	‘you related (a story)’	
b.	/n-moxkát-ji/	[noxkáʦi̥]	‘my foot’	
	/n-moxkát-istsi/	[noxkáʦistsi̥]	‘my feet’	

3. Korean: t t^h → ʥ $ʦ^h$ / _i			(Kim 2001:89)
/mat-i/	maʥi	‘first child’	
/kut-i/	kuʥi	‘firmly’	
/p^hiput^h-i/	p^hiputs^{h}i	‘one’s own child’	
/kat^h-i/	kats^{h}i	‘together’	
/sot^h-i-ta/	sots^{h}ida	‘(it) is a kettle’	
/pat^h-ilaŋ/	pats^{h}iraŋ		

These processes are in complementary distribution in terms of their foci —the target of assibilation is usually a coronal stop, whereas by definition coronalization targets only non-coronals.

The primary goal of this thesis is to show that the phonetic and phonological principles responsible for assibilation are also responsible for coronalization.
I am not the first person to make this proposition. Morin (1974:38) suggests in passing that assibilation and coronalization in Old French could be grouped together as a single process, since both are triggered by a high front vocoid and both produce a strident anterior coronal affricate: *{t k} → ʦ / _j*. In his short discussion of coronalization, Flemming (2002:103-8) also considers the possibility that assibilation lies behind this process: “It happens that loud, sibilant affrication can only be produced with a coronal constriction, so coronalization is a side-effect of assibilation” (p. 104). He briefly proposes to interpret this assibilation as a phonetic enhancement serving to “disperse” contrasts such as that between /ki/ and /ku/:

> Palatalizing the velar to a palato-alveolar, realizing the contrast as [ʧi]-[ku], further enhances the contrast by increasing this difference in duration and amplitude of frication, while still producing a large difference in F2 transitions. (Ibid.)

Beyond this, however, Flemming does not provide a strictly phonological account. I aim to develop his notion of coronalization as assibilation into a formal analysis so that coronalization can be adequately represented within the framework of phonological theory.

I will begin by considering the merits and shortcomings of several previous accounts of coronalization in Chapter Two. The third chapter is dedicated to exploring the facts regarding coronalization and assibilation, and to determining the similarities and differences between these two processes. A formal account of coronalization is presented in Chapter Four, which is then tested in a detailed case study using data from Romanian. The fifth chapter deals with some of the residual issues surrounding the formal account presented in Chapter Four. The thesis is concluded in Chapter Six with a summary of its main points.

1.1 Transcription conventions

I will make use of the International Phonetic Alphabet (IPA) for all transcriptions provided in this thesis. I have avoided the use of slashes and square brackets whenever possible, and they are found only where a distinction between underlying and surface forms is absolutely necessary. In the thesis text IPA characters are italicized, in tables and figures they are presented using plain text. For the sake of visual clarity I will avoid the linking ligature ⁀ in my transcriptions of the affricates *ts*, *dz*, *tʃ*, *dʒ*, *tɕ* and *dʑ*. I have used the asterisk *** to identify reconstructed forms, unattested forms, and to precede constraints. Where the usage of the asterisk is not clear from the context I have clearly labeled the data so that there is no chance of confusion. I have adapted all quotations so that they conform to my transcription conventions.

1.2 Terminology

The term "palatalization" has sometimes been a source of confusion in phonology, since it can be used to refer to three different processes. These processes are displayed in the table below, along with the relevant terms that will be used in this thesis.

Table 3 Terms used in this thesis for "palatalization" processes

	process in rule format	term used in this thesis
1.	t → tʲ / _i	palatalization
2.	s → ʃ / _i	tongue-raising
3.	k → ʧ / _i	(velar) coronalization

The term *palatalization* will refer only to cases where a consonant is articulated with a simultaneous secondary palatal articulation.[1] *Tongue-raising* is used to describe cases where a dental or alveolar consonant becomes a palatoalveolar or an alveolopalatal. *Velar coronalization* is used primarily to refer to cases where a velar stop becomes a strident coronal affricate, but it can be used more broadly to describe any situation where a velar consonant becomes a coronal consonant. For the purposes of this thesis the term *velar coronalization* will be reduced to *coronalization*. Palatalization, tongue-raising and coronalization are all usually triggered by a non-low front vocoid; however there are exceptions to this for all three processes.

[1] This palatal co-articulation is sometimes referred to as an *off-glide*. This term does not convey the fact that the palatal constriction is simultaneous with the primary constriction and will therefore be avoided in this thesis.

Another area of confusion is found in distinguishing the similar terms *alveopalatal* and *alveolopalatal*. *Alveopalatal* has been used by some authors to refer to palatoalveolars such as *ʃ* and *tʃ*, while other authors used this term to refer to segments such as *ɕ* and *tɕ*, which have a slightly higher and more retracted place of articulation. In order to avoid confusion I will avoid the use of *alveopalatal* altogether, and following Ladefoged & Maddieson (1996), I will use the term *alveolopalatal* to refer to segments such as *ɕ*, *ʑ*, *tɕ* and *dʑ*.

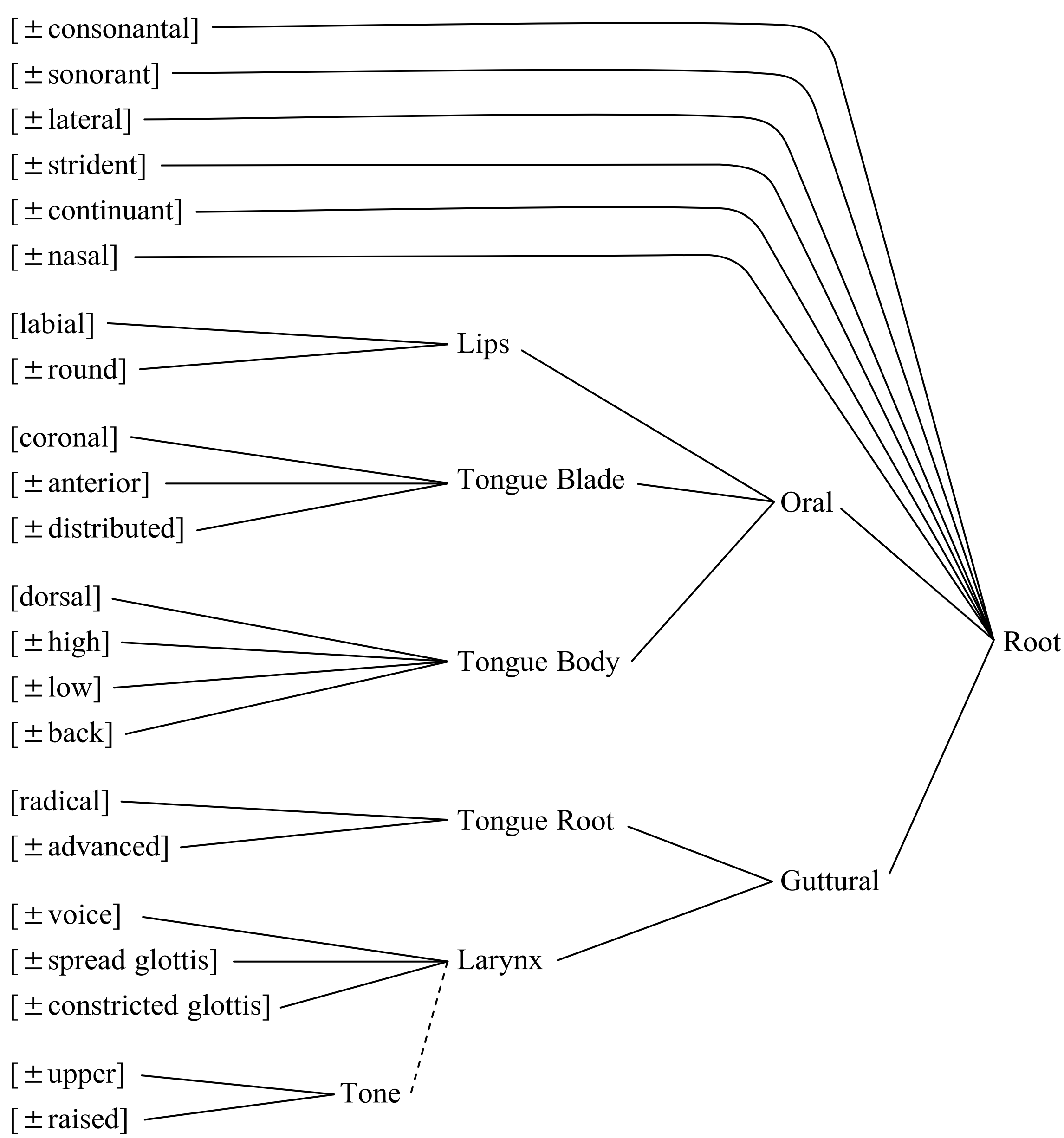
Dental and alveolar consonants are often grouped together in phonological theory, but there is no generally accepted term that can be used to refer to both of these places of articulation as a single category. The term *dentialveolar* is sometimes used, but this label seems unwieldy and has not gained widespread acceptance. I will use the term *anterior coronal* to refer to this group of segments, since they are designated as [+anterior] in most feature theories. Likewise, palatoalveolars and alveolopalatals will be grouped together under the broader term *postalveolar*.

In all cases quotations from other sources are modified so that they conform to the terminology conventions used in this thesis; if a word has been replaced then the substituted word is enclosed in square brackets.

1.3 Theoretical framework

In this thesis I will base my featural representations on those of Revised Articulator Theory (Halle et al. 2000). This feature theory is relatively conservative in that it closely follows the older features presented in Chomksy & Halle (1968). Although it is not commonly used at this time, Revised Articulator Theory appears to be gaining popularity, and has seen recent use by Howe (2004, 2005) and Calabrese (2005). The most important development in Revised Articulator Theory is that designated articulator features, such as [coronal] and [dorsal], are treated as terminal features rather than as intermediate levels (nodes) in the feature hierarchy.

Figure 1 The feature hierarchy of Revised Articulator Theory



This means that they can spread independently from other terminal features, such as [±anterior] and [±high]. The end result is that the feature tree has very little hierarchical structure, since all features are terminal nodes. Halle (2005) has proposed some minor modifications to the organization of the Revised Articulator Theory feature hierarchy, and these have been adopted by Howe (2005). I have adopted Howe's (2005) model here, with one small alteration: the name of the feature [±advanced tongue root] has been simplified to [±advanced]. There is no need to indicate that [±advanced] refers to the tongue root in Revised Articulator Theory because this feature is a dependent of the Tongue Root node.

All of the phonological processes found within this thesis are represented using feature-spreading diagrams which are characteristic of rule-based analyses, but in most cases I have also found it useful to consider accounts in Optimality Theory (Prince and Smolensky 2004). I assume that the reader has a basic familiarity with the OT framework (Kager 1999). It is important to understand that OT is a theory of constraint interaction, and that the composition of OT constraints is highly influenced by representational choices. The reliability of an OT account is, therefore, dependent on the reliability of the theory of phonological features being used to represent segmental interactions. While this thesis does make use of constraints, it is not overly reliant on the precise configuration found in OT accounts. The analysis that follows could easily be reformulated, for example, to fit within a theory that only makes use of markedness constraints, such as that proposed by Calabrese (2005). Nonetheless, when it comes to demonstrating the role of constraints in phonology OT will undoubtedly remain the theory of choice for some time to come, and thus I have chosen to make use of it here.

CHAPTER 2: REVIEW OF THE LITERATURE

Many theories have been developed regarding the causes of velar coronalization, all offering different insights into the nature of this well-known process. In this chapter I will review ten of these theories, although some will receive more attention than others. The reason for including so many different perspectives is two-fold: first, to demonstrate that, despite the diversity of viewpoints on this subject, there is as yet no viable formal account of coronalization, and secondly, to separate out the valuable insights from each theory so that they can be integrated into a comprehensive analysis.

I will begin by considering one of the models of sound change put forward by the Neogrammarians, who held many different views. Chomsky & Halle (1968) challenged some of these older perspectives in their ground-breaking book *The Sound Pattern of English*. Halle, Vaux & Wolfe (2000) elaborated and improved on the work of Chomsky & Halle (1968) and proposed a revised set of phonological features in their Revised Articulator Theory. Some phonologists pursued another line of thought, where high front vowels were treated as [coronal] in order to account for coronalization. This idea is most thoroughly developed in Vowel-Place Theory (Clements and Hume 1995), but is also found in Lahiri & Evers (1991), Hall (1997) and Halle (2005), among others. Calabrese (2005) rejects Vowel-Place Theory and instead suggests that coronalization is the result of a spontaneous shift in the featural representation of palatalized velars.

An entirely different view of coronalization is advocated by Ohala (e.g., 1993), who has long argued that this process is the result of misperception rather than articulatory factors. Following Ohala's lead, Guion (1996, 1998) carried out a set of experiments investigating this possibility, and we will see that her results suggest that an acoustic analysis of coronalization may be more appropriate than an articulatory model. The last analysis I will consider in this thesis is put forward by Lee (2000), who proposes that both acoustic and articulatory factors need to be included in order to properly account for coronalization.

2.1 A Neogrammarian view

Although many different proposals were put forward by the Neogrammarians, one common view was that "sound change happened through gradual changes in articulation" (Guion 1996:25). This view suggests that the production of speech sounds is a process where speakers aim to hit a particular target. Much like an archer, the speaker relatively rarely hits the bull's-eye, but instead makes a number of near-misses that are distributed evenly around the bull's-eye. If interfering factors (such as assimilation) cause these near-misses to be off to one particular side of the bull's-eye then the speaker changes his target accordingly, and sound change takes place.

The primary problem with this view of sound change in the case of coronalization is that this process often results in a radical change in place of articulation, such as *k* becoming *ts* without any intermediary steps, as we will see in Chapter Three. If we carry forward the analogy of an archer aiming at a target, coronalization is the equivalent of the archer suddenly deciding to aim at a completely new target, ignoring the first target altogether. Certainly this is not to be expected if sound change is always slow and incremental. Another problem is determining exactly why the speaker has suddenly abandoned the old target in favour of a new one. The

Neogrammarian view of sound change continues to influence modern phonology, such that most phonologists still consider coronalization to be nothing more than a type of articulatory assimilation. Some linguists (e.g., Hock 1991:76) maintain that coronalization occurs in incremental steps, and have essentially updated the Neogrammarian view so that it is more in keeping with modern phonological theory.

2.2 Chomsky & Halle (1968): The Sound Pattern of English

Although Chomsky & Halle (1968) did provide a brief account of coronalization, which I will discuss below, their more important contribution is the development of the articulatory features which continue to play a role in modern phonology. The tongue body features are of particular interest to us here, since these are used to describe velars before they undergo coronalization.

Table 4 Tongue body features for vowels and dorsal consonants[2]

	palatals palatalization	velars velarization	uvulars uvularization	pharyngeals pharyngealization
	c	k	q	ħ
high	+	+	–	–
low	–	–	–	+
back	–	+	+	+
	i	u	o	ɑ

Chomsky & Halle (1968:308) intentionally neutralized the representation of palatals and palatalized velars, such as k^j, due to the fact that both of these types of segments are

[2] This table is a modified version of that given in Keating (1988a), which is in turn a modification of the table given in Chomsky & Halle (1968:305).

produced under the similar conditions. Other linguists have argued that this neutralization is unjustifiable, and that these types of segments are different enough to warrant separate phonological specifications (Keating 1988a, Lahiri and Keating 1993). In order to eliminate this neutralization some phonologists have suggested that [−back] should be used to characterize palatalized velars (e.g., Archangeli and Pulleyblank 1994, Hall 1997, e.g., Sagey 1990). This implies that the features in the column labeled 'palatals' in Table 4 should be used to represent only palatalized velars, and that a different representation needs to be established for palatals. Determining what exactly that feature representation should be remains a point of some contention, discussed in Keating (1988b, 1991), Ladefoged & Maddieson (1996), Hall (1997) and Ladefoged (1997), among others. I will discuss this issue in further detail in Chapter Five.

The view of coronalization presented in Chomsky & Halle (1968) is quite similar to that put forward by the Neogrammarians. They suggest that velar stops are first fronted before front vowels so that they become palatal stops (*k* → *c*). In order to explain the further change *c* → *tʃ* they rely on markedness conventions that are not directly encoded into the feature theory (Chomsky & Halle 1968:422):

> It is easy to understand why a velar would be fronted —i.e., replaced by *c*— before a front glide or vowel; it is not easy to see why the other features should also change. Recall that…the palatoalveolar *tʃ* is less marked than either the palatoalveolar plosive *t̠* or the palatal plosive *c*.

They go on to argue that *c* is replaced by *tʃ* because the latter is less marked than the former. Improved versions of this argument continue to be put forward to this day (e.g., Calabrese 2005:310, e.g., Clements 1989, Robinson 2001:98). Ohala (1993) is extremely critical of this type of reasoning:

> Arguments of the sort: ‘possible sound *x* changed to *y* in language *A* because that language did not have (did not permit) an *x*’ though commonly encountered in the phonological literature, are circular. Often the only evidence one has that language *A* does not permit an *x* is the absence of *x*, which is the fact one is trying to explain. Such arguments therefore reduce to the tautology: lack of *x* because of lack of *x*. Moreover, sound changes do often introduce sounds to languages, i.e., sounds they had not had before, e.g., nasal vowels in French; front rounded vowels in German due to umlaut.

As with the Neogrammarians, Chomsky & Halle’s (1968) view of coronalization also has difficulties in explaining a direct change *k* → *ts*. Attempts to account for this direct change as a type of articulatory assimilation tend to be either arbitrary (e.g., Halle 2005, see §2.7), or extremely abstract (e.g., Calabrese 2005, see §2.8). In Chapter Four I will demonstrate how an acoustic account of coronalization avoids these pitfalls.

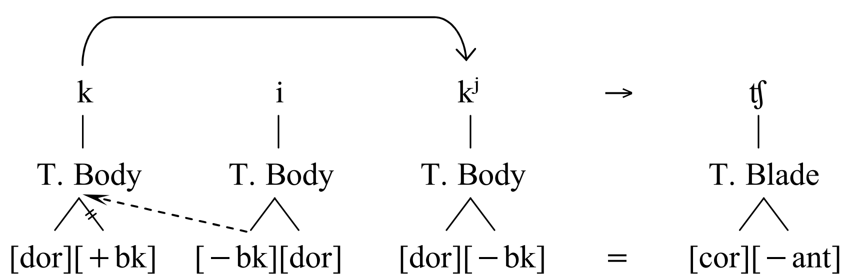
2.3 Halle, Vaux & Wolfe (2000): Revised Articulator Theory

Revised Articulator Theory was proposed in order to remedy some of the shortcomings found in the feature system of Chomsky & Halle (1968) and subsequent works that followed in that vein, such as Sagey (1990). Sagey (1990) proposed that coronalization should be represented by the spreading of the tongue body feature [−back]. Halle, Vaux & Wolfe (2000) chose to adhere to this representational choice, although they were aware of a problem with this system, pointed out by Broselow & Niyondagara (1990:77): “It is a mystery in Sagey’s system why addition of a second dorsal articulation to an original dorsal should change the dorsal to a coronal.” In order to resolve the problem, Halle, Vaux & Wolfe rely on Calabrese’s (1993) equivalency relation between the tongue body features [dorsal, −back] and the tongue blade features [coronal, −anterior], which is stated formally below.

a. [dorsal, −back] = [coronal, −anterior]

The logic behind this equivalency relation is that the tongue is in a similar position when articulating both of these types of segments.

Figure 2 Coronalization in Revised Articulator Theory



That is, a fronted velar has a similar tongue position to a non-anterior coronal; similar enough, in fact, that these two articulations can be interchanged.

An equivalency relation is not an ideal solution to the coronalization problem since it is an arbitrary convention. In addition, the equivalency relation predicts that [coronal, −anterior] segments should sometimes become [dorsal, −back], whereas this type of change is virtually non-existent. This problem could be alleviated by changing the equivalency relation into a phonological rule; however, such a rule would have even less explanatory power. Moreover, this rule would not be able to explain those cases in which a velar stop becomes a [+anterior] affricate *ts* without any intervening stages. As we will see, the appearance of [+anterior] affricates is a problem for most, if not all articulatory accounts of coronalization.

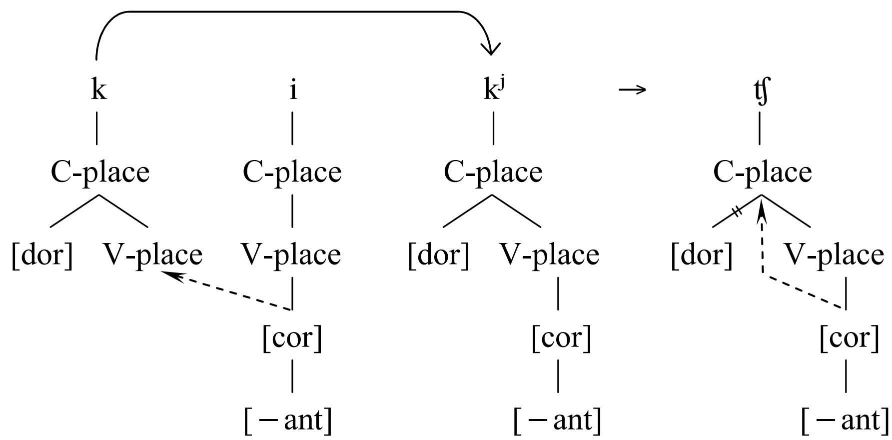
2.4 Clements & Hume (1995): Vowel-Place Theory

Clements & Hume (1995) proposed a radical departure from previous feature theories by suggesting that consonants and vowels share a unified set of features.[3] The primary motivation behind this proposal was the desire to better represent the phonological interactions between consonants and vowels. In order to accomplish this, the tongue body features [±back], [±high] and [±low] are eliminated and vowels are represented with the same features used for consonants: front vowels are [coronal] and back vowels are [dorsal] (and round vowels are [labial]). However, vowel features are still distinguished from consonantal features in order to account for processes such as vowel harmony, which require vowel features to cross intervening consonants. This is achieved by creating a Consonant-place (C-place) node, which dominates a Vowel-place (V-place) node. The C-place node dominates the set of consonant features and the V-place node dominates an identical set of features which are used to represent vocoids.

Vowel-Place Theory represents palatalization and coronalization with relative ease, due to its focus on vowel-consonant interactions. Palatalization is represented by spreading the V-place feature [coronal] from a vowel to the V-place node of a consonant. This represents the intuition that palatalization is the imposition of the articulatory properties of a vowel onto a neighbouring consonant.

[3] Various versions of this idea were also expressed in earlier works, such as Clements (1976, 1989), Broselow & Niyondagara (1990), and in Hume's dissertation (1994).

Figure 3 Coronalization in Vowel-Place Theory[4]



The fact that palatalized consonants carry additional featural material suggests that they are more complex than their plain counterparts. Note that this is not necessarily true in Revised Articulator Theory, where both types of segments contain the same amount of featural material, as seen in Figure 2 above.

A palatalized velar will undergo coronalization if the V-place feature [coronal] is "promoted" to the consonant's C-place node. This forces the [dorsal] feature of the consonant to de-link, and results in a new primary articulation for the consonant. Note that the vowel *i* can spread its [coronal] feature directly to the C-place node of *k*, meaning that Vowel-Place Theory can account for the direct change *k* → *tʃ* as well as the more incremental progression *k* → *k*^{j} → *tʃ* shown in Figure 3. Revised Articulator Theory, on the other hand, requires a velar stop to become palatalized *k*^{j} before coronalization can take place. The fact that coronalization most frequently results in the

[4] These diagrams are taken from Clements & Hume (1995:294-5). They are modified slightly for simplicity.

palatoalveolar affricate *tʃ* has led Clements & Hume (1995:295) to suggest that [coronal] vowels are redundantly specified [−anterior].

The account of coronalization found in Vowel-Place Theory has become quite widely-accepted, and, as we shall see, variations of these ideas have been adopted into many phonological theories. Due to this fact I will dedicate a large section of this thesis to discussing the faults of Vowel-Place Theory. This theory presents an elegant solution to an old and difficult problem, but it does so at the expense of its ability to explain other processes. For example, Halle, Vaux & Wolfe (2000:402) have shown that Vowel-Place Theory cannot account for vowel harmony in Turkish, where a palatalized velar k^j interferes with the spreading of vowel backness. More importantly, however, we will see that Vowel-Place Theory cannot even account for all cases of coronalization. In the sections that follow I will show that using consonantal features to represent vowels is problematic not only for coronalization, but also for other phonological phenomena. I will also show that Vowel-Place Theory cannot explain certain cases of vowel-consonant interaction, the very task it was designed to do. Most of the problems with Vowel-Place Theory discussed below relate at least indirectly to coronalization, but I have also dedicated some space to considering other theoretical issues surrounding this view of phonology.

2.4.1 Problems with treating front vowels as [−anterior]

Like Revised Articulator Theory, Vowel-Place Theory's reliance on [−anterior] detracts from its ability to account for cases of coronalization that result in [+anterior] affricates such as *ts*. Developments in Proto-Romance, and to a lesser degree in Proto-

Slavic, suggest that cardinal front vowels do not bear the feature [±anterior] (or [±distributed]) at all. In these cases we see that a single coronalization process can produce both [+anterior] and [−anterior] consonants. Proto-Romance *k* became [+anterior] *ts* preceding the vowels *i* and *ɛ*, whereas the voiced stop *g* became [−anterior] *ʤ* (Buckley in press, Pope 1934). In most Western Slavic languages, such as Czech, the Proto-Slavic velar stops became [+anterior] affricates and fricatives, while the velar fricative *x* became [−anterior] *ʃ* (Carlton 1990).

Table 5 Results of coronalization in Proto-Romance and Proto-Slavic

1.	First coronalization in Proto-Romance			Buckley (in press)
	Proto-Romance	*Old French*		
a.	kira	tsirə	*cire*	'wax'
	kɛntu	tsɛnt	*cent*	'hundred'
	kɛlu	tsiɛl	*ciel*	'sky'
b.	gingiwa	ʤɛntsivə	*gencive*	'gum'
	gɛlu	ʤiəl	*giel*	'frost'
	argɛntu	arʤənt	*argent*	'silver, money'
2.	Second coronalization in Slavic			Carlton (1990:121-2)[5]
a.	*Proto-Slavic*	*Czech*		
	*k^{j}elə	ts^{j}eliː	'whole'	
	*k^{j}ena	ts^{j}ena	'price'	
	*nog^{j}e	noze	'leg, foot' LOC SG	
	*pomog^{j}i	pomoz	'help' 2ND SG	

[5] I have reconstructed some of the Proto-Slavic forms myself based on the evidence given by Carlton (1990). Also, there are various stages of Proto-Slavic. This case of coronalization was caused by the monophthongization of the diphthong *aj* to *e*, which eventually induced palatalization in a preceding velar consonant. I have chosen to illustrate the final stage of this development in Proto-Slavic.

b.	*xʲerə	ʃeriː	‘grey’ NOM SG MASC
	*strʲexʲe	stre̪ʃe	‘thatch’ LOC SG

Characterizing the front vowels of Proto-Romance or Proto-Slavic as either [+anterior] or [−anterior] is problematic because both values make false predictions for the coronalization of at least one velar consonant. In order to account for this data we must conclude that cardinal front vowels are not specified with regard to [±anterior] or [±distributed], since both values of both features can result from coronalization.

Standard Chinese (also known as Mandarin Chinese) has two unusual syllabic segments which are typically considered to be [coronal] (Duanmu 2000:46, Li 1999:195). These segments are often referred to as syllabic obstruents, but I will refer to them as *homorganic vowels*, since they conform to the place of articulation of the preceding consonant.

Table 6 Homorganic vowels in Standard Chinese[6]

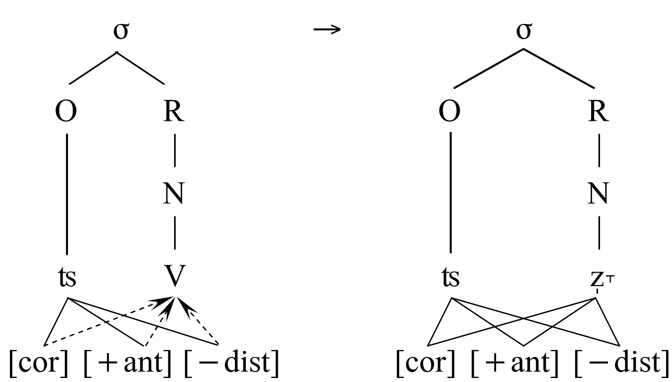
		Pinyin	
1.	tsʰz̩˕	cí	‘magnet’
	tsz̩˕	zì	‘character’
	sz̩˕	sì	‘four’
2.	ʈʂʰʐ̩˕	chī	‘eat’
	ʈʂʐ̩˕	zhī	‘know’
	ʂʐ̩˕	shí	‘ten’
	ɻʐ̩˕	rì	‘sun’

[6] The data are from Duanmu (2000). I have rendered his transcriptions into IPA using the lowering sign ˕ beside the syllabic nuclei z̩ and ʐ̩ in order to indicate that these segments have vowel-like properties.

These vowels only occur in syllables where the onset is *ts, s, tʂ, ʂ* or *ɻ*. Traditionally Chinese phoneticians have treated these segments as "apical" vowels (Pullum and Ladusaw 1996:89-90), however some phonologists have argued that they are really the syllabic obstruents [z̩] and [ʐ̩] (Duanmu 2000:36-7). Other linguists have challenged this analysis based on the fact that these segments have strong formants, and have argued that they are sonorants rather than obstruents (Duanmu 2000:36). Also, these vowels bear tone, which is not normally a property of obstruents (Bao 1999). In short, these segments appear to have some properties that typically belong to vowels and some properties that normally belong to consonants.

In order to explain this paradox Li (1999:195) proposes that these homorganic vowels are the result of complete place assimilation between a vowel and the preceding coronal consonant. Li (1999) uses Vowel-Place Theory to illustrate this process, but ignores the problems associated with this approach. Alveolar consonants are typically represented by the place features [coronal, +anterior, −distributed], while retroflexes are [coronal, −anterior, −distributed].

Figure 4 The formation of Standard Chinese homorganic vowels



When these sets of features are spread to a vowel, they create vocalic obstruents such as *z̩˔* and *ʑ̩˔*. If palatoalveolars, which are usually represented using the place features [coronal, −anterior, +distributed], were also involved in this process we might expect the result to be a segment *ʒ̩˔*. However, Vowel-Place Theory suggests that this combination of features represents the cardinal vowel *i*, not an unusual syllabic segment *ʒ̩˔*. Needless to say, it seems unlikely that the same set of features could be used to represent both *i* and *ʒ̩˔*.

Once again, this problem can be solved by arguing that front vowels such as *i* only bear the feature [coronal], and that they are not specified with regard to [±anterior] and [±distributed]. This detracts considerably from the explanatory power of Vowel-Place Theory, preventing it from predicting the anteriority of an affricate resulting from coronalization. Take note, however, that this explanation is still superior to the account found in Revised Articulator Theory, which must rely on an equivalency relation as well as being unable to accurately predict anteriority. Despite this minor victory, we will see that there are many other problems with Vowel-Place Theory that can only be resolved by dismissing its central tenets.

2.4.2 Problems with treating front vowels as [coronal]

Treating cardinal front vowels as [coronal] without any specified values for [±anterior] or [±distributed] creates an imbalance in the representational system. It suggests that the place features [±anterior] and [±distributed] are mandatory in the representation of consonants, but extremely rare in the representation of vowels. This type of disparity undermines the practicality of using an identical set of features to represent both consonants and vowels. In addition, this stipulation is problematic because there are other, less common vowels which appear to be [coronal] and which have very little in common with cardinal front vowels. Rhoticized vowels, for example, require a tongue blade articulation in addition to their primary tongue body gesture. I will show that it is easier to account for the rhotacized vowels of English and Standard Chinese if we treat cardinal front vowels as [dorsal] rather than [coronal].

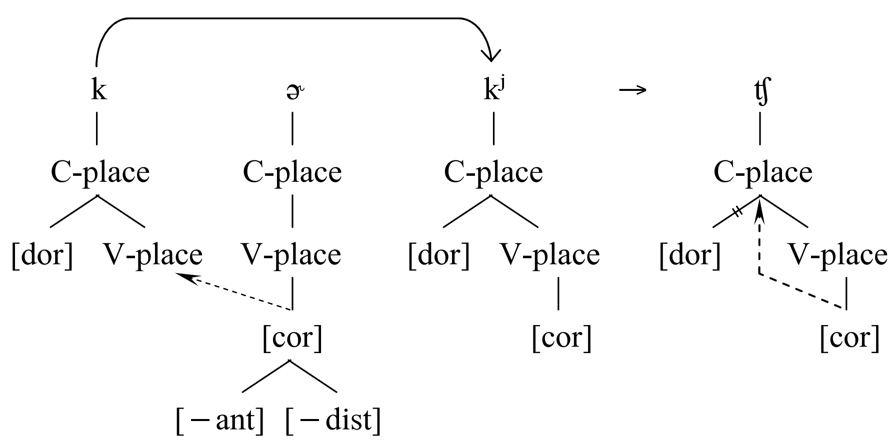
Many dialects of English, particularly those in North America, contain a syllabic rhotic segment that is usually transcribed as *ɹ̩*. This segment is usually grouped together with the syllabic consonants *l̩*, *n̩* and *m̩*, however *ɹ̩* differs from these segments in that can bear stress.

Table 7 Stress restrictions on syllabic consonants in English

			unattested words		
1.	bɹ̩́d	*bird*	*bĺ̩d	*bń̩d	*bḿ̩d
	pətɹ̩́nl̩	*paternal*	*pətĺ̩nl̩	*pətń̩l̩	*pətḿ̩nl̩
	fɹ̩́ðɹ̩	*further*	*fĺ̩ðɹ̩	*fń̩ðɹ̩	*fḿ̩ðɹ̩
	wɹ̩́dɪŋ	*wording*	*wĺ̩dɪŋ	*wń̩dɪŋ	*wḿ̩dɪŋ
	kɹ̩́	*cur*	*kĺ̩	*kń̩	*kḿ̩
	mɹ̩́ɾɹ̩	*murder*	*mĺ̩dɹ̩	*mń̩dɹ̩	*mḿ̩dɹ̩
	ɹɹ̩́l̩	*rural*	*ɹĺ̩l̩	*ɹń̩l̩	*ɹḿ̩l̩
2.	bʌ́ʔn̩	*button*			
	báɾm̩	*bottom*			
	báɾl̩	*bottle*			
	bʌ́ɾɹ̩	*butter*			

In English, the ability to bear stress is normally restricted to vowels. In order to reconcile these facts I propose that phonologists follow phoneticians such as Ladefoged (1993) in characterizing this segment as a rhoticized central vowel ɚ rather than as a syllabic consonant ɹ̩. Another piece of evidence in favour of treating this segment as a vowel is that the flap allophone of English anterior coronals surfaces after vowels and ɹ̩ (Hall 1997:120). Under most feature theories, including Vowel-Place Theory, this rhoticized vowel would have to be represented using the tongue blade features [coronal, −anterior, −distributed]. This creates a false prediction since characterizing ɚ as [coronal] in Vowel-Place Theory implies that it will trigger coronalization, which is unattested.

Figure 5 An unattested pattern of coronalization



Furthermore, describing a central vowel as [coronal] contravenes Vowel-Place Theory's requirement that the [coronal] feature be used to represent front vowels. In order to represent rhotacized vowels such as ɚ in Vowel-Place Theory we would have to stipulate that the feature combination [−anterior, −distributed] is different from other coronal articulations and does not represent a front vowel.

We have seen that treating front vowels as simply [coronal] is problematic, but we have not seen any evidence in favour of an alternative point of view. Based on data from Standard Chinese I will argue that tongue body features, such as [dorsal], [±high] and [±back], must be included in the representation of front vowels. The Beijing dialect of Standard Chinese has a diminutive suffix "-r" which has been analyzed as the addition of the features [−anterior, −distributed] to the target vowel (Duanmu 2000:195-205).[7] This [−anterior, −distributed] articulation causes most vowels to become rhoticized, however when the high front vowels *i* and *y* undergo this process they are centralized to the mid vowel *ɚ*.

Table 8 The diminutive "r" suffix of Standard Chinese[8]

	unsuffixed	*suffixed*	*Pinyin*	
1.	xu	xu˞	hú	'lake'
	wo	wo˞	wō	'nest'
	kɤ	kɤ˞	gē	'song'
	x^{w}a	x^{w}a˞	hūa	'flower'
	p^{h}an	p^{h}a˞	pǎn	'plate, dish'
	kən	kə˞	gēn	'root'
	ɥe	ɥe˞	yùe	'moon'

[7] Duanmu (2000:202) uses the feature [+retroflex].

[8] This data is from Duanmu (2000:202-3). Tones are indicated using the Pinyin system: *ā* first tone (high), *á* second tone (rising), *ǎ* third tone (falling-rising), *à* fourth tone (falling). The Pinyin column represents only the unsuffixed forms of the roots; an <r> is added to the end of the word to represent the "-r" suffix in the Pinyin transcription system.

2.	tɕi	tɕɚ	jī	'chicken'
	tɕin	tɕɚ	jīn	'today'
	ɥy	ɥɚ	yú	'fish'

Since the high front vowels *i* and *y* are [coronal], we might expect the addition of [−anterior, −distributed] to produce *i˞* and *y˞*. In order to understand why the place features of these vowels are altered we must look at the more general patterning of retroflex segments.

Flemming (2003) lists several examples indicating that retroflexes pattern with back vowels and not with front vowels. For example, the Australian language Walmatjari associates retroflex consonants with the non-front vowels *u* and *a*, while only alveolars are associated with the front vowel *i*. Similarly, in the Dravidian language Kodagu front vowels are generally prohibited from occurring before retroflexes (e.g., **iʈ*), and retroflexes become palatoalveolars before front vowels in the Keresan language Acoma (e.g., *ʂ* → *ʃ* / _*i*). This pattern is explained by the fact that "retroflexes are most easily produced with a retracted tongue-body position" (2003:337)).

The features [−anterior, −distributed], which cause rhoticization, are the same features that are used to represent retroflexes. The reason that the place features of *i* and *y* are altered when they undergo rhoticization is that the retroflex articulation is incompatible with the fronted tongue body position of these vowels. If we assume that *i* and *y* bear the features [+high, −back] then we can easily account for the above data by means of a constraint *[−anterior, −distributed, +high, −back]. If, on the other hand, we treat front vowels as [coronal] then this constraint takes the form *[coronal,

−anterior, −distributed], which prohibits all retroflex segments, including consonants. This is problematic, since Standard Chinese has a retroflex series of consonants: *ʈʂ*, *ʈʂʰ*, *ʂ*, *ɻ* (Duanmu 2000:26).[9]

Further evidence in favour of representing all cardinal vowels using tongue body features comes from Howe (2004), who notes that many languages prefer velar consonants following vowels. He proposes that this effect is caused by vowels spreading their [dorsal] feature to following consonants. This theory can only be correct, however, if all vowels bear a [dorsal] feature.

Accounting for the "-r" suffix and homorganic vowels of Standard Chinese is problematic for Vowel-Place Theory. These cases can be easily explained, however, if we treat cardinal vowels as [dorsal] articulations, and leave the feature [coronal] to represent true tongue blade articulations. The tongue blade is used primarily to generate alveolar and postalveolar consonants, but it can also be used to produce both the primary and secondary articulations of vowels, as seen in the homorganic and rhotacized vowels of Standard Chinese. Characterizing all front vowels as [coronal] does not allow us to capture these facts, and so I argue that this hypothesis be discarded in favour of a more traditional view of phonological features.

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[9] Ladefoged & Maddieson (1996:150) argue that this series is not truly retroflex from a phonetic point of view. I suggest that further investigation is required before a final conclusion can be reached on this matter, since these segments are associated with the retroflex gesture of the "-r" suffix (Li 1999:204).

2.4.3 Problems with vowel height in Vowel-Place Theory

One of the primary aims of Vowel-Place Theory was to enhance our ability to account for vowel-consonant interactions, but it is in fact less capable of explaining some of these cases than traditional feature theories. Another undesirable aspect of Vowel-Place Theory is its vowel height system. Vowel-Place Theory has abandoned the tongue body features [±high] and [±low] and relies instead on a single feature [±open]. This feature is duplicated and distributed over a number of separate tiers in order to create all of the vowel heights needed to describe natural language (Clements & Hume 1995:282-3). One problem with this representation is that there is no logical limit to the number of tiers available for making height distinctions. Even if we limit the vowel height system to a maximum of three tiers, this system still over-predicts the number of vowel heights available to the languages of the world. With one tier, only two vowel heights are available ([+open] and [−open]). Two tiers will create four possible vowel heights, and three tiers allows for eight possible vowel heights. Ladefoged & Maddieson (1996:289-90) suggest that the absolute maximum number of contrastive vowel heights available is five, which is the case in Danish for example. This means that we must use three tiers in order to account for languages such as Danish, but that no language uses the full eight vowel heights theoretically available in this system.

Of more concern is the fact that Vowel-Place Theory cannot account for vowel-consonant interactions involving vowel height. One such case is found in Cologne German, where coronal stops have become velars following all high vowels (Howe

2004:34). Howe (2004) accounts for this pattern by spreading the tongue body feature [+high] from the vowel to the consonant.[10]

Table 9 Cologne German velarization

	Standard German	*Cologne German*	
1.	hɔjtə	hyk	'today'
	pintə	piŋk	'pint'
	ʁajn	ʁiŋ	'Rhine'
	nɔjn	nyŋ	'nine'
2.	bʁawt	bʁuk	'bride'
	bunt	buŋk	'colorful'
	bʁawn	bʁuŋ	'brown'
	tsawn	tsuŋ	'fence'

This solution is not available in Vowel-Place Theory, since the feature [±open] applies only to vowels, and cannot spread to consonants. Halle (2005:37) mentions that a Brazilian language, Maimande, has a process where "a coronal consonant is replaced by its dorsal cognate in the coda of a syllable with a [+high] vowel nucleus," identical to the case of Cologne German presented in Table 9. Halle's account of this process is slightly different than the one proposed by Howe (2004); he suggests that the feature [dorsal] spreads from [+high] vowels to the following coronal consonant. Note, however, that even this account is impossible to articulate in Vowel-Place Theory, since front vowels are only [coronal] and therefore have no [dorsal] feature to spread. The case of Cologne German velarization, aside from the problems it creates for Vowel-

[10] See §2.7 for evidence that velars are [+high].

Place Theory's vowel height system, is yet another set of data that cannot be accounted for if front vowels are characterized as [coronal].

Vowel-Place Theory could account for Cologne German velarization if front vowels were characterized as both [dorsal] and [coronal], as some linguists have argued (Calabrese 2005, Gussenhoven and Jacobs 2005:180, Halle 2005). This would mean, however, that a front vowel such as *i* would be more phonologically complex than a central vowel such as *ɨ*, which is only [dorsal] and not [coronal]. If we accept this hypothesis then we might expect to find that front vowels occur less frequently than central vowels, following Rice's (1999) argument that representational complexity is associated with markedness. Maddieson (1984:124) found that the opposite is true: front unrounded vowels were more common than unrounded central vowels in his typological survey (958 unrounded front vowels compared to 547 unrounded central vowels). In addition to this markedness problem, characterizing cardinal front vowels as complex would make it difficult to represent truly complex vowels, such as the rhotic vowels found in Standard Chinese and English, as seen above.

2.4.4 Other problems with Vowel-Place Theory

One long-standing objection to Vowel-Place Theory is that it does not accurately characterize front vowels, which are articulated by the tongue body with a primary constriction near the back of the mouth (Ladefoged & Maddieson 1996:283-5). Nonhigh front vowels such as *æ* are particularly controversial since they are clearly articulated using only the tongue body (Calabrese 2005). A more traditional view of phonological features reflects the phonetic reality more accurately.

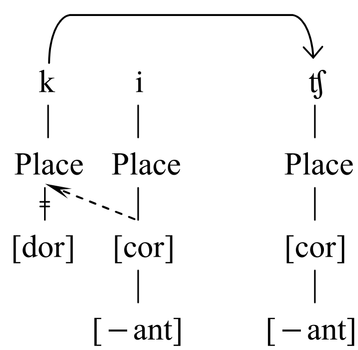
While most phonological theories do not attempt to take language acquisition into account, this is an important area to consider in light of the stark contrast between Vowel-Place Theory and more traditional views. At least one study of first language acquisition has shown that the acquisition of vowels and consonants "differ in a number of ways, thus suggesting that 'vocalic activity does not emerge by the same process as consonantal'" (citing Bever 1961, Stark 1997:149-50). I will not consider the details of phonological acquisition here (see Stark 1997 for a more detailed discussion of this issue), but it is important to note that acquisition patterns can inform us about the nature of the adult grammar. It is true that both vowels and consonants are produced by the same oral tract, but this does not necessarily mean that their cognitive representations should be identical. What we need is a balanced representational system which can account for both the differences and the similarities between vowels and consonants.

In this section I have argued against using the phonological representations proposed in Vowel-Place Theory. Although this theory provides a better account of coronalization than many other theories, it does not stand up to scrutiny when a wider range of phonological interactions is considered. I have shown that some of the central tenets of Vowel-Place Theory, particularly the characterization of front vowels as [coronal] and the use of the feature [±open] to represent vowel height, are problematic in concept as well as in practice. These facts lead me to conclude that, despite its popularity, Vowel-Place Theory is inadequate for describing coronalization.

2.5 Lahiri & Evers (1991)[11]

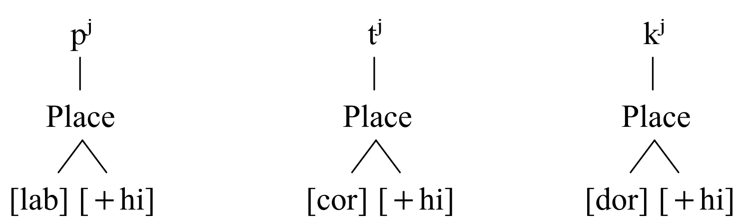
Typically palatalization and coronalization are considered to be related developments, so both processes are given similar representations.

Figure 6 Coronalization in Lahiri & Evers (1991)



Lahiri & Evers (1991) have decided to separate these two processes entirely, and I will briefly investigate the feasibility of this arrangement. They represent coronalization in much the same way as Vowel-Place Theory, but they do not differentiate between a C-place node and a V-place node. This means that a V-place [coronal] feature cannot be used to represent palatalization, so the feature [+high] is used instead.

Figure 7 Palatalization in Lahiri & Evers (1991)



[11] This analysis is repeated in more recent sources, such as Newman (1997).

Evidence supporting this analysis is taken from the fact that palatalized consonants sometimes cause vowel-raising. For example, all unstressed nonhigh vowels are raised after palatalized consonants in Russian, and nonhigh vowels are sometimes raised when followed by a palatalized consonant in Outer Hebrides Gaelic (Lahiri & Evers 1991:93).

Table 10 Vowel-raising in Russian and Outer Hebrides Gaelic

1. Russian							
	a.	p^{j}**ó**tr	'Peter' (nom.)	*cf.*	b.	ts**é**p	'flail' (nom.)
		p^{j}**i**trá	'Peter' (gen.)			ts**e**pá	'flail' (gen.)
2. Outer Hebrides Gaelic							
	a.	k^{j}**ɔː**l	'music' (nom.)				
		k^{j}**uː**l^{j}	'music' (gen.)				

Using different features to represent palatalization and coronalization seems counter-intuitive since both processes are typically caused by high front vocoids and often result in the formation of a postalveolar affricate. While this objection may only be a challenge to the conceptual unity of their theory, I will argue that there is another reason for rejecting Lahiri & Evers' analysis. The characterization of palatalized velar stops as [+high] conflicts with the traditional view of velars, seen in Table 4 above, where plain velars are already [+high]. This specification allows us to differentiate velars from uvulars, since velars are considered to be [+high] and uvulars are considered to be [−high] (Chomsky and Halle 1968:305, 307, Howe 2005:144ff.). Aside from theoretical speculation, there is also phonological evidence that velars are [+high]. Turkana, a Nilotic language, lowers *k* to the uvular *q* when followed by a tautosyllabic nonhigh back vowel. Ordinarily this process is mandatory, however it becomes optional when a high vowel *i* or *u* precedes *k* anywhere in the word, confirming that [±high] is the feature in question (Howe 2005:156-7).

Table 11 Velar lowering in Turkana

1.	/ɛ-kɔrɪ/		[ɛqɔrɪ]	‘rattle’ SG
	/e-kod/		[eqod]	‘tax’ SG
	/ŋɪ-kɑjo/		[ŋɪqɑjo]	‘tree’ PL
2.	nikor	~	niqor	‘Samburu (name of a tribe)’ PL
	luoko	~	luoqo	‘in this lung’
	amʊkɑt	~	amʊqɑt	‘shoes’

If plain velars are already [+high] then they cannot be distinguished from palatalized velars under Lahiri & Evers’ analysis. While the characterization of palatalized coronals as [+high] is not problematic, this account of palatalization must ultimately be rejected due to its failure to adequately account for palatalized velars.

The arguments against treating front vowels as [coronal] and [−anterior] presented in §2.4 are applicable to Lahiri & Evers’ account of coronalization, so this aspect of their analysis must also be discarded.[12] It appears that using unrelated representations for coronalization and palatalization offers no advantage, and thus an account that can establish some kind of relationship between these two processes will probably be more acceptable, both practically and conceptually. One final lesson we

[12] Most of the analyses that follow also assume that front vowels are [coronal]. In order to avoid repeating myself I will ignore this problem from here on in, however I still consider this assumption to be highly problematic.

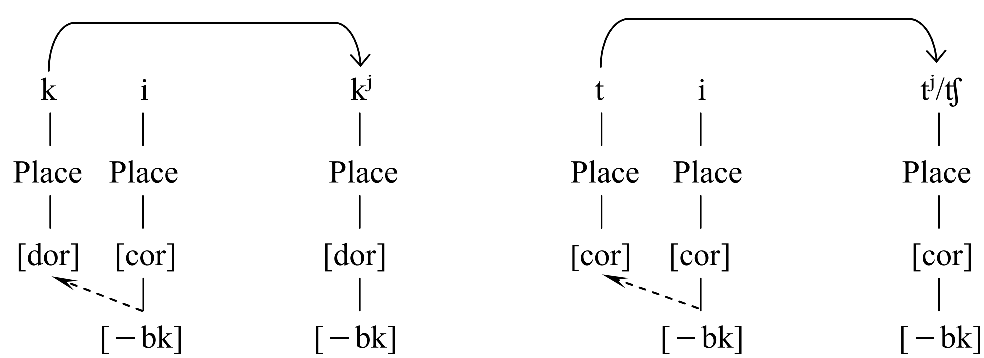
can learn from Lahiri & Evers is that using only one feature to represent palatalization is an oversimplification, since their portrayal works well for some cases (palatalized labials and coronals), but is inadequate for others (palatalized velars).

2.6 Hall (1997)

Hall's (1997) account of coronalization is similar to that of Lahiri & Evers (1991), except that he uses [− back] as the palatalization feature. In addition, he has made an important modification: [− back] is allowed to act as a tongue blade feature along with its usual role as a tongue body feature. This modification allows the feature [− back] to participate in both palatalization and coronalization, providing a more unified account of these processes. Palatalization is described as the spreading of the feature [− back] from a [coronal] vowel to a neighbouring consonant, either [dorsal] or [coronal].

Figure 8 Palatalization in Hall (1997)[13]

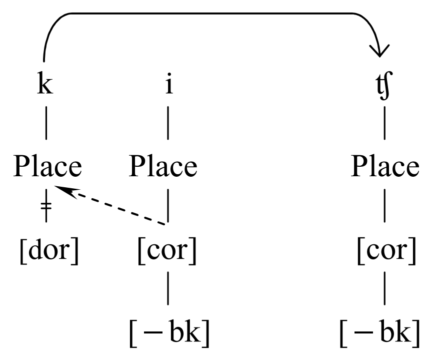
1. velar palatalization	2. coronal palatalization



[13] These are my interpretations based on Hall's diagrams and text (1997:77-9, 82-4)

Coronalization is seen as the spreading to the whole [coronal] node, which forces the [dorsal] node to dissociate so that a [coronal] affricate can be formed.

Figure 9 Coronalization in Hall (1997)



Hall's analysis has several shortcomings, the first of which is the use of [– back] to describe palatalized coronals. This designation suggests that the tongue body is further forward in palatalized coronals than it is in their plain counterparts, but in fact the opposite is true. For example, palatograms taken by Recasens, Fondevila & Pallares (1995:276) show that the front closure of Irish /n^j/ is slightly retracted towards the back of the mouth when compared to that of the plain nasal /n/. Furthermore, there is phonological evidence that plain anterior coronals are already specified [– back]. This evidence comes primarily from diachronic changes where back vowels have been fronted when adjacent to or between coronals.

One example of vowel-fronting induced by coronals is found in the Agn dialect of Armenian (Halle, Vaux & Wolfe 2000:400) where back vowels have been fronted following anterior coronal consonants. Another example is seen in Cantonese (Flemming 2003:335-6), where back vowels were fronted between coronal consonants.

The reflex of this process in the modern language is a lack of syllables where a back vowel is framed by coronal consonants on either side. Flemming argues that these changes can best be explained by positing that non-retroflex coronal consonants bear the feature [−back], which can spread to a neighbouring [+back] vowel.

Table 12 Vowel-fronting in the Agn dialect of Armenian and Cantonese

1.	*Classical Armenian*	*Agn*	
	doɫ	dʰøʁ	'tremor'
	ʧʰors	ʧʰørs	'four'
	gaɫt-uk	gʰaʁdyg	'secret'
	ʧuχa	ʧʰyχa	'cloth'

2.	*Cantonese*		*unattested forms*
	t̪yt̪	'to take off'	*t̪ut̪
	t̪øn̪	'a shield'	*t̪on̪

If plain coronals are already specified [−back] then this feature cannot be used to characterize their palatalized variants, as Hall (1997) suggests.

Hall's account also has difficulty accounting for the common change *tʲ → ʧ*, where palatalized coronals become palato-alveolars.[14] He offers no motivation for a [+anterior] coronal *tʲ* to become [−anterior] *ʧ*. We could propose a constraint *[+anterior, −back], however it would be difficult to justify this constraint since a fronted tongue body should facilitate a [+anterior] articulation rather than impede it.

[14] An example of this type of tongue-raising is seen in the Romanian data presented in §4.2.

Another problem for Hall's account is explaining the coronalization of palatalized velars. In Chapter Three we will see that palatalized velars, such as *k^j*, can undergo coronalization as a context free change. In Hall's account, palatalized velars are represented by the tongue body features [dorsal, −back], and there is no particular reason that this segment should acquire a [coronal] tongue blade articulation. This is essentially the same problem faced by Halle, Vaux & Wolfe (2000), which they resolved by making use of Calabrese's (1993) equivalency relation (see §2.3). Hall could also make use of this equivalency relation, but we saw above that this solution is undesirable, and should be avoided if possible.

One of the more obvious problems with Hall's analysis is the fact that the feature [−back] is now required to be a dependent of both the [coronal] and [dorsal] nodes. There is an apparent asymmetry here, as Hall does not propose that [+back] should also be permitted as a dependent of [coronal]. This minor incongruency can be resolved if we assume that a [coronal] node with a [+back] dependent represents a velarized coronal, analogous to Hall's representation of palatalized coronals. The more important issue here is one of formal representation: allowing one feature to behave inconsistently detracts from the explanatory value of the whole theory. While Hall (1997:84) notes that a number of phonologists have made similar suggestions for other features, he ignores the fact that most of these developments have yet to receive widespread acceptance. The one exception is perhaps Vowel-Place Theory, which allows all place features to act as dependents of both the C-place and V-place nodes, but we have seen above that this representation is also the subject of debate.

Allowing a tongue body feature such as [±back] to dock under [coronal] does not seem completely unjustified, since making constrictions with the tongue tip and blade necessarily requires moving the tongue body. This line of reasoning might lead us to wonder why [±back] is the only tongue body feature permitted in this position; why not [±high] and [±low] as well? Of course, allowing all these features to dock on the [coronal] node would not only undermine the usefulness of the [dorsal] node, but it would also lead to cumbersome and unruly representations. One possible solution to this problem is presented by Flemming (2003:335), who suggests that the "tongue body is always specified in the phonological representations of coronals, even where it is non-contrastive." [15] While I will not adopt the extreme position that tongue body position is always specified, I will assume that taking tongue body features into account is crucial to understanding the phonological patterning of coronals.

Hall (1997) offers an interesting counterpoint to Lahiri & Evers (1991), but it is clear that both accounts lack the explanatory power necessary to provide a lasting analysis of coronalization.

2.7 Halle (2005)

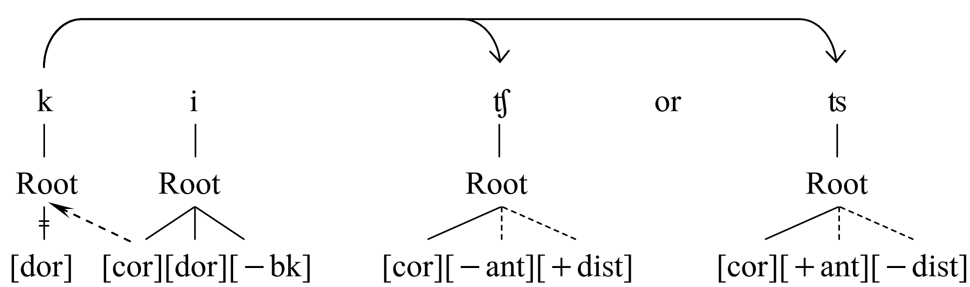
In German, the consonants *l*, *r* and *n* form a natural class with the front vowels *i*, *y*, *e*, *ø* and *ɛ*, since all of these segments cause a following velar fricative *x* to become a palatal *ç*. Halle (2005), like Clements & Hume (1995) before him, proposes that this natural class is defined by the feature [coronal]. Unlike Vowel-Place Theory, Halle notes that

[15] Ladefoged (1997:600) has also stressed the importance of incorporating tongue body position into phonological theory in order to account for vowel-consonant interactions.

front vowels sometimes behave as if they are [dorsal], and in order to account for this fact he suggests that front vowels are both [coronal] and [dorsal]. Similar versions of this concept have been put forward in the past by linguists such as Jacobs (1989), Jacobs & van de Weijer (1992) and Jacobs & Gussenhoven (2005).

Halle's proposal for coronalization operates in much the same way as those of Clements & Hume (1995), Lahiri & Evers (1991) and Hall (1997). The most important difference is that designated articulator features such as [dorsal] and [coronal] do not bear any dependent features, following the assumptions of Revised Articulator Theory. One consequence of this assumption is that the resulting [coronal] segment has no specified values for the features [±anterior] and [±distributed]. Halle proposes that arbitrary values for these features are inserted by rule after [coronal] spreads to the velar consonant.

Figure 10 Coronalization in Halle (2005)



The insertion of these features is represented by the dashed lines in the illustrations of *ʧ* and *ʦ* in Figure 10. Characterizing front vowels as complex [coronal]-[dorsal] segments allows Halle to account for some very challenging sets of data, such as a process known as "dental-velar switch" found in the Kiowa-Tanoan language Kiowa.

In this language velar stops become plain coronal stops before the mid vowel *e*, and conversely coronal stops become velars before the high vowel *i* and the semivowel *j* (Watkins 1984:43).

Since Halle claims that front vowels are complex, he can account for both of these processes in a fairly uniform manner: the [+high, −back] vocoids *i* and *j* spread their [dorsal] feature to the preceding consonant while the [−high, −back] vowel *e* does likewise with its [coronal] feature.

Table 13 Coronalization and velarization in Kiowa[16]

1.	coronalization			k g → t d / _e
	a.	kʰút**k**já	'pop off' (perf.)	
		kʰút**t**ép	'pop off' (impf.)	
	b.	má:**g**ɔ̀	'feed' (perf.)	
		má:**d**ê:	'feed' (impf. hsy.)	
2.	velarization			t d → k g / _i j
	a.	tó:**t**é	'get gathered'	
		tó:**k**jáj	'get gathered' (perf.)	
	b.	hɔ̂:**d**è	'strip off'	
		hɔ̂:**g**ì:	'strip off' (impf. imp.)	

Default rules again fill in the unspecified features, as we saw above in Figure 10.

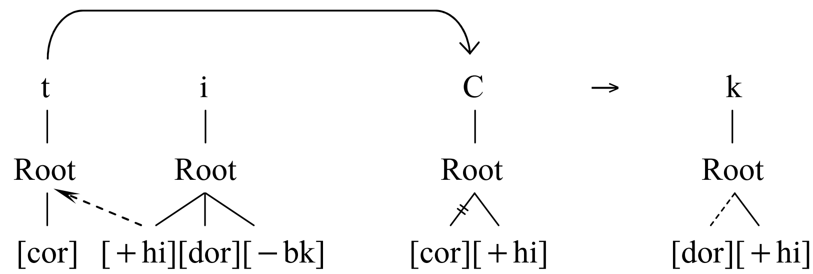
While Halle's analysis of this data appears to be unproblematic, it is in fact less than ideal. One point of concern is the fact that the choice of whether to spread [dorsal]

[16] Data from Watkins (1984:44, 167, 169, 171). Kiowa has three tones: /´/ 'high', /`/ 'low' and /ˆ/ 'falling' (Watkins 1984:26).

or [coronal] is completely arbitrary. If we follow Halle's account, we might expect to find another language where [−high] front vowels spread [dorsal], and [+high] front vowels spread [coronal], precisely the opposite of Kiowa. This pattern is unattested. Moreover, in §2.4.3 we saw that Cologne German, much like Kiowa, also has a correlation between high vowels and velars. It is my position that this similarity between Kiowa and Cologne German is more than a coincidence, and that an ad hoc solution is therefore inappropriate. At this point I will present an alternative account of the Kiowa data which does not require the arbitrary conventions seen in Halle's analysis.

I suggest that the Kiowa data is a case of tongue height assimilation, and that it is in no way similar to the typical cases of coronalization that result in strident affricates. This assimilation is best understood by referring to the tongue body features of the consonants involved: *k* and *t*. Note that *k* is associated with *i*, as it was in Cologne German, and that *t* is associated with *e*. Recall that we have already seen evidence from Turkana that velars are [+high] (§2.5). These facts lead me to propose that the dental stop *t* has a [−high] tongue body position. This means that we can easily account for Kiowa coronalization and velarization by spreading the feature [±high] from a front vowel to the preceding consonant. The receiving consonant must subsequently alter its place of articulation in order to accommodate the new height feature.

Figure 11 Kiowa velarization as tongue height assimilation



In other words, this language prohibits [−high] velar stops and [+high] coronal stops. These two restrictions can be expressed as a single constraint:

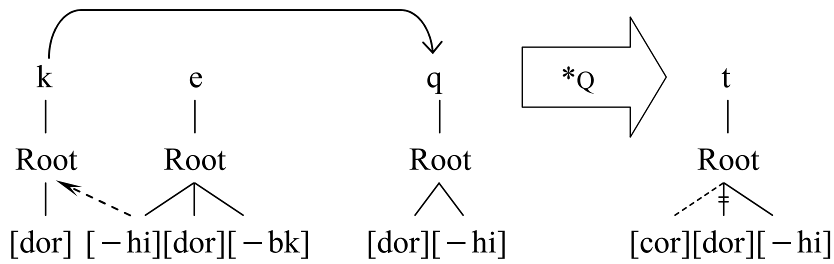
a. AGREE[high]
*[+high][−high], *[−high][+high]
Neighbouring segments cannot have different tongue heights.

We saw that in Turkana (§2.5), a similar height conflict is resolved by lowering a velar stop *k* to a uvular *q*. This is apparently prohibited in Kiowa, which does not have uvular stops.

b. *Q
*[+consonantal, dorsal, −high]
Uvulars are prohibited.

We can now use this constraint to illustrate Kiowa coronalization, where uvulars are avoided in favour of dental stops.

Figure 12 Kiowa coronalization as tongue height assimilation



Kiowa coronalization and velarization can easily be illustrated using feature spreading diagrams as I have done here, however when constraints are involved it is also useful to consider a constraint-based account. The following constraints, in addition to those mentioned above, are required in order to provide an Optimality Theory account that can accommodate Kiowa tongue height assimilation.

c. FAITHV
Preserve the feature values of vowels.

d. IDENT[strid]
Preserve the value of the feature [±strident]

e. $*s^j$
*[+anterior, +high]
A palatalized dental or alveolar is prohibited.[17]

f. FAITHC
Preserve the feature values of consonants.

The constraint $*s^j$ appears to be active in Kiowa, since this language does not have any palatalized dentals or alveolars.

[17] The justification for this constraint is given in §2.11.

Figure 13 Kiowa coronalization and velarization in Optimality Theory

1.	Input: /ti/	AGREE[hi]	FAITHV	IDENT[strid]	*S^j	*Q	FAITHC
	a. ☞ ki						*
	b. t^j				*		
	c. ʧi			*			
	d. te		*				
	e. ti	*					
2.	Input: /ke/						
	a. ☞ te						*
	b. qe					*	
	c. ʧe			*			
	d. ki		*				
	e. ke	*					

A tongue height assimilation account is superior to Halle's (2005) account because it does not require positing that front vowels are complex [coronal]-[dorsal] segments. Halle (2005:37) points out that "…in most languages…consonants may not have more than one articulator," yet he offers no explanation as to why vowels should not also follow this pattern. Recall from §2.4.3 that front unrounded vowels are more common than any other type of vowel, and note that studies in first language acquisition suggest that vowels are acquired before consonants, and that front vowels are acquired before back vowels (Stark 1997:151). This evidence suggests that unrounded front vowels should have a relatively simple representation in the phonological system. Treating front vowels as complex is certainly undesirable for any account of coronalization. I have shown that this supposition is not required in order to account for Kiowa tongue height assimilation. In Chapter Four I will show that standard cases of coronalization can also be explained without treating front vowels as complex.

Halle's view of coronalization is problematic for some other reasons. Recall that the process which determines whether a resulting affricate will be [+anterior] or [−anterior] is completely arbitrary. This offers no insight into why [−anterior] affricates are the most common outcome of coronalization. Another problem with Halle's view is that it does not explain why standard cases of coronalization result in a strident affricate *tʃ* or *ts*, rather than a plain stop *t*. A thorough account of coronalization will have to address these facts.

2.8 Calabrese (2005)

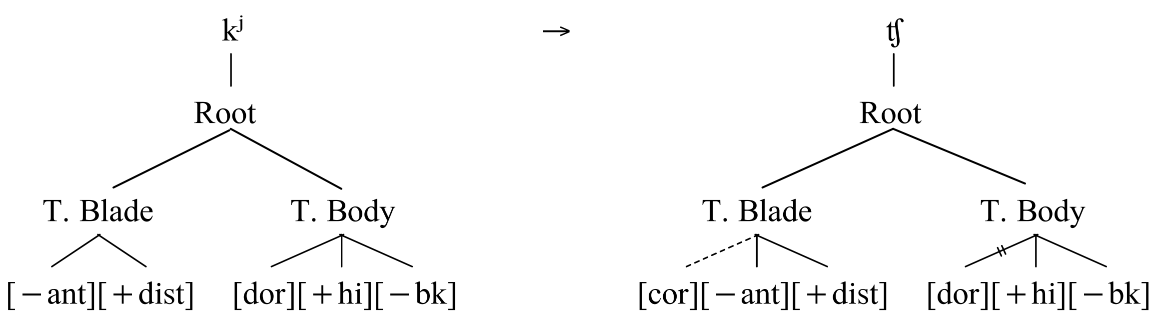
In §2.4 we saw that Vowel-Place Theory considers the change $k^j \rightarrow$ *tʃ* to be a result of the "promotion" of the feature [coronal]. Calabrese (2005) has essentially adopted this idea into Revised Articulator Theory, so that coronalization is seen as a spontaneous change in feature organization rather than as a direct result of articulatory assimilation. This account relies on the assumption that the phonological system includes a "correlation statement" which demands that the featural combination [+high, −back] be accompanied by the tongue blade features [−anterior, +distributed], and vice versa. Here is a formal representation:

a. [+high, −back] ⇔ [−anterior, +distributed]

Note that this correlation statement is very similar to the equivalency relation we saw in §2.3 above, which was also proposed by Calabrese (1993).

According to Calabrese (2005), a palatalized velar k^j bears the tongue body features [dorsal], [−back] and [+high], meaning that it must also be represented by the tongue blade features [−anterior] and [+distributed]. Note that this segment does not bear the feature [coronal] even though it does include other tongue blade features. The coronalization of a palatalized velar is precipitated by the "promotion" of the [coronal] feature. Essentially this means that a [coronal] feature is inserted into the feature matrix so that the tongue blade is now the primary articulator rather than the tongue body.

Figure 14 Coronalization in Calabrese (2005)



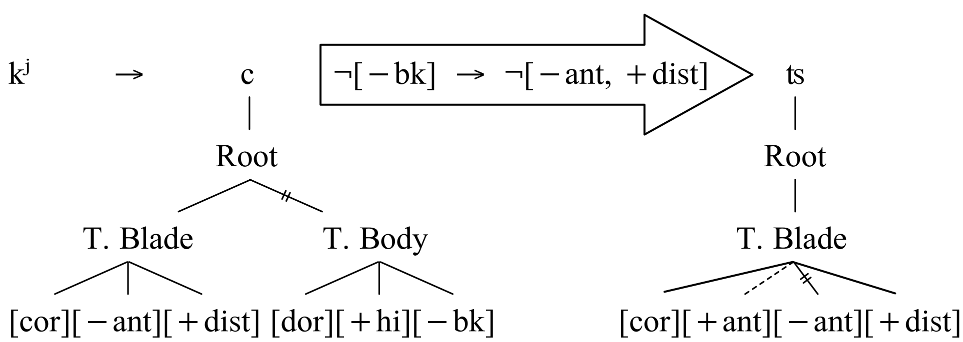
If the [dorsal] node is not dissociated then a palatal stop *c* is formed instead of a palatoalveolar affricate *tʃ* (Calabrese assumes that palatal stops are complex [coronal]-[dorsal] segments following Keating 1988b). While front vocoids are not directly responsible for coronalization under this analysis, they still play an important role. It is the [−back] feature of front vowels that spreads to a neighbouring [+back] velar and causes the velar to become palatalized.

Where Calabrese (2005) differs most dramatically from previous theories is that he provides an explanation for the direct change *k → ts*. In Figure 14 we saw that the [dorsal] feature is dissociated in order to avoid the formation of a palatal stop *c*. This course of action is motivated by the assumption that palatal stops are marked because they require a complex [coronal]-[dorsal] articulation (Calabrese 2005:333-4). Dissociating the feature [dorsal] is one strategy that is used to repair the prohibited segment *c*, but another option, Calabrese suggests, is to delete the whole Tongue Body node, including its dependents [dorsal, + high, − back]. Recall that the correlation statement mentioned above requires [− anterior, + distributed] articulations to also include the features [+ high, − back]. If these features cannot be included, then the combination [− anterior, + distributed] is illegitimate. This is stated formally below:

b. ¬[− bk] → ¬[− ant, + dist]
If not [− back], then not [− anterior, + distributed]

Since [− back] has been deleted, the grammar is forced to repair the featural combination [− anterior, + distributed] so that it can be articulated. This is achieved by replacing [− anterior] with its opposite value, [+ anterior].

Figure 15 Coronalization resulting in an anterior affricate in Calabrese (2005)



It could be said that an anterior affricate is produced as a result of a repair of a repair. The marked segment *c* is repaired by dissociating the Tongue Body node, and then the resulting segment is again repaired by inserting the feature [+anterior].

Calabrese (2005) contains many insights into the nature coronalization that I will also include in my analysis, found in Chapter Four. One of these insights, which has also been expressed by Flemming (2003), is that non-contrastive features play a role in phonological interactions. Another insight is that the process of assibilation is closely related to coronalization, since both processes occur in the same environment (before a high front vowel *i*). One obvious drawback of Calabrese's theory is that it cannot easily account for cases of coronalization where there is a direct change $k \rightarrow tʃ$ without an intermediary k^j stage. Due to the historical nature of most cases of coronalization it is often impossible to ascertain whether or not a k^j stage existed, so it is difficult to disprove this analysis based on this criterion.

Another point of concern is the correlation statement that is required in this account of coronalization. In some cases, the correlation statement requires the tongue blade to perform a certain articulation in order to accommodate the tongue body. This seems unnecessary, since the tongue body can move quite freely when the tongue blade is in its neutral position. One way to illustrate this point is to compare the tongue to the human arm. In this analogy the tongue blade is represented by the hand, while the rest of the arm represents the tongue body. It is clear that the arm can easily be moved in any direction without requiring assistance from the hand. If the hand is used to perform an action, however, then the arm must accommodate the hand by making sure it is in the proper position to perform that action. For example, if the hand is used to grab a glass from a high shelf then the rest of arm must raise the hand to the appropriate height. In the same way, the tongue body must alter its position in order to accommodate tongue blade articulations. If one only wishes to raise one's arm then the position of the hand will also be raised, but the hand need not be activated in order to perform this gesture. This is similar to a tongue body articulation: the position of tongue blade will be slightly altered, but it does not need to make any particular gesture in order to accommodate the tongue body. This view of the tongue is supported by Flemming (2003), who proposes that the tongue body has non-contrastive featural specifications in [coronal] articulations, but does not suggest that the tongue blade is specified for [dorsal] articulations.

Calabrese (2005) cannot explain why the change *tʃ* → *k^j* never occurs. If the [coronal] feature of *k^j* can be promoted, why can't the [dorsal] feature of *tʃ* also be promoted? This is a problem for most, if not all, articulatory accounts of coronalization. Any modification made to Calabrese's analysis in order to account for this fact would undoubtedly be ad hoc in nature, and would offer little explanatory value to this theory. In the next section we will see that an acoustic explanation can account for this incongruency.

The most problematic part of Calabrese's account of coronalization is his explanation of the direct change *k* → *ts*. In Figure 15 we saw that the combination [−anterior, +distributed] is repaired by replacing [−anterior] with [+anterior]. However, there is no reason why this featural combination could not also be repaired by replacing [+distributed] with [−distributed], creating a retroflex consonant. The fact that retroflexes never result from coronalization may lead us to question the legitimacy of this account. Another problem is that Calabrese must crucially assume that *ts* does not bear the feature [−back], since the entire Tongue Body node must be deleted in order for *ts* to result from coronalization. In §2.6, however, I suggested that all coronal consonants are inherently [−back]. Aside from these obstacles, we also have to consider the complex and abstract nature of this account. Even if we do accept Calabrese's (2005) explanation of the change *k* → *ts*, we would still most likely discard it if a simpler and less abstract analysis was put forward.

2.9 Guion (1998)

All of the accounts of coronalization we have reviewed up to this point have treated it as a process of articulatory assimilation. I have shown that all of these accounts are problematic in some regard. Other linguists, such as Ohala (1993), Plauché, Delogu & Ohala (1997), Chang, Plauché & Ohala (2001) and Guion (1998), have suggested that coronalization is the result of acoustic and perceptual factors. We will look closely at Guion (1998) who carried out a series of three experiments investigating this hypothesis. Her motivation for this study comes from the work of Ohala (1992:320), who maintains that coronalization cannot be a result of articulatory assimilation for two reasons:

> First, many of these [coronalizations] result in a place of articulation that is actually further forward than the narrowest constriction for [j] or [i] and certainly for that of any mid or lower front vowel. Segments exhibiting place of articulation assimilations often undershoot what they assimilate but they do not overshoot, e.g., before the vowel /ɔ/ which has its narrowest constriction in the pharynx, a /k/ is at most uvular, not pharyngeal. Second, the "active" articulator is different 'before' and 'after' these changes: the tongue body in a "fronted" velar but the tongue apex

> or blade in the resulting apical stops or affricates. These articulators are too different for the change to be due to articulatory assimilation. On the other hand, a very plausible case can be made for the confusion of all these articulatorily quite distinct sounds due to their acoustic-perceptual similarity.

In addition to this, Guion (1998) has noted that in many cases of coronalization only the voiceless velars are affected, while the voiced series remains unaltered. According to her assessment, about 40% of the cases of coronalization found in Bhat's (1978) survey follow this pattern, while the other 60% show a uniform treatment of both voiced and voiceless velars. There are no examples, however, of a language which coronalizes a voiced velar to the exclusion of a voiceless one. Guion argues that this pattern is very difficult to explain from an articulatory standpoint, since voicing is generally independent of tongue movement. Based on these arguments, Guion explores the possibility that standard cases of coronalization are a result of auditorily-based substitution rather than articulatory assimilation.

In order to investigate the feasibility of an acoustic-perceptual model of coronalization, Guion carried out three experiments. The first experiment investigated the potential acoustic similarities between velars and palatoalveolars. Voiced and voiceless velars and palatoalveolars were recorded in word-initial position preceding the vowels [i ɪ ej ɛ æ ɑ ɔ ow ʊ u ʌ], as spoken by native English speakers in both citation speech and faster speech. An average spectrum was made for the burst portion of each stop, and the highest amplitude of each spectrum was measured. Other analyses were carried out on the data as well, but the most striking results come from comparing the spectral measurements. In the data taken from the faster speech of male speakers, we see that the average spectral peak of *k* fluctuates significantly depending on the backness of the following vowel, but *tʃ* shows only a slight amount of variance. Furthermore, we see that the average spectral peak of *k* preceding front vowels is almost identical to that of *tʃ*.

Table 14 Average peak spectral frequencies for [ʧ] and [k] from faster speech of male speakers (in Hz)[18]

		Vowel	
		Front	Back
Consonant	k	4000	2300
	ʧ	3800	3600

While the average spectral peaks of *g* and *dʒ* were also more similar before front vowels, they did not show the same degree of convergence as their voiceless equivalents. This evidence seems to favour an acoustic-perceptual view of coronalization, since the acoustic facts can account for the change in place of assimilation (due to auditorily-based substitution) and for the discrepant behaviour of voiced and voiceless velars. This conclusion led Guion to conduct two more experiments investigating the perceptual similarities between velars and palatoalveolars.

In the second experiment, digitally edited tokens of *k* and *tʃ* in the context of the vowels *i*, *u* and *a* were presented to listeners for identification. The tokens were modified in two different ways. The first set was modified so that the voiced portion of the vowel was deleted, leaving the stop burst and aspiration of the velars, and the

[18] This data is extrapolated from a graph given by Guion (1998:26). Front vowels are [i ɪ ej ɛ æ] and back vowels are [ɑ ɔ ow ʊ u ʌ].

release and frication of the palatoalveolars. In the second condition all but the first 30ms of the consonant was deleted, so that the stop burst and affricate release were truncated. Listeners were presented with a forced choice so that they could only identify each sound as *k* or *tʃ*. Guion found that the listeners did not have a great deal of difficulty identifying the truncated set of stimuli except for *k* when it occurred preceding *i* (Guion 1998:32). Her data show that the reverse was not true; truncated tokens of *tʃ* were not confused with *k* when they occurred before *i*. Thus the perceptual data is in agreement with another pattern found in coronalization: it appears to be a one-way process. More importantly, listeners apparently found it difficult to identify *k* before *i* when the stop burst information was withheld, but did not show any similar problems when *k* occurred before the other vowels.

Table 15 Percentage of tokens perceived as *k* and *tʃ*

		Spoken											
		All consonantal information						First 30 ms of consonant					
		ki	kɑ	ku	ʧi	ʧɑ	ʧu	ki	kɑ	ku	ʧi	ʧɑ	ʧu
Heard	k	98	100	100	-	-	-	53	97	97	-	2	6
	ʧ	2	-	-	100	100	100	47	3	3	100	98	94

This appears to be a clear confirmation that the acoustic similarity between *k* and *tʃ* in the environment of a following front vowel can lead to listener confusion. An acoustic-perceptual view of coronalization suggests that this listener confusion could ultimately lead to a sound change such as coronalization.

The second experiment only gave the listeners two choices for identifying the consonants in question. The results regarding truncated tokens of *ki* suggest that the listeners may have simply been guessing when they identified the consonant, or, possibly, they may have perceived a consonant that was not available to them as a choice. In order to address this, the third experiment was designed so that the listeners would have four choices instead of two. The third experiment was also designed so that the confusion rate of voiced velars could be compared to that of the voiceless velars. This experiment was very similar to the second experiment, except that masking noise was used to obscure the consonants rather than truncation in an effort to more accurately represent real-world listening conditions. In addition, the tokens were all 100ms long. 69% of the noise-masked stimuli were identified with a correct response, far above chance (25%), while the normal tokens were correctly identified 96% of the time. I have only provided the data from the masked condition here, since tokens from the unmasked condition were identified with a high degree of accuracy, as they were in Experiment Two.

Table 16 Experiment 3 Noise-masked token identifications expressed as percentages[19]

		Spoken											
		k			tʃ			g			dʒ		
		i	ɑ	u	i	ɑ	u	i	ɑ	u	i	a	u
Heard	k	43	84	46	10	10	13	4	4	5	9	2	11
	tʃ	35	13	31	85	87	84	4	-	3	28	23	22
	g	10	3	12	-	-	-	71	87	76	12	10	17
	dʒ	12	-	11	5	3	3	21	9	16	51	65	50

[19] From Guion (1998:35).

While these results show some unexpected variations, the primary pattern we saw in Experiment Two remains intact. The misidentification of *k* as *tʃ* before *i* occurred in 35% of those tokens, and *k* was correctly identified in this environment only 43% of the time. The confusion rate of *g* as *dʒ* in this same environment was, as expected, lower than that of *k* and *tʃ* at 21%. Somewhat problematic for Guion is the fact that *u* caused much the same effect as *i* in both the voiceless and voiced contexts. She notes that this vowel was quite fronted in the speech of the speakers used in this experiment (from Texas, U.S.A), and her acoustic analysis of this vowel suggests that it should be identified as a central vowel [ʉ] rather than a back vowel [u] (Guion 1998:22, footnote 1). The more central position of this vowel is probably responsible for this unexpected result, but further study would need to be conducted in order to confirm this hypothesis.

In addition to the above results, Guion also investigated the properties of the individual tokens of *k* in order to identify any further patterns. She found that *k* was most often identified as *tʃ* when its peak spectral frequency was between 3500 and 4000 Hz, and that the number of *tʃ* responses tapered off at both higher and lower frequencies. In addition to this, Guion observed that the length of the voice onset time (VOT) for *k* was also correlated with an increase in *tʃ* identifications. This effect was most noticeable when the VOT was over 100 ms, especially when a relatively long VOT was associated with a peak spectral frequency above 3500 Hz. These results serve to further establish a relationship between coronalization and acoustic-perceptual factors, and the VOT data offers an explanation for the disparate behaviours of voiced and voiceless velars. Guion's analysis of the data suggests that voiced velars are less likely to be perceived as palatoalveolars due to the fact that they have a minimal VOT. If they are less likely to be perceived as palatoalveolars, then consequently they are less likely to undergo coronalization.

The results of this acoustic and perceptual study provide convincing arguments for viewing coronalization as a process that is at least partly mediated by non-articulatory factors. One problem with the perception experiments is that the forced-choice format did not allow a response that was not either a velar stop or palatoalveolar affricate. The subjects may have responded differently if they had been given more choices. These experiments did not consider the fact that coronalization sometimes results in *ts*, a fact that should be investigated given the positive results of this study. Along with this, the effects of front vowels on velar fricatives, such as *x*, also need to be measured, since they too are susceptible to coronalization. If further research is conducted in this area then Guion's experiments should probably be revised in order to account for the fact that *u* was seen to have an effect similar to that of the front vowel *i*. The fact that *u* is pronounced as [ʉ] by these speakers is not a complete explanation, since [ʉ], and central vowels in general, are not known to cause coronalization (Bhat 1978).

2.10 Lee (2000)

I am aware of only one account of coronalization that includes both articulatory and perceptual factors. This analysis, put forward by Lee (2000), is not expressed in formal terms, but instead relies on phonetic description, much like Guion (1998). Following the same line of reasoning as Chomsky & Halle (1968), which was outlined in §2.2 above, Lee (2000) argues that coronalization is the result of a desire to avoid a palatal stop *c*. Lee (2000) shows that palatal stops require greater tongue movement and a larger contact area than stops at other places of articulation, and that they therefore involve a greater degree of articulatory effort. Coronalization results from an attempt to reduce this articulatory effort. Lee (2000) suggests that the reason palatoalveolars and alveolopalatals are chosen to replace palatals is that these types of segments are perceptually similar to palatals. The reason that palatoalveolars are chosen more frequently than alveolopalatals is that, according to Lee (2000), alveolopalatals require a greater amount of articulatory effort. This supposition is based on the observation that alveolopalatals require greater upward displacement of the tongue than palatoalveolars.

While this account is quite acceptable for describing the change *c* → *tʃ*, it cannot easily capture all cases of coronalization. This analysis requires an intermediary stage before the velar is realized as a coronal: *k* → *c* → *tʃ*. It is difficult to verify whether or not this happens in actual cases of coronalization, since this process is generally diachronic in nature. However, recall from Chapter One that Acadian French allows *k* ~ k^j ~ *tʃ* to occur in free variation before front vowels, suggesting that a palatal stage is not required in order for *k* to undergo coronalization. In addition to this, note that the change *c* → *tʃ* appears to be quite rare,[20] and that palatal stops appear to be very stable, even in languages where they were derived through historical phonological processes, such as Hungarian (Benko & Imre 1972:54) and the Majorcan dialect of Catalan

[20] The only language I know of where the change *c* → *tʃ* has taken place in a dialect of Bulgarian (Calabrese 2005:347).

(Wheeler 2005:10). These facts suggest that the change *k* → *c* rarely leads to coronalization, which is problematic for Lee's (2000) analysis.

An even greater problem for Lee (2000) is explaining the direct change *k* → *ts*. The production of an anterior coronal affricate *ts* does not generate palatal frication, so it is unlikely that this segment is perceptually similar to a palatal stop *c*. This problem suggests that Lee's (2000) account is no better than the purely articulatory theories which also cannot explain *k* → *ts*.

2.11 Summary

In this chapter we saw that there has been a great deal of discussion regarding the topic of coronalization, but that there is no generally accepted solution to this riddle. One problem faced by these analyses is that while they can account for most cases of coronalization, they cannot account for all of them, particularly the direct change *k* → *ts*. This problem seems to be perpetuated in part because the authors were not familiar with all of the available data regarding coronalization. In order to ensure that this mistake is not repeated, a large portion of the next chapter is dedicated to investigating this process. We have seen that all articulatory accounts, including those proposed very recently, have fallen somewhat short of adequately explaining coronalization. Guion's (1998) acoustic account, on the other hand, has shown some promise, but it is clear that articulatory factors need to be included as well. Lee's (2000) attempt to integrate both types of factors is a step in the right direction, but still cannot account for all cases of coronalization.

Throughout this chapter I have alluded to problems with the representation of palatalization, but have not provided my own account. I will do so now, since all of the relevant facts have been discussed above. As indicated in §2.6 and §2.7, I follow Flemming (2003) in assuming that some phonological patterns can be explained by allowing coronals to be specified with tongue body features. I suggest that palatalization is one such pattern, and that palatalized coronals and velars are distinguished from their plain counterparts solely by their tongue body feature specifications. In §2.5 we saw that palatalized velars cannot be characterized using only the feature [+high], and in §2.6 we saw that palatalized coronals cannot be characterized using only the feature [−back]. It seems then, that palatalization needs to be represented by both features. This makes logical sense, since palatalization is most often caused by the high front vowel *i*, which is both [+high] and [−back]. This would mean that velars can be palatalized by any front vowel, but that coronals can only be palatalized by high vowels.

We also need to consider the related process of tongue-raising, where an anterior coronal becomes a palatoalveolar: *s* → *ʃ*. For example, Bhat (1978:62) notes that the causative suffix *-su* of the Havyaka dialect of Kannada is pronounced *-ʃu* when preceded by *i*, *e* and *j*. The fact that the mid vowel *e* also participates in this process suggests that anterior coronals such as *s* are in fact [+low], and that they can be raised not only by the spreading of [+high], but also by [−low]. In order to account for this fact I propose that palatalization can be represented by either [+high], [−low] or [−back], depending on the place of articulation of the palatalized segment. Anterior coronals are palatalized by [−low], postalveolars are palatalized by [+high] and velars are palatalized by [−back]. Note that all three of these features are compatible with each other and that, as before, they are all found in the high front vowel *i*.

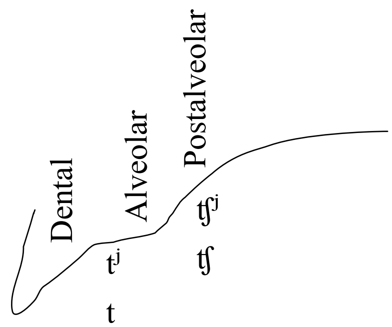
As just mentioned, I propose that anterior coronals have a [+low] tongue body position. This is not the case for palatoalveolars, however, which are pronounced with a higher tongue body position than anterior coronals (Ladefoged & Maddieson 1996:145-9). In my view, the palatalization of all coronals is caused by a slight raising of the tongue body. This means that palatalized anterior coronals are slightly higher than their plain counterparts, and that palatalized palatoalveolars are likewise higher than plain palatoalveolars. The feature specifications for all of these segments are summarized below.

Table 17 Tongue height features for plain and palatalized coronal consonants

	[+anterior]	[−anterior]
[+high, −low]	-	$tʃ^j$ / tɕ
[−high, −low]	t^j	tʃ
[−high, +low]	t	-

Note that the configuration of these coronal segments in the feature grid leads to a shape similar to that of the front of the mouth, as shown in Figure 16 below.

Figure 16 Sagittal view of the front of the mouth



The tongue must maintain a lower body position when producing dentals and alveolars so that the tongue blade can reach these places of articulation. Likewise, a low tongue body position prevents the tongue blade from reaching the palatoalveolar and alveolopalatal regions, which explains why postalveolars are [−low].[21]

This feature system does not explain why the change *s* → *ʃ* takes place under the influence of front vowels. If we spread [−low] to *s*, we expect a palatalized consonant s^j to result. While this effect was seen in Old Irish, where the anterior coronals *t*, *d* and *s* became t^j, d^j and s^j when followed by the vowels *i* and *e* (Thurneysen 1946:97), it is not the expected outcome *ʃ*. Why [+anterior] *s* or s^j would become [−anterior] *ʃ* is something of a mystery then, since the feature [−anterior] is not present in the input. I suggest that this mystery can be solved if we assume that palatalized anterior coronals are phonetically complex, and therefore frequently avoided. The reason for this complexity is that palatalized anterior coronals require two antagonistic gestures. The feature [+anterior] requires the front of the tongue to move forward, while [−low]

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[21] I follow Ladefoged & Maddieson (1996:150) and Hall (1997:73) in treating alveolopalatals as phonetically and phonologically equivalent to palatalized palatoalveolars: *tɕ* = *ʧʲ*.

pulls the tongue slightly upwards. Moving the tongue body upwards results in the retraction of the tongue blade, making it more difficult to produce [+anterior] consonants. This is formalized as a markedness constraint below.

a. *s^j (adapted from Chitoran 2002:181)
*[+anterior, −low]
A palatalized dental or alveolar is prohibited.

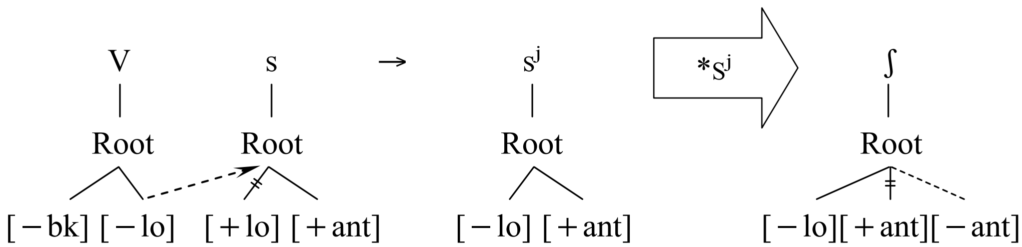
Typically this constraint is satisfied by replacing [+anterior] with [−anterior], creating a palatoalveolar segment. Another possible repair is to replace the feature [−low] with [+low], resulting in de-palatalization: $s^j \rightarrow s$. Both of these repair strategies can be found in the pronunciation of the initial onset of the word *Tuesday* in North American English. Some speakers follow the pattern of British English and use the consonant cluster *tj* in this position, others use the palatoalveolar *tʃ*, and the majority of speakers use the plain stop *t*.[22] In some cases of tongue-raising a palatalized coronal t^j is replaced by an alveolopalatal consonant *tɕ* rather than a palatoalveolar *tʃ*. This change has taken place in Irish, Japanese, Polish, Russian dialects, Gaelic (Kochetov 2002:23) and Standard Chinese (Li 1999:96). I suggest that this is usually due to the spreading of [+high] from a neighbouring high vowel, but it could also result from the need to maximize the distinction between two different sets of postalveolar consonants. This is most likely the case in Standard Chinese and in Polish, which both maintain a contrast between two sets of postalveolar consonants. Alveolopalatals may have

[22] This case requires a syntagmatic constraint *sj rather than the paradigmatic constraint *s^j.

developed in order to increase the phonetic and acoustic distance between these two sets of stops (this type of change is motivated by Keating's (1984) polarization principle).

Making use of the constraint *S^j, the change $s \rightarrow ʃ$ found in the Havyaka dialect of Kannada can be illustrated as follows:

Figure 17 Tongue-raising in Havyaka



In order to put forward an OT account of this process I will require the use of the constraint AGREE[low], similar to AGREE[high] seen above.

b. AGREE[low]
*[+ low][− low], *[− low][+ low]
Neighbouring segments cannot have different tongue heights.

The appropriate candidate is selected when *S^j and AGREE[low] are ranked above the constraint FAITHC, described in §2.7 above.

Figure 18 Havyaka tongue-raising in OT

Input: /is/		$*s^j$	AGREE[low]	FAITHC
a. ☞	iʃ			*
b.	is		*	
c.	is^j	*		*
Input: /es/		$*s^j$	AGREE[low]	FAITHC
a. ☞	eʃ			*
b.	es		*	
c.	es^j	*		*

This analysis suggests that tongue-raising is motivated in part by feature spreading and in part by the articulatory markedness of palatalized anterior coronals such as t^j and s^j. In Chapter Four I will rely on this analysis to explain why palatoalveolars are the most common outcome of coronalization.

CHAPTER 3: COMPARING CORONALIZATION AND ASSIBILATION

Despite the observations made by Morin (1974) and Flemming (2002) reported in Chapter One, most phonologists have neglected to consider the fact that coronalization shares some striking similarities with another phonological process: assibilation. This chapter will investigate the facts regarding both processes and compare their similarities and differences.

3.1 Coronalization

Coronalization is so commonplace that it is usually considered to be well-understood, and is often taught to undergraduate students alongside much more transparent processes such as intervocalic voicing and homorganic nasal place assimilation. Despite the fact that coronalization is such a well-attested process, there is very little comparative literature available on this subject. The best summary to date remains Bhat's (1978) survey, which contains some valuable insights, but ultimately lacks the thoroughness and attention to detail required in order to draw comprehensive typological conclusions. Guion (1996, 1998:20) gives a brief overview of coronalization, including detailed examples taken from seven different languages, but this sample size is too small to be useful for an in-depth analysis. Clearly a comprehensive typological survey of coronalization is required before conclusive generalizations can be made regarding this topic, yet a few reliable observations can be made at this point on the basis of the extensive coverage this subject has received in past publications.

Table 18 Examples of velar coronalization triggered by a following vocoid

Language	Change	Environment	Source
Proto-Indo European ("satem" languages)	*k^j → ʃ / s *g^j → ʒ / z	-	Meier-Brügger (2003:130-2)
Slavic (1st)	k → ʧ g → ʒ x → ʃ	{j i ɪ e ɛ}	Carlton (1990)
Slavic (2nd)	k → ʦ g → ʣ x → s	{i e} (< aj)	Carlton (1990)
Indo-Iranian	*k → ʧ *g → ʤ *g^h → ʤ^h	{i e}	Guion (1998)
Old English	*k → ʧ *ɣ → j *kk → ʧ *gg → ʤ	{i ɪ e eː æ æː}	Hogg (1992)
Faroese (North Germanic)	k → ʧ^h g → ʤ	{i ɪ eː ɛ ɛiː}	Thrainsson *et. al.* (2004)
Proto-Romance (Late Latin)	k → ʦ g → ʤ	{i e ɛ}	Pope (1934:122-7), Buckley (in press)
Gallo-Roman	k → ʧ g → ʤ	{i ɛ æ æu}	Pope (1934:128), Buckley (in press)
Acadian French	k → k^j ~ ʧ g → g^j ~ ʤ	{i ɛ ɥ ø œ}	Hume (1994)
Spanish	k → ʦ g → ʣ	{j}	Penny (2002:73)

Standard Italian	k → ʧ g → ʤ	{j}	Calabrese (2005:320)
Puglia, Salento and Lucania dialects of Italian	k → ʦ g → Ø	{j}	Calabrese (2005:323), Flemming (2002:104)
Romanian	k → ʧ g → ʤ	{i}	Chitoran (2002)
Tswana (Bantu)	*k → ʦ^{h}, s *g → ʦ, Ø	{*i˔ *i *e *u̯˔}	Creissels (1999)
Kirundi (Bantu)	k → ʦ g → ʣ	{i e}	(Broselow and Niyondagara 1990)
Mam (Mayan)	k → ʧ	{i e}	Guion (1998)
Standard Chinese	k → ʨ k^{h} → ʨ^{h} x → ɕ	{j i ɥ y}	Duanmu (2000), Li (1999)
Navajo (Apachean)	*k^{j} → ʦ *k^{jh} → ʦ^{h} *k^{j}’ → ʦ’ *x^{j} → s	-	Young (1983), Calabrese (2005), Howe & Fulop (2005)
Cowlitz Salish (Salishan)	k^{j} → ʧ k^{j}’ → ʧ’ x^{j} → ʃ	-	Kinkade (1973)
Nuuchahnulth (South Wakashan)	*k^{j} → ʧ *g^{j} → ʤ *k^{j}’ → ʧ’ *x^{j} → ʃ	-	Howe (2000:69-70)
Po-ai dialect of Tai (Tai-Kadaian)	k → ʧ	{j}	Ohala (1993)

Kannada (Dravidian)	k → tʃ	{i}	Murthy (1984)
Proto-Samoyed (Uralic)	*k → s / ʃ	{i y e ø æ}	Collinder (1960:48-9)
Vote (Uralic)	k → tɕ	{i e æ}	Collinder (1960:47-8)

Bhat (1978) conducted a preliminary survey of the phonological effects of palatalization. Based on his findings, he divided this phenomenon into three distinct processes: "tongue-fronting", "tongue-raising" and "spirantization." Bhat notes that all three of these processes can come into play when velars are coronalized, so I will consider each one separately. "Tongue-fronting" describes the process that I refer to as (velar) palatalization: *k → kʲ*. Unfortunately the term "tongue-raising" is somewhat confusing since it is used to refer to two related processes. The first of these processes is what I have defined as the palatalization of coronals and labials: *t → tʲ*, *p → pʲ*. The second process is the alteration of an anterior coronal, either plain or palatalized, into a palatoalveolar: *t/tʲ → tʃ*. In order to avoid ambiguity I have re-defined *tongue-raising* so that it refers only to the latter of these two processes, as mentioned in Chapter One. Bhat (1978:50) describes the third process, "spirantization", as the "addition of stridency to the consonant under consideration" resulting in either an affricate or a fricative. This process can affect both alveolars and velars, but invariably results in a coronal sibilant. I will argue that Bhat's "spirantization" is in fact a type of assibilation.

3.1.1 Coronalization triggers

There are a few generalizations we can make about the vocoids that trigger coronalization. Bhat (1978) found that only front vowels and glides are ever responsible for this process. He also found that if coronalization is triggered by a nonhigh vowel then typically a high vowel will also induce this change (Bhat 1978:54). There are a few rare cases where a high vowel will cause coronalization, but a palatal glide *j* will not. The only two languages that showed this pattern in Bhat's survey were Zoque and Nupe (Bhat 1978:52). Coronalization is nearly always triggered by a following vocoid; however there are a few cases where a preceding vocoid is the source of this change. Bhat (1978) notes three languages that follow this pattern: Proto-Slavic, Old English and German; however Lakota should also be included in this list (Shaw 1978). Of these four languages, Proto-Slavic and Old English both had more productive types of coronalization in environments where the vowel followed the velar. German and Lakota are the only languages I know of where velar coronalization is restricted to an environment in which the trigger precedes the consonant. I propose that in these cases velar palatalization took place before coronalization: $ik \rightarrow ik^j \rightarrow itʃ$. This proposal is discussed at length in Chapter Five.

3.1.2 Coronalization outcomes

Nearly all cases of coronalization result in a strident coronal affricate or fricative (Bhat 1978:59). This affricate or fricative is typically a palatoalveolar, but in some cases an anterior consonant is produced. Bhat (1978:59) notes that Proto-Slavic, Spanish, and the Greek dialects of Lesbos produced anterior coronals, and we saw above that this is also true for Old French, some dialects of Italian, Navajo, and many Bantu languages, including Kirundi and Tswana. Some linguists (e.g., Newton 1972) have proposed that these anterior coronals are the result of "de-palatalization" that takes place after coronalization: *k → ʧ → ʦ*. Calabrese (2005:337) points out that this cannot be correct, however, citing evidence from Navajo and the Ligure dialect of Italian. These languages had palatoalveolar consonants before coronalization took place, and these palatoalveolars were preserved even when coronalization created anterior coronals.

I will consider the case of Navajo in more detail in order to fully illustrate this point. Navajo belongs to the Apachean branch of the Athapascan language family, and is spoken in the southwestern part of the United States. All of the Apachean languages underwent the coronalization process in question (Young 1983). Proto-Athapascan already had an anterior coronal series (**s *z *ʦ *ʦ*^{h} **ʦ'*) and a palatoalveolar series (**ʃ *ʒ *ʧ *ʧ*^{h} **ʧ'*) before coronalization took place. When the palatalized velar series (**x*^{j} **k*^{j} **k*^{jh} **k*^{j}*'*) underwent coronalization it could have merged with either the anterior coronals or the palatoalveolars. Comparing cognates from Navajo and Proto-Athapascan indicates that the palatalized velars became anterior coronals, as we can see here.

Table 19 Coronalization in Navajo

Proto-Athapascan	*Navajo*	
*k^{jh}aːn	-ʦ^{h}ą́	'belly, base'
*kik'ə	tiʦé	'berry'
*k^{jh}aːn	-ʦ^{h}ą́	'rain'
*k^{jh}eʔ	-ʦ^{h}eːʔ	'tail'
*-k^{jh}ṵːt	-ʦ^{h}óːt	'seize'
*k^{j}'ʊχ	ʦ'oh	'quill'
*k^{jh}a̰ːɣ	ʦ^{h}aː	'big'
*x^{j}ẽːs	sẽːs	'wart'
*-ʧ^{h}ĩːx^{j}	ʧ^{h}ĩ́(ː)s-	'nose'

cf. *tsəɬ	tsiɬ	'mountain'
*-ts'ən	ts'in	'bone'
*ts'ã̠:kʲ'	ts'ã:ʔ	'basket'
*sa·xʲ	séj	'sand'

In order to confirm that the Proto-Athapascan palatoalveolars were not affected by this process let us compare them to their modern Navajo cognates. If the anterior coronals resulting from coronalization had undergone "de-palatalization" then the original Proto-Athapascan palatoalveolars would have also been subjected to this process. The fact that the palatoalveolars are preserved in Navajo indicates that the palatalized velars must have become anterior coronals without any intermediary stages: *k* → *ts*.

Table 20 Preservation of Proto-Athapascan palatoalveolars in Navajo

Proto-Athapascan	*Navajo*	
*-ʧʰən	-ʧĩh	'smell'
*-ʧʰixʲ	-ʧi:h	'ochre/red'
*ʧʰaʔ	ʧʰa:ʔ	'beaver'
*ʧ⁽ʷ⁾ʰ...	-ʧʰó	'grandmother'
*-ʃe̠:q'	ʃé:ʔ	'spit' PERF
*ʧe̠ʁ	-ʧa:ʔ	'ear'
*ʧe̠:χ	ʧe:h	'gum'
*ʧ'əχt	ʧ'ah	'hat'
*ʧ'…	-ʧ'í:ʔ	'guts'
*ʧ'əwə	ʧ'ó	'spruce'
*ʧ'ənʔ	-ʧ'ĩʔ	'towards'

Coronalization resulting in *alveolopalatal* fricatives and affricates is rare, but is attested in Standard Chinese, where **k*, **kʰ* and **x* became *tɕ*, *tɕʰ* and *ɕ* when followed by high front vowels and glides. It appears that Standard Chinese already had three sets of coronal consonants before coronalization took place (Li 1999:173). Coronalized stops were apparently prevented from merging with any of these series', and thus an alveolopalatal series was brought into being. Other languages show a similar pattern, where coronalization resulted in the creation of a new place of articulation. Note, however, that many of the well-known cases of coronalization are found in languages descended from Proto-Indo-European, which did not have any postalveolar consonants; the only coronal phonemes reconstructed for PIE are anterior. This means that the coronal region was, in phonological terms, relatively impoverished.[23] It is therefore not surprising that the outcome of coronalization filled this gap in many Indo-Eurpean languages. Reconstructions of Proto-Bantu suggest that it also lacked a palatoavleolar place of articulation (Creissels 1999:314); however velar coronalization often produced anterior coronals in the daughter languages. Nonetheless, it seems clear that the development of a new postalveolar place of articulation is a potential side-effect of coronalization.

3.1.3 Voicing asymmetry in velar coronalization

Guion (1998) notes that it is not uncommon for voiceless velars to undergo coronalization while voiced velars remain unaffected. She suggests that roughly 40% of the cases of coronalization found in Bhat (1978) follow this pattern. She gives no other qualifying remarks about this statistic, however, which is somewhat suspect since

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[23] If affricates are included, the most common number of places of articulation for consonants is four. 43.8% of the languages in Maddieson's (1984:34) survey follow this pattern. The four most common places of articulation are labial, anterior coronal, palatoalveolar and velar.

details are so hard to come by in Bhat's survey. The collection of coronalization examples seen in Table 18 suggests that this percentage should be lower, perhaps closer to 20%. To make matters more confusing, Guion is not explicit about how she is counting cases where voiced velars are simply not present, as in Standard Chinese and Navajo, which distinguish stops based on aspiration rather than voicing. There may also be cases of coronalization that occur in languages with only a single set of laryngeal features for their stops. These cases, if any exist, cannot rightfully be counted in a study of VOT asymmetry because they make no VOT distinctions. Guion's statistics on this matter need to be verified before they can be accepted without skepticism; however, we can conclude that voiced (or unaspirated) velars never undergo coronalization to the exclusion of voiceless (or aspirated) velars.

There are other differences in the behaviour of voiced and voiceless velars when they undergo coronalization:

(1) Voiced velars show a preference for becoming palatoalveolars.

(2) Voiced velars are more likely to become fricatives; voiceless velars are more likely to become affricates.

(3) Voiced velars are more likely to become a palatal glide or to be deleted altogether.

The first difference is reflected in the broader typological context, where voiced palatoalveolar affricates are disproportionately common when compared to other strident voiced coronal fricatives and affricates. This is seen in Table 21, where the voicing ratio is an expression of the relative frequency of voiced and voiceless phoneme consonants, calculated by dividing the number of languages with the voiced variant by the number of languages that include the voiceless variant.[24] Strident coronal fricatives seem to have a voiced variant roughly one third of the time, as do dental and alveolar affricates. Voiced palatoalveolars are far more common however, occurring in more than half of the languages that include *ʧ*. Maddieson goes so far as to suggest that this discrepancy "may be related to the frequent historical descent of palatoalveolar affricates from velar or palatal stops" (1984:39).

Table 21 Relative frequency of strident coronal affricates and fricatives[25]

	Dental / Alveolar				Palatoalveolar			
	Fricatives		Affricates		Fricatives		Affricates	
Voiceless	/s/	266	/ʦ/	95	/ʃ/	146	/ʧ/	141
Voiced	/z/	96	/ʣ/	30	/ʒ/	51	/ʤ/	80
Voicing Ratio	0.36		0.32		0.34		0.57	

This is an interesting supposition, but it ignores the fact that anterior coronals can also be drawn from stops, either through coronalization or, as we will see below, through assibilation. A phonetic account of this phenomenon would be the most plausible, but

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[24] In this thesis the term 'voicing ratio' refers solely to the typological measurement described in Maddieson (1984), is is not to be confused with the phonetic measurement of the same name.

[25] Data from Maddieson (1984:38, 45). The data represent the number of languages in Maddieson's survey that included these consonants as phonemes. There were a total of 317 languages in the survey. The voicing ratio given in the table does not include aspirated affricates. 33 languages in Maddieson's survey possessed a phoneme *ʦʰ*, and 42 languages included *ʧʰ*. If these affricates are counted as voiceless and are included in the voicing ratios then we obtain a result of 0.23 for the dental / alveolar affricates, and 0.44 for the palatoalveolars. While these numbers are different than those in the table above, they maintain the same overall pattern: voiced palatoalveolar affricates are disproportionately common.

no such explanation is available at this time. Nonetheless, it is probably fair to hypothesize that whatever is responsible for favouring voiced palatoalveolar affricates cross-linguistically is also responsible for giving them preferential treatment in the process of coronalization.

The second and third voicing discrepancies found in coronalization are probably related to each other. In addition, both of these assymetries are undoubtedly linked to lenition processes, where voiced consonants are typically more prone to weakening than their voiceless counterparts. It seems that the general markedness patterns found across languages are reflected in the typology of coronalization, but a detailed study of lenition in relation to this process is required before any firm conclusions can be reached.

3.1.4 Summary

There are five important generalizations regarding coronalization that can be made at this point:

(1) Front vowels and glides cause coronalization.

(2) Nonhigh vocoid triggers imply high vocoid triggers.

(3) Triggers typically follow the target.

(4) The output is a sibilant affricate or fricative.

(5) Voiced targets imply voiceless targets.

There is a great deal of evidence in favour of these generalizations, and exceptions are either extremely rare or belong to unusual cases that require further investigation.

3.2 Assibilation

The term assibilation is usually used to describe a situation where a plain stop becomes a sibilant affricate or fricative (Kim 2001:81). Typically the stop is a dental or alveolar, so the most common cases of assibilation are changes of the type *t* → *ts*. This process is not as common as coronalization, but is by no means rare, and is found in at least 45 different languages according to Hall and Hamann's (2003) preliminary survey of this phenomenon. Although their survey is not intended to act as a comprehensive typology of assibilation, Hall & Hamann have compiled a very thorough review of the relevant data and have drawn some noteworthy conclusions from their observations. Another important document dealing with the phonological treatment of assibilation is Kim (2001). In this article she proposes that assibilation can be represented phonologically by adding the feature [+strident] to the feature matrix of the plosive being affected. Following Kim (2001) I will assume that the feature [±strident] is responsible for distinguishing sibilants from non-sibilants. Her analysis will be discussed below.

3.2.1 Assibilation triggers

In their typological survey, Hall and Hamann (2003) found that assibilation is almost universally caused by high front vocoids such as *i*, *ɪ*, *j*, *y*, *ʏ* and *ɥ*. Their survey focused on the relationship between *i* and *j* in assibilation, and does not provide details about the other vocoids responsible for this process. Some exceptions to the above generalization are found in the following three languages.

Table 22 Assibilation caused by non-high and non-front vowels

Turkana (Eastern Nilotic)	t → s / _{i ɪ e ɛ}	Dimmendaal (1983:8-9)
Japanese	t d → ʦ z / _ɯ	Akamatsu (1997, 2000)
Woleaian (Oceanic)	t → s / _{i e u o}	Hall & Hamann (2003:122)

We can see here that mid front vowels, high back vowels, and apparently even mid back vowels can cause assibilation. There are no known cases where low vowels cause assibilation. More research needs to be done on non-high and non-front triggers before a definitive statement can be made about this aspect of assibilation.

Another important finding of their survey is the following implicational universal: if a language allows *i* to act as an assibilation trigger then it will also allow *j* to act as an assibilation trigger. In addition to this, they found that the assibilation trigger almost always follows the target. There were only three languages in their survey that did not abide by this generalization (Hall and Hamann 2003:113).

Table 23 Cases of assibilation caused by a preceding trigger

Pima Bajo	t d → ʧ ʤ / i_
Apalai	t → ʧ / i_
Basque	t → ʧ / i_

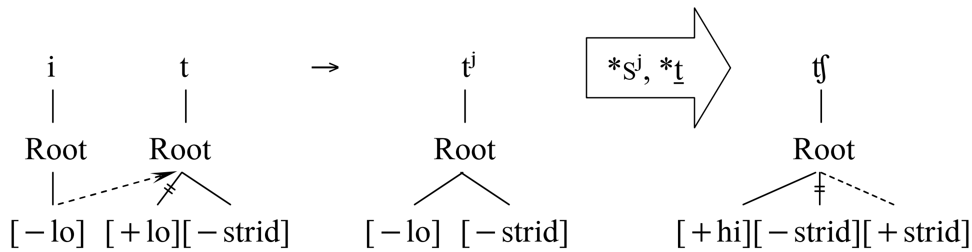
Interestingly all of these cases involve tongue-raising in addition to assibilation (i.e *t* becomes *ʧ* instead of *ʦ*). This coincidence leads me to propose that these cases should be treated as tongue-raising rather than as standard cases of assibilation. Note that these cases are very similar to the change *s → ʃ / {i e j}_* found in the Havyaka dialect of Kannada mentioned in §2.11 above. In the case of Havyaka, however, we can be sure that the change is purely articulatory in nature, since both the input and the output are strident coronal fricatives. It seems, then, that assibilation can sometimes be a side effect of tongue-raising.

Phoneticians, such as Catford (1977), have noted that a large amount of contact between the tongue and the roof of the mouth is required in order to produce a palatoalveolar stop *t̠*. The large amount of surface area involved makes it difficult to release this contact quickly, and a period of airstream turbulence occurs before the stop is completely released, creating an affricate. Calabrese (2005) suggests that this phonetic fact should be represented in the phonology by a constraint against the featural combination *[−continuant, +distributed]. I propose instead that this constraint should take the form *[−anterior, −strident]. This constraint is formalized below.

a. *t̠
*[−anterior, −strident]
A non-strident palatoalveolar is prohibited.

Following LaCharité (1993) and Kim (2001) I assume that strident affricates can be represented as simple stops using the features [−continuant] and [+strident]. The constraint *s^j from §2.7 above can be combined with the new constraint *t̠ in order to illustrate the change *it* → *itʃ*.

Figure 19 Tongue-raising causing assibilation



The above analysis can also be expressed within the framework of Optimality Theory. This will require the use of the constraints IDENT[strid], seen in §2.7, and AGREE[lo], seen in §2.11.

Figure 20 Tongue-raising causing assibilation in OT

Input: /it/	*t̲	*sʲ	AGREE[low]	IDENT[strid]
a. ☞ itʃ				*
b it			*	
c. itʲ		*		
d it̲	*			

My purpose in presenting this analysis is to show that assibilation triggers follow their targets in all cases. This analysis allows us to classify the change *it → itʃ* as a case of tongue-raising, where assibilation is a coincidental side-effect, meaning that there are no cases of standard assibilation where the trigger precedes the target. With this in mind we can move on to investigating the types of segments produced by standard cases of assibilation.

3.2.2 Assibilation outcomes

Hall and Hamann (2003) found that assibilation always results in a sibilant affricate or fricative. Note, however, that assibilation is not known to produce retroflex affricates and fricatives. Hall & Hamann (2003:122) divide the outcomes of assibilation into the following three categories: affrication (*t d → ʦ ʣ*), spirantization (*t d → s z*), and tongue-raising (*t d → ʧ ʤ*).

Table 24 Number of languages producing affrication, spirantization and tongue-raising as outcomes of assibilation[26]

affrication	spirantization	tongue-raising
t d → ʦ ʣ	t d → s z	t d → ʧ ʤ
24	15	14

We can clearly see that affrication is considerably more common than both spirantization and tongue-raising. This suggests that spirantization and tongue-raising are additional developments, which are supplementary to the primary assibilation process of affrication. There were eight languages in Hall & Hamann's survey which had more than one assibilation outcome. Of these, three had both affrication and tongue-raising (Japanese, Runyoro-Rutooro and Cheyenne), and five had both affrication and spirantization (Romanian, West Slavic, Dutch, Shona and Solomon Islands languages). None had both spirantization and tongue-raising.

[26] The data are extracted from Hall & Hamann's (2003) survey of assibilation in 45 languages. If a language has two different outcomes from assibilation processes then both outcomes are counted (e.g. Japanese has both affrication and tongue-raising and is therefore counted twice, once under each category).

Studies of assibilation often overlook the possibility that this process might also affect stops at other places of articulation, such as velars. The change *ki → k͡si* is exceedingly rare, but it is found in at least two languages: Blackfoot, an Algonquian language spoken in southern Alberta (Frantz 1978, 1991, Proulx 1989), and Nanti, a Kampa language spoken in Peru (Lev Michael, pers. comm.). Blackfoot shows a typical pattern of assibilation, where *t → ts / _i*, but also changes *k* to *k͡s* in many of the same environments (Frantz 1991, Kaneko 2000, Proulx 1989).

Table 25 Blackfoot velar assibilation

a.	/iʔna**k**-ipokaa/	iʔna**k͡s**ipokaa	'baby, infant'
	/omah**k**-míːsinsːki-ik͡si/	omah**k͡s**íːsinsːkiːk͡si	'big badgers'
	/áː**k**-i-kokoto-wa/	áː**k͡s**ikokotowa	'it will be frozen'
b.	Proto-Algonquian	Blackfoot	
	*sa**k**ipweːwa	si**k͡s**ipiːwa	'she bites her'

There is evidence that Blackfoot velar assibilation is historical in nature, which has led Proulx (1989) to suggest that Blackfoot was affected by the following rule as it diverged from Proto-Algonquian: **k → k͡s / _ *i.*

While the facts regarding Nanti are not yet entirely clear, preliminary research seems to indicate that velar stops are affricated before the front vowels *i* and *e* (Lev Michael, pers. comm.).

Table 26 Velar affricates in Nanti[27]

k͡senaʃi	‘species of tuber’
k͡ʃinʲkateni	(name of a creek)
g͡zerʲo	‘take it!’
g͡ʒimag͡zerʲo	‘make it sleep!’

It is interesting to note that the place of articulation of the fricative portion of these affricates varies depending on the triggering vowel. The high vowel *i* creates the affricates *k͡ʃ* and *g͡ʒ*, while the mid vowel *e* is responsible for generating the affricates *k͡s* and *g͡z*.

The reason that these cases are frequently overlooked is that *k͡s* is often considered to be two separate segments rather than an affricate. This view, however, is particularly problematic for Nanti, where syllables take the form (C)V(V)(N), indicating that complex syllable onsets are prohibited and that only nasals are permitted in the syllable coda (Crowhurst and Michael 2005). If the velar affricates mentioned above are treated as separate phonemes then Nanti syllable structure would need to be modified in order to accommodate them. Moreover, in her large crosslinguistic study of obstruent clusters Morelli (2003) argues that *sk* is less marked than *ks*, such that no language should allow *ks* but not *sk*, which would be the case if *ks* is bisegmental in Nanti. Treating these segments as affricates allows us to avoid this problem.

The cases of velar assibilation found in Nanti and Blackfoot confirm that dentals and alveolars are not the only targets of the assibilation process. It is quite probable

[27] I extend my heartfelt thanks to Lev Michael, who provided me with this data in a personal communication.

that other segments, such as labials, can also undergo assibilation, but this possibility is peripheral to the main arguments of this thesis, and will not be considered here.

3.2.3 Voicing asymmetry in assibilation

Much like coronalization, assibilation shows a preference for affecting voiceless stops. 14 of the languages included in Hall and Hamann's (2003) survey assibilate only *t*, while both *t* and *d* undergo assibilation in the remaining 31 languages. There were no languages where only *d* underwent assibilation. Unfortunately Hall & Hamann did not specify whether or not the languages that only assibilate *t* also have a phoneme *d*. Nonetheless, we can be certain that at least some of these 14 languages do contain *d*, such as Hittite, Dutch, Italian dialects, Shona, Turkana, Latin and German.

In addition to the typological data, Hall, Hamann & Zygis (2004) conducted a phonetic study in an attempt to account for the typological results. They found, as expected, that the length of the friction phase was longer for the sequences *tj* and *ti* than it was for *dj* and *di*. When these sequences are ordered according to the average length of the friction phase, from longest to shortest, the following ranking is obtained: *tj* < *ti* < *dj* < *di* (Hall et al. 2004:217). These patterns suggest that there is a correlation between the length of the friction phase and the probability that a segment will undergo assibilation: the longer the friction phase, the higher the probability.

Like coronalization, assibilation patterns also tend to show a disparity between the outcomes of voiced and voiceless stops. Voiced stops tend to undergo spirantization (*d* → *z*) while the voiceless stops simply become affricates (*t* → *ts*). Recall from above that Hall and Hamann (2003) found five languages that undergo both affrication and spirantization: Romanian, West Slavic, Dutch, Shona and Solomon Islands languages. Of these, Romanian (Chitoran 2002) and some West Slavic languages (Czech and Slovak, Carlton 1990:138) follow the pattern mentioned above (*t* → *ts*, but *d* → *z*). In the other three languages, Dutch, Shona and Solomon Islands languages, only *t* undergoes assibilation (Hall and Hamann 2003), so there is no opportunity for a voicing disparity to arise. There are no languages where assibilation causes spirantization of the voiceless stops (*t* → *s*) while at the same time affricating the voiced stops (*d* → *dz*). This disparity is undoubtedly governed by the same principle that causes the very similar pattern found in velar coronalization, as discussed in §3.1.3.

3.2.4 Assibilation as an acoustic process

There are not many phonological accounts of assibilation, perhaps because it is difficult to account for this process by spreading features. One possibility is that assibilation is a result of a consonant assimilating to a neighbouring vowel. Phonologically this would be represented by spreading the feature [+continuant] from the vowel to the consonant. Kim (2001) points out that this analysis cannot explain why assibilation is typically triggered by high vocoids.

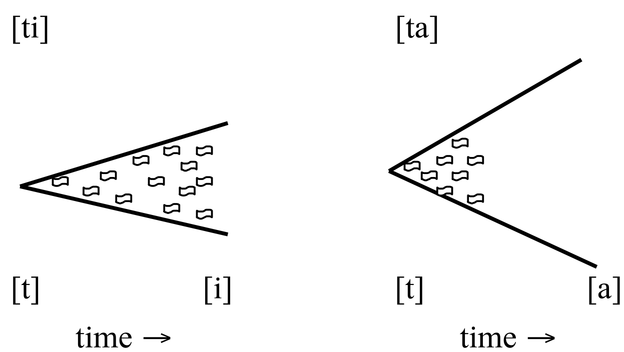
Calabrese (2005) suggests that coronalization results in anterior and postalveolar affricates because of a constraint *[−continuant, +distributed]. Although he does not explicitly state that assibilation is caused by this same constraint, it is implied in his analysis that this is the case. One way to falsify this hypothesis is to find a language where [−distributed] stops have undergone assibilation. Blackfoot may be just such a language, since the coronal stop *t*, which undergoes assibilation, is described as alveolar in place of articulation (Frantz 1991). Alveolars are typically apical, and therefore [−distributed]. Another language that may have an apical *t* is Japanese, where the anterior coronal stops are described as "apico-dental/alveolar" in place of articulation (Akamatsu 1997:78). It is interesting to note that the Japanese affricate *ts*, which was created by assibilation, is described as "lamino-alveolar" (Akamatsu 1997:98), meaning that this segment could be classified as [+distributed]. This observation leads me to suggest that the presence of the feature [+distributed] is an effect, rather than a cause, of assibilation.

Also problematic for Calabrese (2005) is explaining why it is that high vowels are the primary triggers of assibilation. Since he assumes that high front vowels are specified [−anterior, +distributed], he can propose that the latter feature is spread to a preceding *t* in order to create a segment that violates the constraint *[−continuant, +distributed]. This segment would then be repaired by inducing assibilation. While this account works for assibilation caused by *i*, it does not explain why high back vowels can also instigate this change. In Japanese, for example, the high back unrounded vowel *ɯ* causes *t* to become *ts*. In order to account for this, Calabrese would have to stipulate that *ɯ* is specified [+anterior, −distributed], which is problematic to say the least.

Articulatory features are of little use in explaining assibilation, so we must look to acoustic features instead. Of the many acoustic features found in the Jakobsonian feature system, only [±strident] was preserved by Chomsky & Halle (1968), and this is precisely the feature that is altered in the change *t* → *ts*. The only formal phonological account of this process known to me is that presented by Kim (2001), who suggests that assibilation is a result of misperception.

Kim (2001) begins by pointing out that there is a greater amount of air turbulence generated when a dental or alveolar stop is released into a following high vowel, as in the sequence *ti*, than in a situation where *t* is followed by a low vowel, such as *a*. Elaborating on earlier ideas presented by Ohala (1981) and Clements (1999), Kim (2001) argues that this turbulence can be misinterpreted by listeners as the feature [+strident], which is then inserted into the feature matrix.

Figure 21 The generation of air turbulence in the release of *ti* and *ta*[28]

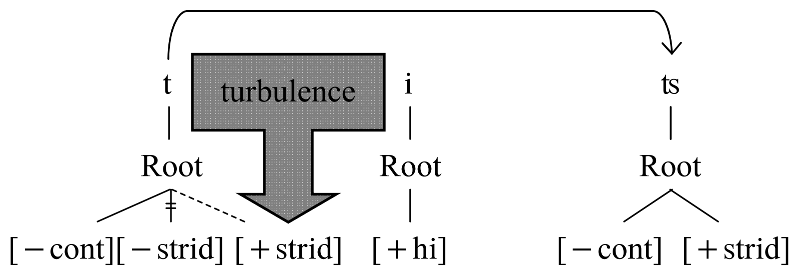


The listener then produces the stop as a strident affricate in future utterances. Ladefoged & Maddieson (1996:145) state that in fricatives such as *s* "the principal source of the sound is the turbulent airstream produced when the jet of air created by the dental or alveolar constriction strikes the teeth." It is not difficult to see how this "turbulent airstream" might be quite similar to the turbulence generated in the transition

[28] Diagram taken from Kim (2001:95); the curly bars represent turbulent airflow.

between *t* and *i*, where the high position of the tongue creates a narrow constriction which, like sibilant fricatives, produces a jet of air that strikes the back of the teeth.

Figure 22 An acoustic account of assibilation[29]



Hall, Hamann & Zygis (2004) have essentially confirmed Kim's hypothesis by showing that the duration of the friction phase of the stop release is correlated with the likelihood that a stop will undergo assibilation. However, this hypothesis still requires further phonetic investigation, including spectral analysis and perception experiments. Nonetheless, Kim's (2001) analysis has been well-received by other phonologists working in this field (e.g., Hall and Hamann 2003), and I will likewise adopt it in this thesis.

In §3.2.1 we saw that assibilation can result as a side-effect of tongue-raising. Since high front vocoids are the principal trigger of both tongue-raising and assibilation, it is virtually impossible to tell if a change *ti → tʃi* is the result of the simultaneous occurrence of both tongue-raising and assibilation, or if it is caused by tongue-raising alone. Looking at other phonological patterns in a language is usually the best way to tell whether or not both processes are responsible. Japanese presents a particularly

[29] This is a slightly modified version of the diagram given in Kim (2001:102).

interesting case study, since it has a tongue-raising process that operates independently of its assibilation process.

Table 27 Japanese assibilation and tongue-raising[30]

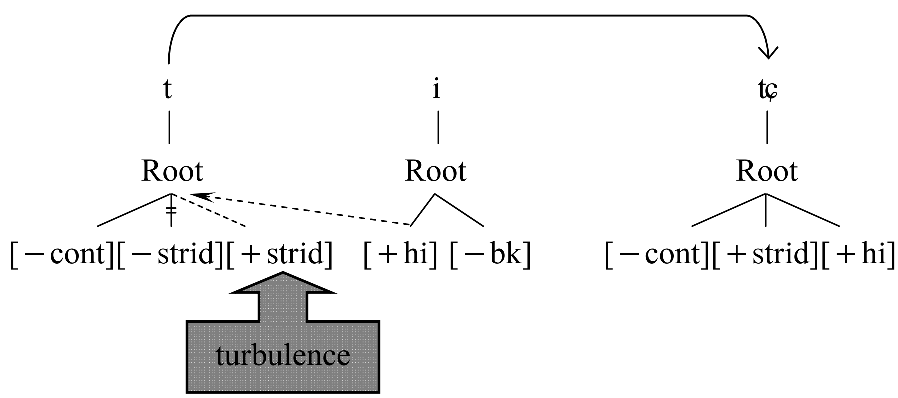
1.	tongue-raising			s z → ɕ ʑ / _i
	/sio/	ɕio	‘salt’	
	/zisin/	ʑiɕĩN	‘earthquake’	
2.	assibilation			t d → ʦ z / _ɯ
	/kat-ɯ/	kaʦɯ	‘win’ PRES	
	/tat-ɯ/	taʦɯ	‘stand’ PRES	
	/hɯtɯɯ/	fɯʦɯɯ	‘ordinary’	
	/mikadɯki/	mikazɯki	‘increasing moon’	
		ʦɯ:pi:sɯ	< English: ‘two piece(s)’	
		ʦɯ:rɯ:zɯ	< French: ‘Toulouse’ (place name)	
		kaʦɯreʦɯ	< English: ‘cutlet’	
c.	tongue-raising / assibilation			t d → ʨ ʑ / _i
	/tatitɯteto/	taʨiʦɯteto	‘t column’ (from the Japanese syllabary)	
	cf. /kakikɯkeko/	kakikɯkeko	‘k column’ (from the Japanese syllabary)	
	/tat-i-mas-ɯ/	taʨimasɯ	‘stand’ POLITE PRES	

Here we see that *i* has a tongue-raising effect on alveolar fricatives, which is clearly distinct from the assibilating effect that *ɯ* has on alveolar stops. When alveolar stops are followed by *i*, however, we cannot tell if assibilation is active or not. The simplest explanation is to suggest that tongue-raising is operating alone, since the change *t → ʨ*

[30] Data taken from Akamatsu (1997, 2000). The underlying forms may instead be understood to represent historical forms; the issue of whether these alternations are synchronic or diachronic is beyond the scope of this thesis.

perfectly parallels the change *s* → *ɕ*. However, there are independent factors which suggest that this process is the culmination of both assibilation and tongue-raising. Preliminary research into implicational universals of assibilation suggest that if a back vowel causes assibilation in a language then a front vowel also causes assibilation (Hall and Hamann 2003). Since the high back vowel *ɯ* causes assibilation in Japanese it is appropriate to assume that the front vowel also triggers this process, in keeping with the proposed typological universal. Here is a featural representation of the change *t* → *tɕ* / _*i* found in Japanese.

Figure 23 Simultaneous assibilation and tongue-raising in Japanese[31]



Historical data may help to clarify the nature of this type of change. For example, if there is evidence that assibilation took place before tongue-raising then we know that this is a two-part process, at least from a diachronic point of view. While this change is very likely a two-part process in Japanese, in other languages it may simply be tongue-

[31] In §2.11 I argued that there is no segment with the features [+anterior, +high]. In order to account for the Japanese data I assume that there is a constraint against this featural combination, and that this constraint is satisfied by replacing [+anterior] with [−anterior], which creates the alveolopalatal *tɕ*.

raising, and in many cases it is simply impossible to tell if one or both processes are at work.

In this section I have shown that assibilation is most likely an acoustically-driven process, and I have spelled out the formal details of how this process is seen to work in phonological terms, following Kim's (2001) analysis. I have also shown that it is extremely difficult to tell if a change *t* → *tʃ* involves assibilation or not, suggesting that it is best to rely on other sources, such as typological and historical data, in analyzing this type of phonological change.

3.2.5 Summary

Here are five generalizations regarding assibilation similar to those given for coronalization in §3.1.4 above.

(1) High vowels and glides cause assibilation.

(2) Non-high and non-front vocoid triggers imply high front vocoid triggers.

(3) Triggers always follow the target.

(4) The output is usually a sibilant affricate or fricative.

(5) Voiced targets imply voiceless targets.

Mid and back vowels can cause assibilation, but this is quite rare. A more complete survey of assibilation is required before we can say exactly how rare these atypical triggers are, but at this point the list seems to be limited to three languages: Japanese, Woleaian and Turkana.

3.3 Comparing Coronalization and Assibilation

A brief comparison of the two processes investigated in this chapter yields some remarkable similarities. These similarities lead me to propose that coronalization and assibilation are essentially the same process; that is to say, coronalization is a result of the assibilation of velars. I suggest that the differences between the two processes are explained by the fact that their target segments differ in their place of articulation: assibilation typically affects coronals, while velar coronalization necessarily affects only velars.

Table 28 Generalizations regarding coronalization and assibilation

	coronalization	*assibilation*
all high vowels can act as triggers[32]	✗	✓
all front vowels can act as triggers	✓	✗
high front vowels are the primary trigger	✓	✓
trigger typically follows target	✓	✓
voiced targets imply voiceless targets	✓	✓
outcome is a sibilant affricate or fricative	✓	✓

The rest of this thesis will be dedicated to fleshing out the details of this proposal and considering the implications it has for other related processes, such as velar fronting.

[32] The high back "fricative vowel" **u̝* reconstructed for Proto-Bantu caused coronalization in many Bantu languages, including Tswana, as we saw in Table 18. In another Bantu language, Holoholo, this vowel became *i* (Labroussi 1999:346), suggesting that **u̝* shares some properties with cardinal high front vowels. It seems, however, that coronalization is never caused by cardinal back vowels.

CHAPTER 4: AN INTEGRATED APPROACH

In Chapter Two we looked at many theories of coronalization; nearly all of them were attempts to explain this process as a type of articulatory assimilation. Others, such as Guion (1998), proposed that coronalization is a result of acoustic similarities, and did not make any reference to articulatory factors. Lee (2000) suggested that both types of factors need to be taken into consideration, but that articulatory factors play a more prominent role than acoustic factors. While I take a position similar to that of Lee (2000), I will argue, on the contrary, that coronalization is primarily an acoustic process, but that articulatory factors also need to be included in order to account for certain facts.

4.1 Coronalization as assibilation

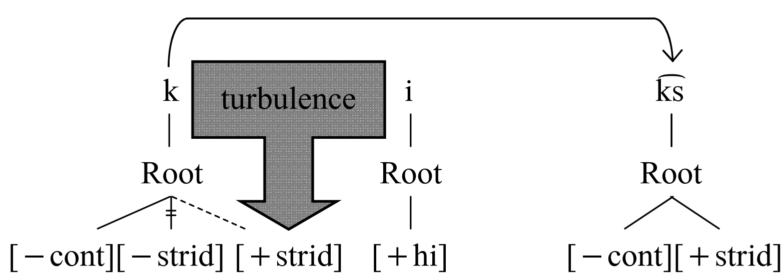
The remarkable similarities between coronalization and assibilation have led me to claim that these two processes are closely related. In Chapter One I pointed out that Flemming (2002:104) had already recognized this relation, but did not go on to express it in strictly phonological terms. I will now endeavour to amend this situation by putting forward a thorough analysis of coronalization that can account for the properties it shares with assibilation.

4.1.1 The proposed analysis

In §3.2.4 we saw that Kim (2001) accounts for assibilation by proposing that the increased stop release turbulence before a high vocoid can be interpreted as the feature [+strident]. Moreover, we saw in §3.2.2 that assibilation is not limited to dental and

alveolar stops; although it is rare, velars can also undergo this process to become strident velar affricates such as *k͡s* or *k͡ʃ*. While Kim's (2001) analysis was intended to account specifically for dental and alveolar cases of assibilation, I propose to generalize it to account for velar assibilation as well. Recall that according to Kim (2001), assibilation is a result of generating turbulence in the release burst of the stop. The generation of turbulence, however, depends on the imposition of the high front vowel articulation on the release of the stop. Velars are clearly susceptible to this type of imposition, since they are often fronted, and even palatalized before front vowels.
It is interesting to note that palatalized velars are characterized by a larger amount of laminal tongue contact than plain velars (Lahiri and Keating 1993). I suggest that this larger degree of contact creates a situation where it is difficult to release the stop quickly and cleanly, and that these conditions are favourable for the generation of turbulence.

Figure 24 An acoustic account of velar assibilation



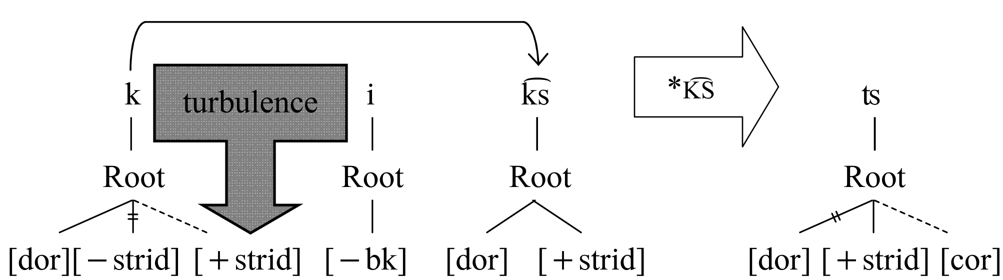
The fact that strident velar affricates such as *k͡s* and *k͡ʃ* are extremely rare suggests that they are phonologically marked. In order to account for this, I propose a constraint which states that the combination of the features [dorsal] and [+strident] is prohibited.

a. *K͡S
*[dorsal, +strident]
Strident velar affricates are prohibited.

The primary motivation for this constraint is the observation that these segments are phonetically complex, since they require both a tongue body gesture and a tongue blade gesture, much like the dorsal-coronal clicks found in some southern African languages. The infrequent appearance of strident velar affricates suggests that this constraint is rarely violated, and that it is therefore highly-ranked in most languages.

I propose that when a velar stop *k* undergoes assibilation, it is typically prevented from becoming a strident affricate by the constraint *K͡S. This could result in a complete failure of assibilation, where a sequence such as *ki* might simply remain unchanged. Another possibility is that the grammar may wish to preserve the [+strident] feature introduced by the assibilation process.

Figure 25 Coronalization as a result of assibilation



Since the velar affricate *k͡s* is prohibited the grammar is forced replace the [dorsal] feature with [coronal], creating a coronal affricate in place of the velar stop. This new affricate does not inherit any tongue blade specifications from the velar stop, so default tongue blade features are supplied by the grammar. I propose that the default tongue blade feature is [+anterior] after Chomsky and Halle (1968:406, 407, Howe 2000, Lombardi 2000, see also Morelli 1999:128-9, Pulleyblank in press, Roca and Johnson 2000:585). This proposal is supported by the typological observation that languages with only one set of coronal stops will produce those stops at a dental or alveolar place of articulation (Maddieson 1984).

The process illustrated in Figure 25 can also be accounted for using Optimality Theory. This requires us to employ the constraint IDENT[strid], given in §2.7 above, as well as the following constraint:

b. *KI (from Hall & Hamann 2003:124)
*[dorsal, −continuant][+high, +sonorant, −consonantal]
A sequence *ki* is prohibited.

c. *TI (from Hall & Hamann 2003:124)
*[coronal, −continuant][+high, +sonorant, −consonantal]
A sequence *ti* is prohibited.

Note that *KI and *TI are syntagmatic constraints, meaning that they prohibit certain sequences of segments. This is in contrast to paradigmatic constraints, such as *K͡S, which prohibit the combination of certain features within a single segment.

Figure 26 An OT account of coronalization resulting from assibilation

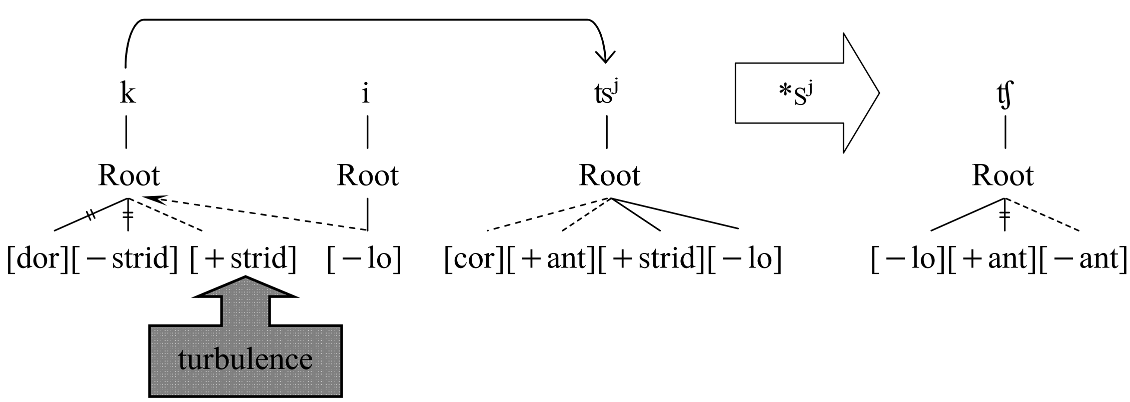
Input: /ki/	*KI	*K͡S	*TI	IDENT[strid]
a. ☞ tsi				*
b. ti			*	
c. k͡si		*		*
d. ki	*			

The motivation for coronalization is different in each account. The feature-changing account given in Figure 25 is essentially derivational, and can be broken into two stages. In the first stage, the feature [+strident] is introduced into the feature matrix, and in the second stage, that feature is preserved at the expense of [dorsal]. In the OT account however, we saw that faithfulness to [strident] was given an extremely low ranking, and assibilation of the coronal was instead motivated by the constraint *TI. The OT account could be harmonized with the feature-changing account by assuming that the input includes the strident velar affricate *k͡s*, based on listener's perceptions rather than the speaker's actual output. This possibility will have to await further research, as there is not space to pursue it here.

In §3.1 we saw that coronalization typically results in a palatoalveolar affricate *tʃ*, while a dental or alveolar affricate *ts* is a relatively rare outcome. One possible explanation for this fact is the overall typological scarcity of *ts* and *dz* compared to their palatoalveolar counterparts *tʃ* and *dʒ*, as we saw in §3.1.3. This typological disparity might be explained by the fact that the contact area between the tongue and the passive articulators has a larger surface area in palatoalveolars (Catford 1977), which creates more turbulence in the stop release, which in turn makes it easier to produce the acoustic feature [+ strident]. This suggestion predicts that, if given the option, strident dental and alveolar affricates will gravitate towards a palatoalveolar place of articulation in order to facilitate the production of the feature [+ strident]. While this explanation for the typological distribution of strident coronal affricates may contribute to the predominance of palatoalveolars as the outcome of coronalization, there is likely another reason that *tʃ* is a more common result that *ts*.

I propose that non-low front vocoids, which typically trigger coronalization, also spread their [− low] feature to the resulting affricate or fricative in order to produce a palatoalveolar. This development is very similar to the tongue-raising process we saw in §3.2.1, where non-low vowels such as *i* and *e* can cause neighbouring anterior coronals to become palatoalveolars. Since non-low front vowels and glides are the primary triggers of coronalization, they are typically adjacent to the resulting coronal affricate. As mentioned above, the grammar may choose to insert the default features [+ anterior, − high, + low], or, the grammar may instead allow the nascent coronal affricate to conform to the tongue height features of a neighbouring vowel.

Figure 27 Tongue-raising concurrent with coronalization



In Figure 27 the raising process is shown to be simultaneous with coronalization, reflecting the fact that in many cases coronalization appears to advance directly from *k* to *tʃ* (e.g. Standard Chinese and Cowlitz Salish, where the outcome *ts* would have created a merger with the existing affricate *ts*). However, it is possible that tongue-raising could instead occur at a later stage, creating a series of changes *k* → *ts* → *tʃ*. This is precisely the pattern that Pope (1934:130) proposes for dialects of Gallo-Roman spoken in the northern region of France. In most cases, however, we simply lack the evidence to be sure of the exact sequence of events. This analysis predicts that both direct changes and incremental changes are possible, and can account for either situation.

Like many of the processes described above, the situation depicted in Figure 27 can also be represented using OT. This is accomplished by relying on the constraint AGREE[low] seen in §3.2.1 above.

Figure 28 Tongue-raising concurrent with coronalization in OT

Input:	/ki/	*KI	*K͡S	AGREE[low]	*S^j	IDENT[strid]
a. ☞	ʧi					*
b.	ts^{j}i				*	*
c.	tsi			*		*
d.	k͡si		*			*
e.	ki	*				

One shortcoming of this analysis is that it cannot explain why palatoalveolars arise as a result of coronalization in cases where there is no triggering vowel. Nuuchahnulth is an example of this. Recall from §3.1 that palatalized velars underwent coronalization as a context-free change in Nuuchahnulth, and that this change resulted in a series of palatoalveolars: *kʲ → tʃ*.[33] It is important to note, however, that Nuuchahnulth already had a set of anterior coronal affricates, *tsʰ*, *dz* and *ts'*, before coronalization took place, but that it did not have any palatoalveolar consonants. Therefore it seems likely that coronalization did not result in an anterior coronal place of articulation in order to avoid a merger with the anterior coronals that already existed (cf. Martinet (1955) on "marge de sécurité" (p. 47-8) and "attraction du système" (p. 80-1)). A similar argument is possible in the case of the "satem" languages of the Indo-European family. Proto-Indo-European is thought to have only one coronal fricative, **s*. If we assume that affricates were not permitted in these languages then we might expect the result of coronalization to be a palatoalveolar *ʃ* in order to avoid a merger with **s*.

I know of only one other case of context-free coronalization, and that is found in the Apachean branch of the Athapascan language family. In §3.1 this change was illustrated using Navajo. Proto-Athapascan is thought to have had affricates at both anterior coronal and palatoalveolar places of articulation before coronalization took place in Navajo (Howe and Fulop 2005:10, Young 1983:395). It is therefore not surprising to learn that this case of coronalization resulted in a merger. What is perhaps surprising is that the palatalized velars were merged with the anterior coronals, and not

[33] It appears that these velars underwent palatalization in order to help distinguish them from other phonemes, such as uvulars and rounded velars (Howe 2000:69).

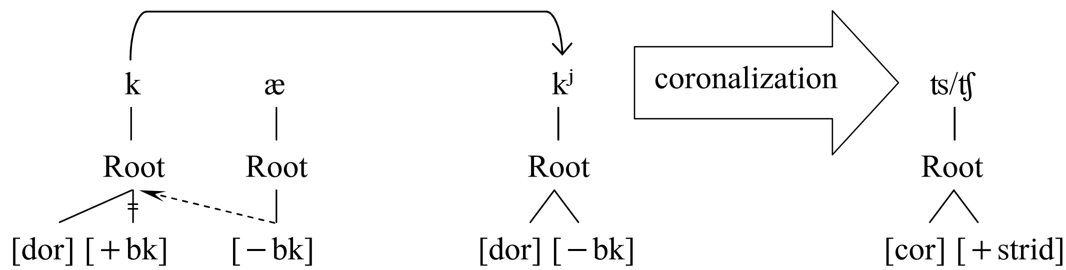
with the palatoalveolars. I suggest that this remarkable pattern supports my claim that anterior coronals are the default outcome of coronalization.

I furthermore propose that there are two factors which can prevent this default articulation: (1) articulatory assimilation to a neighbouring vowel, or (2) the prevention of a phonemic merger. Since anterior coronal affricates are considerably less common than postalveolar affricates, the need to prevent a merger of this type is extremely rare, and is found only in South Wakashan languages such as Nuuchahnulth and possibly in some of the "satem" languages of the Indo-European family.

4.1.2 Velar palatalization leading to coronalization

In §3.1 we saw that coronalization is caused not only by high front vowels, but also by mid front vowels, and, in a few rare cases, even by low front vowels. I argued above that coronalization is a form of assibilation and is thus caused by a constricted vocal tract during the release phase of the articulation of a velar stop. Low vowels, however, should not be able to create the necessary constriction, since their low tongue and jaw position keep the vocal tract relatively open and free from obstacles. This leads me to suggest that coronalization in these environments goes through an intermediate stage where the velar is extremely fronted, or even palatalized, by the low front vowel. This process is represented by a change in the feature [± back], where [− back] spreads from a front vowel to the preceding velar consonant. The resulting palatalized velar k^j then undergoes coronalization in much the same way as a sequence *ki*, as illustrated in Figure 25.

Figure 29 Velar fronting leading to coronalization



This account of coronalization can also be expressed using a single tableau in OT with the use of the following additional constraints:

a. AGREE[back]
*[+back][−back], *[−back][+back]
Neighbouring segments cannot have different tongue backnesses.

b. $*K^j$
Palatalized velars are prohibited.

The paradigmatic constraint $*K^j$ takes the place of the syntagmatic constraint *KI used in the previous tableaux. The constraint $*K^j$ suggests that a palatalized velar k^j creates a constriction in the stop release, much like that of a sequence *kj* or *ki*. Justification for this constraint comes from two sources. First, in §3.1 we saw that palatalized velars in Proto-Indo-European, Proto-Athabascan and South Wakashan underwent coronalization as a context-free change, suggesting that these segments are in fact marked in much the same way as a sequence *ki*. Secondly, Hall and Hamann (2003) found that the palatal glide *j* is the most prolific trigger of assibilation, and Hall, Hamann & Zygis (2004) found that when *j* follows an alveolar stop it creates a longer friction phase than a following high front vowel *i*. If we assume that *j* has similar effects on velars, and that palatalized consonants share many of the acoustic properties of *Cj* sequences, then a constraint *ᴋʲ is expected.

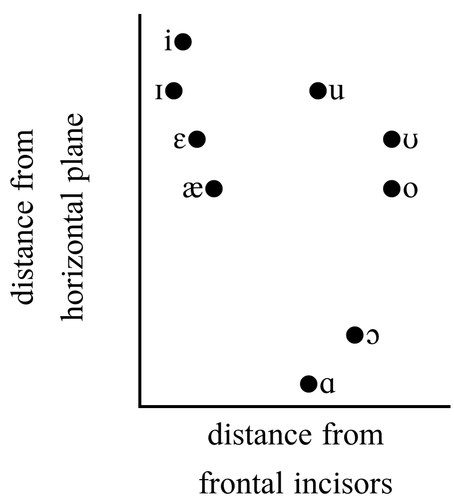
Figure 30 An OT account of velar fronting leading to coronalization

Input: /kæ/	*ᴋʲ	*ᴋ͡ѕ	AGREE[back]	FAITHC
a. ☞ tsæ				*
b. kæ			*	
c. k͡sʲæ		*		
d. kʲæ	*			

It is quite possible that velars are always palatalized before they undergo coronalization, even in those cases where this process is triggered by high and mid front vowels. This suggests that coronalization involves an intermediary stage where the velar is palatalized before it becomes a coronal: $k \rightarrow k^j \rightarrow$ *tʃ*. Recall from Chapter One and §2.10 that this is precisely the pattern of free variation found in Acadian French when velars precede front vowels. Another piece of evidence in favour of this view of coronalization comes from languages such as Proto-Slavic (Carlton 1990:112-3) and Late Latin (Pope 1934:122-3), which had widespread palatalization processes in place some time before coronalization took place (often coronalization took place independently in the daughter languages). This view of palatalization favours a more derivational approach, like that seen in Figure 29, where coronalization is essentially a two-stage process: $k \rightarrow k^j \rightarrow ts$. However, this does not mean that a direct change of $k \rightarrow ts$ is impossible, or that all cases of coronalization follow exactly the same sequence of events. I will not make any strong claims regarding this matter since it is clear that further research is required. For the purposes of this thesis I will assume that low vowels can only cause coronalization by palatalizing a neighbouring velar.

There is another possible means by which low front vowels might cause coronalization that should not go unmentioned. This possibility hinges on the fact that low front vowels are in fact quite high phonetically. As we can see in Figure 31 the low front vowel *æ* of American English has a tongue height roughly equivalent to the mid back vowel *o*. This fact leads me to suggest that *æ* may in fact have a high enough tongue position to create a significant constriction in the stop release of a consonant. However, I do not know of any languages where *æ* causes assibilation in dentals or alveolars, so the validity of this hypothesis is in doubt unless such evidence is found.

Figure 31 Mean tongue positions for American English vowels[34]



[34] From Ladefoged & Maddieson (1996:284). The position of the tense mid vowel *e* and the low vowel *a* found in some American English dialects were not provided in the original diagram.

Of course further phonetic studies are also required in order to determine how much influence a low front vowel such as *æ* has on the stop release of a preceding velar.

One interesting aspect of this hypothesis is that it relies on the supposition that there are two sets of features: phonological features and phonetic features. In this case, the low front vowel *æ* is still viewed as [+low] from a phonological point of view, since it is the lowest of the front vowels, however, it may also be specified as [−low] from a phonetic point of view. I will not discuss the topic of feature organization further here, but we can see that the theoretical implications of this hypothesis are potentially far-reaching. Unfortunately this possibility will have to await further investigation before it can be verified or discredited. For the time being I will rely on my earlier analysis, where mid and low front vowels are thought to induce coronalization only through the medium of palatalization.

4.1.3 The coronalization of velar fricatives

Up until now I have concerned myself only with the coronalization of stops, however, in §3.1 we saw that fricatives are also susceptible to this process. For example, *x* became *s* and *ʃ* in the two cases of coronalization in Slavic, and Proto-Athapascan x^j became *s* in Navajo. Unfortunately the possibility of fricatives undergoing coronalization was not considered by Guion (1996, 1998), so there is no phonetic study of velar fricatives equivalent to her study of velar stops. Nonetheless, research into co-articulation in CV sequences indicates that stops and fricatives are both influenced by a following vowel in much the same way (Tabain 2000:156). I speculate that when a velar fricative *x* is followed by a high front vocoid, the vocal tract is constricted just as it is in the release phase of a velar stop. This naturally leads to an increase in turbulence, which can in turn lead to assibilation, following the argument set out in §4.1.1 above.

4.2 Romanian: a case study

The Romanian language is an excellent illustration of the relationship between assibilation and coronalization, since it contains a single phonological development that initiates both of these processes (Chitoran 2002). This development is instigated by two homophonous Romanian suffixes which are both derived from Latin, where they took the form *-i*. One of these morphemes is the plural marker, which can be added to both nouns and adjectives, and the other is the second person singular marker, which is suffixed to verbs. In modern Romanian these morphemes manifest as palatalization on the last consonant of the root.

Table 29 The phoneme inventory of Romanian[35]

	Consonants					Vowels			
stops	p b	t d		k g		high	i	ɨ	u
affricates		ts	tʃ dʒ			mid	e	ə	o
fricatives	f v	s z	ʃ ʒ		h	low		a	
nasals	m	n							
liquids		l r							
glides	w		j						

[35] Chitoran (2002) considers the glides *j* and *w* to be allophones of the vowels *i* and *u*, but this analysis is not universally accepted.

This palatalization has varying effects on the different types of consonants. The sonorants *m*, *n*, *r*, *l*, the glottal fricative *h* and the labials *p*, *b*, *f*, *v* are largely unaffected, and typically acquire a secondary palatal articulation (e.g., $m \rightarrow m^j$). The only exception to this is *l*, which becomes a palatal glide *j* in some words, but is simply palatalized to *l*^{j} in others. This irregularity will not be accounted for here, since it is separate from the main themes of assibilation and coronalization.

Our real interest lies with the coronal and velar obstruents, which become palatalized and also undergo additional changes. The voiceless dental stop *t* is assibilated to *ʦ*^{j}, while its voiced counterpart *d* additionally undergoes spirantization to become *z*^{j}. The dental affricate *ʦ* receives only a palatal secondary articulation, so it is neutralized with the result of *t* in this environment. In contrast to the stops, the dental fricatives *s* and *z* undergo tongue-raising to become the palatoalveolars *ʃ*^{j} and *ʒ*^{j}. Both palatoalveolar affricates and fricatives maintain their original form to become *ʧ*^{j}, *ʤ*^{j}, *ʃ*^{j} and *ʒ*^{j}. Note that this results in a neutralization of dental and palatoalveolar fricatives in this environment, for example, *s* and *ʃ* both become *ʃ*^{j} when palatalized. Finally, the velar stops *k* and *g* undergo coronalization to become *ʧ*^{j} and *ʤ*^{j}, creating a third neutralization, this time between the velars and the palatoalveolar affricates.

Table 30 Romanian morphological palatalization (Chitoran 2002:187-8)[36]

a.	labials				
	p → pʲ	rup	rupʲ	‘tear’	1ST-2ND
	b → bʲ	bob	bobʲ	‘grain(s)’	
	f → fʲ	kartof	kartofʲ	‘potato(es)’	
	v → vʲ	grozav	grozavʲ	‘fantastic’	SG-PL
b.	dental stops				
	t → tsʲ	soldat	soldatsʲ	‘soldier(s)’	
	d → zʲ	brad	brazʲ	‘fir tree(s)’	
c.	dental affricate				
	ts → tsʲ	struts	strutsʲ	‘ostrich(es)’	
d.	dental fricatives				
	s → ʃʲ	pas	paʃʲ	‘step(s)’	
	z → ʒʲ	obraz	obraʒʲ	‘cheek(s)’	
e.	palatoalveolar affricates and fricatives				
	tʃ → tʃʲ	retʃe	retʃʲ	‘cold’	
	dʒ → dʒʲ	ledʒe	ledʒʲ	‘law(s)’	
	ʃ → ʃʲ	laʃ	laʃʲ	‘coward(s)’	
	ʒ → ʒʲ	vraʒə	vrəʒʲ	‘magic(s)’	
f.	velar stops				
	k → tʃʲ	rak	ratʃʲ	‘crab(s)’	
	g → dʒʲ	drag	dradʒʲ	‘dear(s)’	

[36] These transcriptions are intended to represent the phonological characteristics of these segments rather than the precise phonetic details.

Following my argumentation in §2.11 above, I assume that palatalized consonants have a [+high, −low, −back] tongue body position, except for palatalized anterior coronals, which are simply [−low, −back]:

Table 31 Tongue height features for plain and palatalized coronal consonants

	[+anterior]	[−anterior]
[+high, −low]	-	ʧʲ
[−high, −low]	tʲ	ʧ
[−high, +low]	t	-

This means that [+high], [−low] and [−back], are the "floating features" which are responsible for tongue raising and palatalization, and indirectly also for assibilation and coronalization. Three floating features may seem excessive, but this is what is required in order to explain the data at hand.[37] Although I assume that all three palatalizing features are present in all cases, I will only show two of these features in each diagram in order to make the diagrams easier to follow.

4.2.1 Palatalization of dental stops

We saw above that dental stops undergo assibilation as a result of palatalization. Furthermore, the voiced stop *d* loses its [−continuant] feature to become a fricative *z*. In order to account for these changes we need to make use of two constraints:

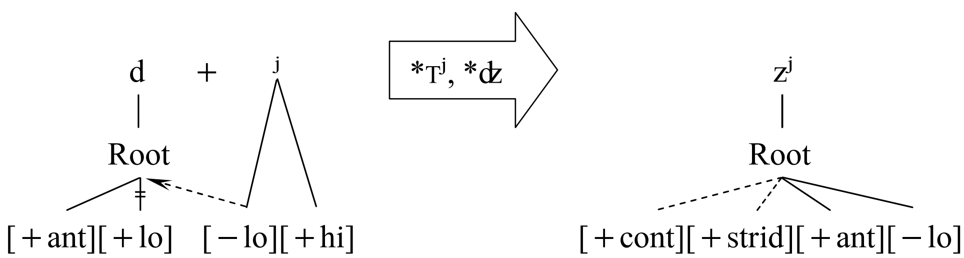
[37] The number of floating features can be reduced to two if one makes the assumption that the presence of [+high] implies the presence of [−low].

a. *Tʲ (adapted from Hall & Hamann 2003)
A non-strident palatalized anterior coronal stop is prohibited.[38]

b. *ʣ (Shinohara 2004)
*[+voice, −continuant, +strident, +anterior]
A voiced anterior coronal affricate ʣ is prohibited.

The first of these two constraints will be used to motivate the assibilation process illustrated in §3.2.4. The second constraint is justified by the typological facts presented in §3.1.3. The theoretical choices I have made regarding the representation of coronals require an additional constraint.

Figure 32 Palatalization of Romanian dental stops



The reason that [+high] does not spread to the preceding dental stop is that the featural combination [+anterior, +high] is phonetically impossible according to my argumentation in §2.11. This issue will be thoroughly investigated in the next section, after I have discussed the effects of palatalization on dental fricatives.

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[38] Note that this constraint is different from the broader articulatory constraint *Sʲ described in §2.11. *Tʲ motivates assibilation, whereas *Sʲ motivates a change in place of articulation.

In an OT account of morphological palatalization we have to ensure that the palatalization features are not simply deleted. Normally this would be accomplished by the constraint MAXIMALITY (Kager 1999), but this constraint usually refers only to segments, and not to individual features. Casali (1997:507) proposed a constraint that specifically prevents the deletion of monosegmental morphemes: MAXMS. This constraint is defined as follows: "Every input segment which is the only segment in its morpheme must have a corresponding segment in the output." I suggest that this constraint be modified so that it can also account for non-segmental morphemes that consist only of "floating features." In keeping with Casali's constraint, this constraint will be called MAXNS.

c. MAXNS
Every input feature in a non-segmental morpheme must have a corresponding feature in the output.

Furthermore, I propose that this constraint can be broken down into MAX constraints that refer to the individual features involved. In the case of palatalization, these features are [+high], [−low] and [−back]. I will only make use of the constraints referring to [+high] and [−low] in the analysis that follows

d. MAX[+high]
An input feature [+high] must have a corresponding feature [+high] in the output.

e. MAX[−low]
An input feature [−low] must have a corresponding feature [−low] in the output.

Using individual constraints for each "floating feature" allows them to be prioritized by assigning them different rankings within the constraint hierarchy. For example, we saw in Figure 32 that in the case of dental stops it is more important to spread [−low] than it is to spread [+high]. This will be discussed further in the next section.

Figure 33   Romanian dental assibilation in OT

Input: /brad+^{j}/	*ʣ	MAX[−low]	*T^j	IDENT[strid]
a. ☞ braz^j				*
b. brad^j			*	
c. brad		*		
d. braʣ^j	*			*

Describing the palatalization of the voiceless dental stop *t* in OT requires the addition of the constraints IDENT[cont] and *ʦ, which fall within the constraint ranking as follows: *ʣ, MAX[−low] » *T^j, IDENT[cont] » IDENT[strid], *ʦ. These additional constraints are needed in order to account for the fact that *t* becomes an affricate *ʦ*^{j} instead of becoming a fricative like its voiced counterpart. The palatalization of the affricate *ʦ* requires little clarification, since it simply gains a [−low] feature without any additional changes: *ʦ* → *ʦ*^{j}.

4.2.2 Palatalization of dental fricatives

In contrast to palatalized dental stops, palatalized dental fricatives undergo tongue-raising to become palatalized palatoalveolars. This pattern indicates that the palatalization of voiced dental stops mentioned above is a case of opacity. The segment *z*^{j} resulting from the palatalization of an underlying *d* is opaque to the tongue-raising process which affects an underlying *z* in the same environment. One way to account for this opacity is to take a diachronic perspective of events:

Figure 34   A diachronic account of opacity in Romanian dental stops and fricatives

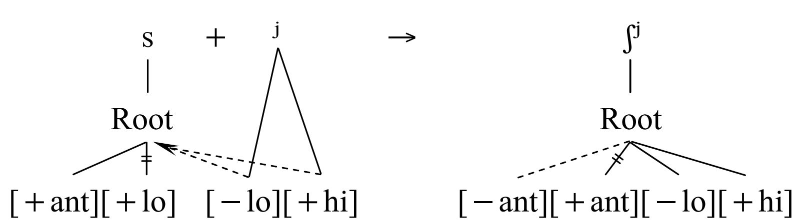
Stage 1		Stage 2		Stage 3
d^j	→	d^j	→	z^j
z^j	→	$ʒ^j$	→	$ʒ^j$

We can see here that even a diachronic account cannot explain why tongue-raising affected only fricatives. In order to resolve this problem I propose that in some languages (Romanian, also Irish: Kochetov 2002) it is more important to preserve tongue blade features when they belong to stops than it is when they belong to fricatives. This generalization is captured by the following constraint:

a.   IDENT[ant]/[−cont]
Preserve the value of the feature [±anterior] in a stop.

This constraint is important for capturing the difference between the treatment of dental stops and dental fricatives, but it is not required for illustrating the change *s* → *ʃ*^{j}.

Figure 35   Palatalization of Romanian dental fricatives resulting in tongue-raising



The crucial difference between the palatalization of dental stops and dental fricatives is that the stops are affected by the constraint IDENT[ant]/[−cont] while the fricatives are not. This contrast is best illustrated in OT, but first we need to reconfigure IDENT[ant]/[−cont]. While this constraint is adequate for a situation where dental stops do not undergo spirantization, as was the case in Stage 2 of Figure 34, it cannot account for the opacity found in modern Romanian. Since [+continuant] *d* becomes [−continuant] *z* when it is palatalized the constraint IDENT[ant]/[−cont] no longer applies.

A diachronic solution to this problem would be to propose that the process illustrated in Figure 35 took place long before the process shown in Figure 32, suggesting that tongue-raising has not been an active process in Romanian for a relatively long period of time. While I accept that this is a real possibility, I will not pursue this line of thinking here. For the purpose of demonstration I instead adopt the usual OT assumption that all morphological operations are synchronic. This means that IDENT[ant]/[−cont] must be altered so that it can refer to the underlying features of input segments.

b. *t → ʧ
/−cont/ ⇒ IDENT[ant]
Preserve the value of [±anterior] in a segment which has the feature [−continuant] in its underlying form.

Accounting for cases of opacity is notoriously difficult in OT and often requires controversial stipulations (Kager 1999). I feel that proposing a constraint *t → ʧ is the least problematic way to handle this difficult situation.

Figure 36 Palatalization of Romanian dental stops and fricatives in OT

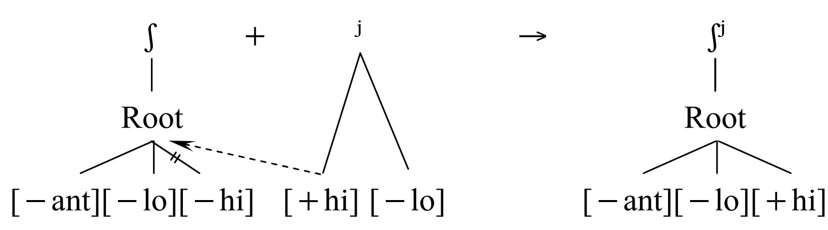
			*t → ʧ	*ʣ	Max[− lo]	MAX[+ hi]	*T^j	IDENT[ant]
1.	Input:	/pas + ^{j}/						
	a. ☞	paʃ^j						*
	b.	paʃ				*		*
	c.	pas^j				*		
	d.	pas			*			
2.	Input:	/brad + ^{j}/						*
	a. ☞	braz^j				*		
	b.	brad^j				*	*	
	c.	brad			*			
	d.	braʣ^j		*		*		
	e.	braʒ^j	*					*

We can see that Romanian is generally faithful to the features of the palatalization affix, but that the constraint *t → ʧ disrupts this pattern in dental stops so that a palatalized dental results instead of a palatalized palatoalveolar.

4.2.3 Palatalization of palatoalveolars

The palatalization of palatoalveolars is relatively straightforward.

Figure 37 Palatalization of Romanian palatoalveolars



These segments are already [−low] and [−back], so the only feature that is required to undergo spreading is [+high]. An OT account of this change is also straightforward, requiring only two constraints.

Figure 38 Palatalization of Romanian palatoalveolars in OT

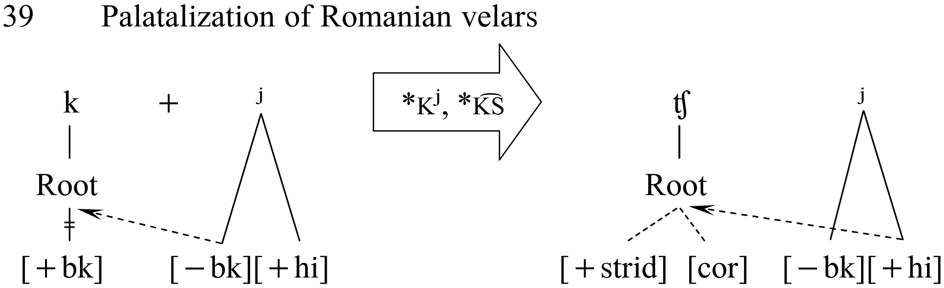
1.	Input: /retʃ+^{j}/	MAX[+hi]	IDENT[hi]
	a. ☞ retʃ^{j}		*
	b. retʃ	*	
2.	Input: /laʃ+^{j}/		
	a. ☞ laʃ^{j}		*
	b. laʃ	*	

Part of the reason that palatoalveolar segments are only minimally affected by palatalization is that they are all [+strident], so they cannot undergo assibilation.

4.2.4 Palatalization of velars

When velar stops are palatalized they undergo coronalization and become palatalized palatoalveolar affricates. In §2.11 I argued that [−back] is the feature responsible for palatalization in velars. In the case at hand [−back] is provided by the morpheme ^{j}.

Figure 39 Palatalization of Romanian velars



The [+high] feature of the morpheme ^{j} also associates with the resulting coronal in satisfaction of MAX[+hi], as can be seen in the following tableau.

Figure 40 Palatalization of Romanian velars in OT

Input: /rak+^{j}/	*K^j	*$\widehat{KS}$	MAX[+hi]	IDENT[dor]
a. ☞ ratʃ^j				*
b. ratʃ			*	*
c. rats^j			*	*
d. rak͡s^j		*		
e. rak^j	*			

In §4.1.1 I argued that the constraint *S^j is responsible for the common appearance of *tʃ* as a result of coronalization, but this constraint is not used in my account of the Romanian data. This is because MAX[+hi] does the work of *S^j by demanding palatalized palatoalveolars in most contexts, so *S^j vacuously satisfied in Romanian. Most cases of coronalization, on the other hand, result in plain palatoalveolars rather than palatalized palatoalveolars. I suggest that this is a result of the feature-spreading account outlined in §4.1.1, which is motivated by the constraint *S^j.

4.2.5 Blocking assibilation in Romanian

There are some additional outcomes of the palatalization process that are also of interest to us here. Assibilation of a palatalized dental stop *t* does not occur when a word-final consonant cluster *st* or *ʃt* is palatalized, and instead the segment *t^j* is realized on the surface. Chitoran (2002:192-3) points out that Romanian never allows two strident consonants in a syllable coda, and analyzes this result as a case of [+strident] dissimilation. While this type of blocking is not especially remarkable in itself, the fact that this environment also distorts coronalization is quite interesting. If a velar stop *k* is a member of a word-final cluster *sk*, it also becomes t^j when it undergoes palatalization.

Table 32 Romanian palatalization in word-final clusters

1.	a.	prost	proʃtʲ	'stupid'	SG-PL
		anost	anoʃtʲ	'boring'	SG-PL
		politisist	politisiʃtʲ	'policeman'	SG-PL
		arbust	arbuʃtʲ	'shrub(s)'	
	b.	peʃte	peʃtʲ	'fish'	SG-PL
2.	a.	kask	kaʃtʲ	'yawn'	1st-2nd
		opresk	opreʃtʲ	'stop'	1st-2nd
		baskə	bəʃtʲ	'cap(s)'	
		muskə	muʃte	'fly'	SG-PL
	b.	ʧe̯aʃke	ʧeʃtʲ	'cup(s)'	

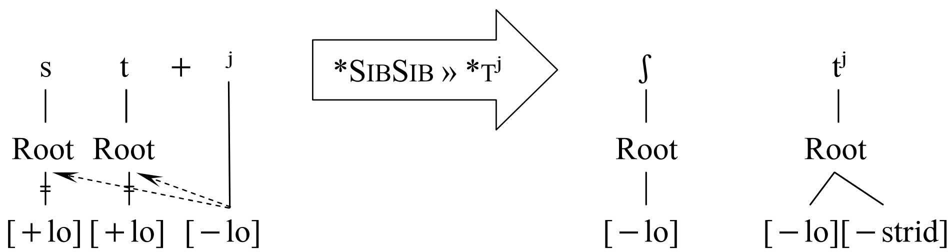
The most striking aspect of these data is that when coronalization is blocked, the underlying segment k^j does not surface, and is instead replaced by the palatalized dental t^j. This fact could be explained by taking a diachronic point of view, where one might assume that a series of changes $sk^j \rightarrow ʃʧ^j \rightarrow ʃt^j$ took place over a period of time. Since we lack supporting evidence to verify this theory it is beneficial to be able to explain this alternation from a synchronic perspective.

I follow Chitoran (2002) in analyzing the above data as a case of [+strident] dissimilation.

a. *SIBSIB (adapted from Hall 2004) *[+strident][+strident] $]_\sigma$
A syllable coda cannot contain two segments that are [+strident].

This constraint outranks the one that motivates assibilation, $*T^j$, explaining why assibilation is prohibited in these circumstances.

Figure 41 Tongue-raising and assibilation-blocking in Romanian



The fact that *s* becomes *ʃ* in this environment has led me to assume that the palatalization features associate not only with the word-final consonant, but also with other consonants in the word-final syllable coda. In §4.2.2 we saw that *s* becomes $ʃ^j$ when it is palatalized in word-final position, but here we see the change *s* → *ʃ*. I suggest that this discrepancy is due to a general constraint against the occurrence of palatalized consonants before other consonants. This postulation is supported by Kochetov (2002:29), who investigated the perception and production of palatalized consonants in various phonotactic environments.

b. $*C^jC$
*[+consonantal, +high, −back][+consonantal]$_\sigma$
A palatalized consonant cannot be followed by another consonant within the same syllable.

Ranking the constraint *SIBSIB above *T^j allows the palatalized dental stop *t^j*, which is normally prohibited in Romanian, to surface in some phonological contexts. Constraint-based theories excel at accounting for this type of incongruity, as we can see in the following tableau.

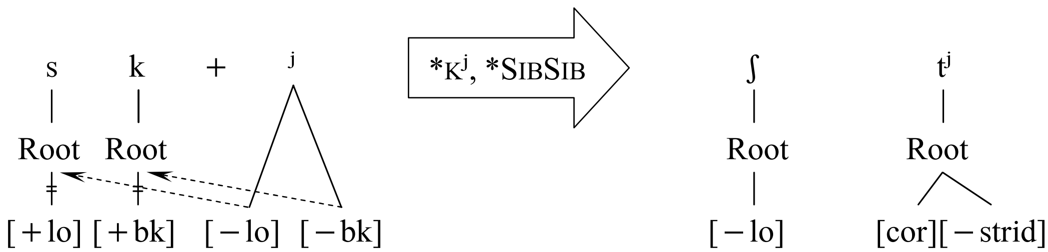
Figure 42 An OT account of Romanian assibilation-blocking

Input: /prost + ^{j}/	*C^{j}C	*SIBSIB	MAX[−lo]	MAX[+hi]	*T^j
a. ☞ proʃt^j					*
b. prost^j				*	*
c. proʃt				*	
d. prost			*	*	
e. proʃts^j		*			
f. proʃ^{j}t^j	*				*

In addition, the high rank of the constraint *C^{j}C explains why the palatalization of *s* can result in either *ʃ^j* or *ʃ*.

When a [+strident] obstruent precedes a velar stop the coronalization process is altered so that a non-strident coronal *t^j* surfaces instead of *tʃ^j*. The constraint *SIBSIB is largely responsible for this effect, however it does not account for the fact that the underlying velar *k^j* does not surface, as we might expect. This result is due to the fact that the constraint *K^j outranks *T^j, meaning that a palatalized velar *k^j* is more marked than a palatalized dental *t^j*, at least in Romanian.

Figure 43 Non-assibilating coronalization in Romanian



Once again this kind of constraint interaction is easily summarized in an OT tableau. Here we see that the constraint ranking *K^{j}, *SIBSIB » *T^{j} forces the grammar to choose a non-strident outcome of coronalization even though coronalization is motivated by the addition of the feature [+strident]:

Figure 44 An OT account of Romanian non-assibilating coronalization

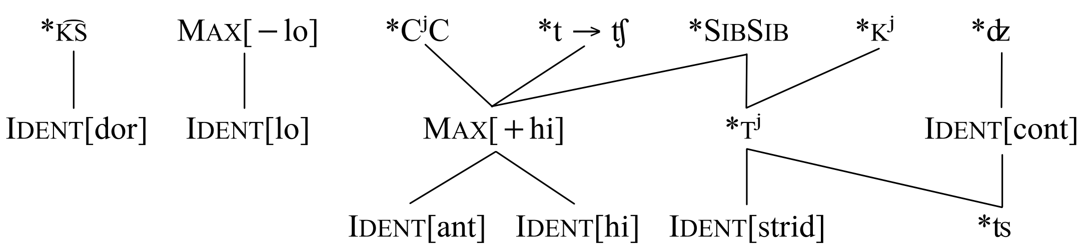
Input: /kask+^{j}/	*K^{j}	*C^{j}C	*SIBSIB	MAX[−lo]	MAX[+hi]	*T^{j}
a. ☞ kaʃt^{j}						*
b. kast^{j}					*	*
c. kaʃt					*	
d. kast				*	*	
e. kaʃtʃ^{j}			*			
f. kaʃ^{j}t^{j}		*				*
g. kaʃk^{j}	*					

Without the assibilation-blocking data we would not be able to determine the relative ranking of the constraints *K^{j} and *T^{j}. At the outset this set of data might appear to be problematic for any account of Romanian palatalization, however in this analysis it has not only been explained, but also used to provide more information about Romanian phonology.

4.2.6 Assibilation and coronalization in Romanian

In this section I have shown that a unified analysis of all the varied outcomes of Romanian palatalization is possible if we view coronalization as a type of assibilation. This unified analysis serves to confirm the main proposal of this thesis: that coronalization and assibilation are closely related processes. Here is an illustration of the relative rankings of the most important constraints used in this analysis.

Figure 45 The constraint lattice for Romanian palatalization



CHAPTER 5: RESIDUAL ISSUES

The above analysis is incomplete without considering some other closely-related topics. First, there are a few cases where coronalization is caused by a preceding trigger, and it is not immediately obvious how the above analysis might account for such cases. Secondly there is the unresolved question of the phonological representation of palatal glides, stops and fricatives. My analysis of coronalization has some implications for these segments which are significant to phonological theory.

5.1 Coronalization caused by a preceding trigger

The above analysis of coronalization focuses on cases where a front vowel follows a velar obstruent, but does not account for the situations found in languages such as Lakota and German. In these cases the coronalization trigger precedes the velar, posing a challenge to the acoustic analysis presented earlier, which suggested that coronalization is the result of a velar being released into a high front constriction. I propose that these are cases much like those of Navajo, Nuuchahnulth and Proto-Indo-European, where palatalization clearly preceded coronalization. The only difference is that in German and Siouan palatalization was induced by a preceding vowel.

5.1.1 Coronalization in German

I will use the case of German coronalization to illustrate my argument, since we have more accurate historical data regarding this group of dialects. In German there is a well-documented process of velar fronting known as *ich*-laut which began sometime after the High German Sound Shift, where the velar fricative *x* became a palatal *ç* following front vowels and the sonorants *n*, *l* and *r* (Robinson 2001:16).

Table 33 German *ich*-laut Environments[39]

1. a. *x → ç / {i e ai} _*

i[ç]	‘I’
bre[ç]en	‘break’
Lei[ç]e	‘body’

b. *x → ç / {y ø ɛ ɔʏ} _*

Bü[ç]er	‘books’
Lö[ç]er	‘holes’
Bä[ç]e	‘brooks’
Bäu[ç]e	‘bellies’

c. *x → ç / {n l r} _*

man[ç]	‘many’
Dol[ç]	‘dagger’
dur[ç]	‘through’

2. *x → x / {u o a au} _*

Bu[x]	‘book’
Lo[x]	‘hole’
Ba[x]	‘brook’
Bau[x]	‘belly’

In the central region of Germany this change has been extended so that *x* now alternates with a palatoalveolar fricative *ʃ* in these environments.

[39] The approximate phonetic values for the vowels are based on Wiese (1996).

Table 34 Central German coronalization[40]

1.	Central German alternations			
	Ba[x]	Bä[ʃ]e	'brook'	SG-PL
	Lo[x]	Lö[ʃ]er	'hole'	SG-PL

2.	*Central German*	*Standard German*	
	i[ʃ]	i[ç]	'I'
	man[ʃ]	man[ç]	'many'
	wel[ʃ]	wel[ç]	'which'
	dur[ʃ]	dur[ç]	'through'

Again, many analyses, including recent accounts such as Robinson (2001), treat this process as a synchronic alternation. I will show that the relative chronology of German phonology is problematic for a synchronic account of this phenomenon, making a diachronic account much more tenable.

The problem with treating coronalization as a synchronic process is that in many German dialects *r* became a uvular trill *ʀ* in coda position (Howe 2004:27, King and Beach 1998). The exact timing of this change remains a point of debate, but there is general agreement that in some of the larger cities it was complete by the late 17th century, at the very latest (King & Beach 1998:280). The uvular trill *ʀ* is now rare in modern Standard German, and has been variably replaced by a uvular approximant, a uvular fricative *ʁ*, or a "lower mid unrounded vowel between central and back," represented using the symbol *ɐ* (Wiese 1996:252). It seems that the change from an alveolar trill *r* to some kind of uvular was fairly ubiquitous throughout northern and

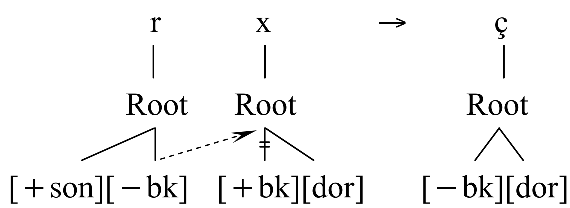
[40] From Robinson (2001:93, 96).

central Germany, at least in coda position (Howe 2004), and that only the south remained immune to this change (Wiese 1996:253). German phonotactics do not allow consonant clusters such as *rç* and *lç* in the syllable onset, so it was always a coda-position *r* that caused velar fronting.

Central German coronalization, on the other hand, is a much more recent phenomenon. According to Robinson (2001:94), this change arose in the middle of the 19th century, meaning that it clearly took place after *r* uvularization. Thus an alveolar *r* could not have been responsible for this process, so it must have been the result of assimilation to a uvular rhotic, or, more likely, it was a context-free change that did not have an external trigger. Uvulars are, of course, unlikely to cause velar fronting because they are pronounced with a relatively low back tongue body position. Despite this fact, Robinson (2001:78-85) argues that both velar fronting and coronalization are the result of synchronic articulatory assimilation which is triggered by a uvular consonant or a lowered central-back vowel *ɐ*. I propose instead that velar fronting occurred before *r* uvularization took place, and that coronalization came about as an independent development very similar to coronalization processes seen in languages like Navajo and Proto-Indo-European.

As mentioned in §2.7, above, some linguists use German velar fronting as justification for treating front vowels as [coronal], since this process is caused by both vowels and coronal sonorants. I have shown that this pattern can instead be explained by the fact that coronals and front vowels share a [−back] tongue body position.

Figure 46 German velar fronting[41]



Evidence for this representational choice is found in the cases of vowel fronting seen in §2.4.3, where coronal segments induce [+back] vowels to become [−back]. Under this analysis velar fronting is virtually identical to velar palatalization, since I assume, following Hall (1997), that palatal fricatives are phonologically equivalent to palatalized velar fricatives (i.e., $ç = x^j$). This means that palatal fricatives have the inherent properties which allow them to be misinterpreted as [+strident], as outlined in §4.1.3 above. I suggest that the high front tongue body position required to articulate palatal fricatives creates significant turbulence in the airstream, which in turn can be perceived as the feature [+strident]. In reproducing this segment the listener is then forced to articulate a coronal fricative, since there are no dorsal fricatives that are [+strident].

In order to represent this process I propose a constraint *PAL[+strid] to represent the fact that there are no strident consonants with a palatal place of articulation.

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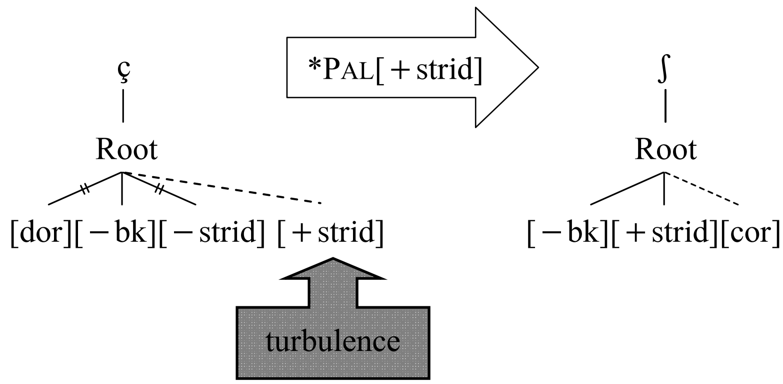
[41] For the purposes of illustration I have shown velar fronting as caused by *r* in Figure 46, but it is meant to represent all instances of this process. Note that the feature [coronal] is not included in the representation of the [−back] vowels which trigger velar fronting.

a. *PAL[+strid]
*[dorsal, −back, +strident]
The feature [+strident] does not occur in palatal consonants.

Figure 47 Coronalization in Central German



This analysis rests on the assumption that *ç* gained phonemic status before *r* underwent uvularization. This stipulation is somewhat controversial since some linguists have argued that *ç* is still an allophone of *x* in modern German. In a comprehensive study of *ich*-laut, however, Robinson (2001) convincingly argues that these segments are separate phonemes in modern German. This analysis is supported by other accounts of modern German phonology, such as Wiese (1996). My analysis requires the additional stipulation that *ç* has been a German phoneme for a relatively long period of time; probably since well before the 17th century. If it can be shown that this assumption is incorrect then this analysis will have to be discarded.

5.1.2 Coronalization in Lakota

I suggest that the coronalization process that took place in the Dakotan branch of Siouan languages was very similar to that of German. A preceding high front vowel induced palatalization in a following velar stop, which eventually underwent coronalization independently. Evidence that velar palatalization can be caused by a preceding high front vocoid is taken from two languages spoken in Mexico. One of these languages is Zoque, which belongs to the Mixe-Zoque family, and the other is the Oto-Manguean language Pame. In Zoque a preceding *j* manifests as palatalization on a following consonant, and in Pame *i* causes a following obstruent to become palatalized (Sagey 1990:75, 80).

Table 35 Velar palatalization caused by a preceding vocoid in Zoque and Pame

1.	Zoque		
	/j-kama/	k^{j}ama	'his cornfield'
	/j-ɡaju/	ɡ^{j}aju	'his rooster'
	/tsaj-kʌsi/	tsak^{j}ʌsi	'on the vine'
	/nj-ken/	nɡ^{j}enu	'you looked'
	/nj-ɡustatsʌhk/	nɡ^{j}ustatsʌhk	'you enjoyed yourself'
2.	Pame		
	/tʃi-kao/	tʃik^{j}ao	'his/her ear'
	/ni-k'eʃ/	nik^{j}'eʃ	'his/her paper'

Sagey (1990:75-6) interprets the Zoque data as the spreading of the feature [−back], which becomes a "phonologically unordered additive articulation on the segment." The data from Pame follows precisely the pattern that I propose for an earlier stage of Lakota.

Table 36 Coronalization in Lakota[42]

1.	a.	kuʔ	'he is coming home'
	b.	gli-ʧuʔ	'he reached home here'
2.	a.	oʔ-ma-kiye	'he helped me'
	b.	oʔ-ni-ʧiya he	'did he help you?'
3.	a.	wa-kʰute	'he shoots at me'
		ma-kʰute	'I shoot at him'
	b.	ni-ʧʰute	'he shoots at you'
4.	a.	kaʔ-kʰiya	'over yonder'
	b.	heʔ-ʧʰiya	'over there'
5.	a.	k'a	'dig'
	b.	mni-ʧ'a-pi	'well' (water-dig-PL)
6.	a.	ma-k'u	'he gave it to me'
	b.	ʧʰi-ʧ'u	'I gave it to you'

I suggest that the Lakota stops *k*, k^h and *k'* became palatalized to k^j, k^{jh} and k^{j}*'* when they occurred after front vowels, much like the case of German velar fronting seen in Figure 46. Subsequently the palatalized stops were reinterpreted as [+strident], and were thus coronalized to the palatoalveolars *ʧ*, $ʧ^h$ and *ʧ'*.

My analysis of coronalization caused by a preceding trigger requires two distinct historical stages. In the first stage the velar is fronted or palatalized, and in the second stage it is reanalyzed as a [+strident] coronal. Evidence that the first stage exists is found in many languages, including Zoque, Pame, and Standard German.

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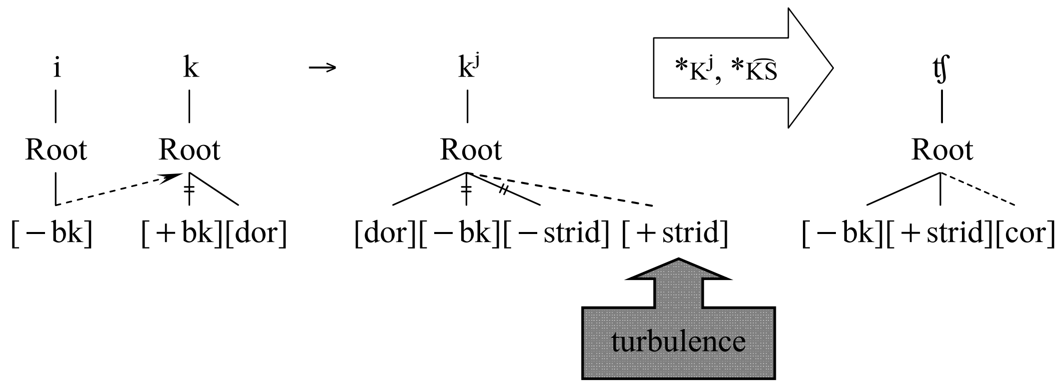
[42] This data was taken from Shaw (1978:228) and Taylor & Rood (1996).

Figure 48 Coronalization in Lakota



Accounting for the second stage is the main aim of this thesis, and argumentation for this has been presented above.

5.2 The place of articulation of *j*

Much like high front vowels, the place of articulation of the voiced palatal semivowel *j* has been a subject of some debate. This is in part because *j* patterns with both the high front vowel *i* and with coronal consonants such as *ʒ*. Traditionally all vowels were considered to be tongue body gestures, so *j* was treated as a tongue body gesture as well in order to maintain a strong formal relationship between *i* and *j* (Chomsky & Halle 1968:307). However this could not explain why *j* sometimes becomes a coronal as a result of fortition. For example, Latin *j* became *ʒ* in Portuguese (Williams 1968:60). Furthermore, in North American English *j* is not permitted to follow coronals in the syllable onset (Hall 1997:5). This pattern can be accounted for as coronal dissimilation if *j* is treated as [coronal] (Davis and Hammond 1995).

Keating (1988b) proposed that all palatals, including *j*, are complex segments that bear two place features: [coronal] and [dorsal]. This idea has been strongly promoted by Gussenhoven & Jacobs (2005), but is somewhat problematic in that true complex segments, such as coronal-dorsal clicks, are relatively rare. Maddieson (1984) found that *j* was present in 85% of the languages in his typological survey, suggesting that it is a relatively simple segment. In Vowel-Place Theory, Clements & Hume (1995) decided to treat *j* as simply [coronal], and in §2.4 we saw that this is also problematic.

I propose that the semivowel *j*, like *i*, is simply [dorsal]. Using the same place features for vowels and semivowels is justified by the phonetic similarities between these two types of segments. One phonetic study found that the only difference between semivowels and their corresponding vowels is that semivowels "are produced with narrower constrictions in the vocal tract" (Ladefoged & Maddieson 1996:323). I suggest that this distinction should be represented using major class features, such as [±consonantal], rather than place features, such as [dorsal] and [coronal]. For the purposes of the following argumentation I will assume that *j* is [+consonantal], but it may instead be distinguished from *i* using another feature, such as [±vocalic] (Chomsky & Halle 1968:302-3).

We saw above that in some situations the semivowel *j* appears to pattern as a coronal. I suggest that this is due to the tongue body feature [−back], which is shared by most, if not all, non-retroflex and non-velarized coronals. When a palatal semivowel *j* undergoes fortition we might expect it to become a consonant of the same place of articulation, and this is precisely what happened in Old Spanish, where Latin *j* became a palatal fricative *ʝ* (Penny 2002:62). In some cases, however, the palatal fricatives *ç* and *ʝ* seem to be avoided. This could be due to structure-preserving constraints that prohibit the formation of a segment that is not already present in the phonemic inventory of a given language. There is also the possibility that palatal stops and fricatives are avoided because they are phonetically complex, but this is not agreed upon. In these cases the grammar is forced to alter the place of articulation of the palatal consonant while at the same time preserving as many features as possible. The outcome of this process is usually the voiced palatoalveolar fricative *ʒ*. I suggest that this result occurs because *ʝ* and *ʒ* share the tongue body features [−back, −low]. Alveolopalatals also share these features, so it would not be surprising to find that this process sometimes results in an alveolopalatal stop or fricative.

The case of North American English, where the segments *θ*, *ð*, *t*, *d*, *s*, *z*, *n*, *l*, *ʃ*, *ʒ*, *tʃ*, *dʒ*, and *ɹ* are prohibited before *j* in the syllable onset, can likewise be explained by referring to tongue body features. Recall the constraint *S^{j} from §2.11 which bars the formation of segments which are both [+anterior] and [−low]. This paradigmatic constraint can be reformulated into a syntagmatic constraint *Sj, but this requires some changes to the features involved. The semivowel *j* is [+high], so [−low] will be replaced with [+high]. However, preventing a sequence [+anterior][+high] would disallow the consonant cluster *sk*, which is found in both onsets and codas in English.

In order to avoid this problem I will stipulate that it is only [−back, +high] consonants that are prohibited following an alveolar. Note that alveolars are also [−back], but that they are always [−high], according to my argumentation in §2.11. Therefore the constraint *Sj prohibits a sequence of segments with the following features: [+anterior, −high, −back, +consonantal][+high, −back, +consonantal]. This constraint prohibits *θ*, *ð*, *t*, *d*, *s*, *z*, *n* and *l* from occurring before *j*, but it says nothing about the other [coronal] segments, *ʃ*, *ʒ*, *tʃ*, *dʒ* and *ɹ*, which are also disallowed in this environment. I argued in §2.11 that plain palatoalveolars also have a [−high, −back] tongue body position. If the feature [+anterior] is removed from the formal description of *sj then this constraint also prevents sequences where a palatoalveolar precedes *j*. I will rename this constraint *sj/ʃj in order to indicate that it prohibits both of these types of sequences.

a. *sj/ʃj
*[−high, −back, +consonantal][+high, −back, +consonantal]
Coronals cannot be followed by a high front consonant.

Finally we must consider why it is that the sequence *ɹj* is prohibited. This sequence is different from the others, since it is prohibited in British English as well as in North American English. The explanation for this prohibition is clearly laid out by Flemming (2003), who demonstrates that retroflexes are easiest to articulate with a [+back] tongue body. A following [−back] segment, such as *j*, is therefore dispreferred, since it creates a conflict with the tongue body position of the retroflex segment. When in onset position English *ɹ* is perhaps better represented as a true retroflex *ɻ* (Pullum & Ladusaw 1996:165), which therefore abides by this principle. Flemming (2003) proposes the paradigmatic constraint RETRO→BACK to illustrate this point; I will use the notation *s̺j to represent a syntagmatic constraint that follows the same principles.

b. *s̺j
*[−anterior, −distributed][+high, −back, +consonantal]
A retroflex cannot be followed by a high front consonant.

I will now consider the differing constraint orders for the most common dialects of British and North American English. British English prohibits *ɹj* but allows all the other possibilities, which can be accounted for using the following constraint ranking: *s̺j » IDENT-IO » *sj/ʃj. In contrast, North American English has re-ranked the markedness constraint *sj/ʃj so that it outranks IDENT-IO: *sj/ʃj, *s̺j » IDENT-IO. An account of this phenomenon which simply states that North American English disallows a sequence of a coronal and a coronal glide cannot explain why the sequence *ɹj* is disallowed in both dialects. If this prohibition involves only the feature [coronal] then why is one particular coronal treated the same way in both dialects while the rest are treated differently? It is very difficult to explain this discrepancy without taking other features into account.

While the arguments for treating *j* as [dorsal] might seem weak compared to the arguments for treating it as [coronal], the overall unity of the phonological system is compromised if we follow the latter course. It is undoubtedly clear that *i* and *j* have a close relationship which needs to be maintained in the formal representation of both segments. The argumentation in §2.4 indicates that *i* should be treated as [dorsal], not [coronal], and therefore *j* must also be treated as [dorsal]. I have shown above that the reason *j* sometimes becomes a coronal segment as a result of fortition is due to the similar tongue body positions of these segments. I have also shown that *j* is sometimes marked following coronals because it is not completely identical to these segments. This explanation additionally offers some insight as to why the sequence *ɹj* is prohibited in both British and North American English.

5.3 The place of articulation of palatal stops and fricatives

Another area of disagreement is the treatment of palatal stops, and to a lesser extent, palatal fricatives. Much like *j*, some linguists claim that palatal stops have a [coronal] component (Keating 1988b, 1991), while others maintain that palatals are articulated with the tongue body and are therefore [dorsal] (e.g. Ladefoged & Maddieson 1996). Consider the following statement made by Ladefoged & Maddieson (1996:31):

> When places of articulation are grouped according to the active articulator used, palatal articulations, which use the body of the tongue rather than the blade, fall outside the Coronal class of articulations. Rather, they are connected to the velar and uvular places. We use the term Dorsal for this group.

In support of this premise Ladefoged & Maddieson (1996:32) reproduce an x-ray tracing of a Hungarian palatal stop where we can clearly see that the tongue blade is not making contact with the hard palate, the alveolar ridge, the upper teeth or any other part of the roof of the mouth. In addition, Ladefoged & Maddieson (1996:165) observe that that palatal stops are articulated with the tip of the tongue down behind the lower front teeth, and that the tongue is raised towards the hard palate, “as if the aim were to push the tongue through the roof of the mouth”. They also note that palatal stops seem to be pronounced with an advanced tongue root.

These observations lead me to believe that depressing the tip of the tongue is a sympathetic gesture which facilitates the movement of the tongue body towards the hard palate. An advanced tongue root may also facilitate this gesture, or it may simply be a side-effect of tongue tip depression. These additional gestures could help to explain why palatal stops are so marked cross-linguistically when compared to palatoalveolars.

While palatoalveolars do require a sympathetic gesture (the tongue body must move slightly upwards and forwards), they do not require two parts of the tongue to move independently, and therefore require less articulatory effort. It appears that palatal stops, on the other hand, usually require a downward displacement of the tongue tip while the tongue body moves dramatically upwards and forwards. This observation may also indicate why palatal stops seem to have a [coronal] articulation: the tongue blade is activated in order to assist the tongue body. The current definition of [coronal] does not include a downward tongue blade gesture. I suggest that it might be prudent to redefine [coronal] so that it includes all segments requiring activation of the tongue blade, regardless of whether the tongue blade moves upwards or downwards.

Most sets of phonological features are not able to adequately describe tongue tip depression, since the only features typically available are [±anterior] and [±distributed]. Linguists who consider palatals to be [coronal] usually classify them as [−anterior, +distributed], but this featural designation also includes speech sounds made without a depressed tongue tip, such as palatoalveolars. In order to address this deficiency additional features have been proposed, such as the contrastive pair [tip up] and [tip down], and the monovalent feature [lower incisors contact] (Keating 1991:43-4). In keeping with these suggestions and with the structure of Revised Articulator Theory, I propose that a tongue blade feature [±depressed tip] should be taken into consideration for future research. Such a feature is quite controversial however, since the designation [+depressed tip] would be required to describe very few speech segments. Some articulations of alveolopalatals and high front vocoids could potentially be treated as [+depressed tip], but these speech sounds can be differentiated using existing features.

Treating palatals as [dorsal], as Ladefoged & Maddieson (1996) suggest, is somewhat problematic for Revised Articulator Theory because the featural designation [+high, −low, −back] is already used to describe palatalized velars, such as k^j. This problem can be resolved by adding the feature [±front] to the tongue body inventory. Since it has already been argued that some vowel systems require a three-way backness distinction (Flemming 2003, Ladefoged and Maddieson 1996:290, Ladefoged 1997, Parker 2000), the addition of this feature is not particularly controversial. The features for dorsal consonants would then be as follows:

Table 37 Tongue body features for dorsal consonants

	c	k^j	k	q	ħ
high	+	+	+	−	−
low	−	−	−	−	+
front	+	−	−	−	−
back	−	−	+	+	+

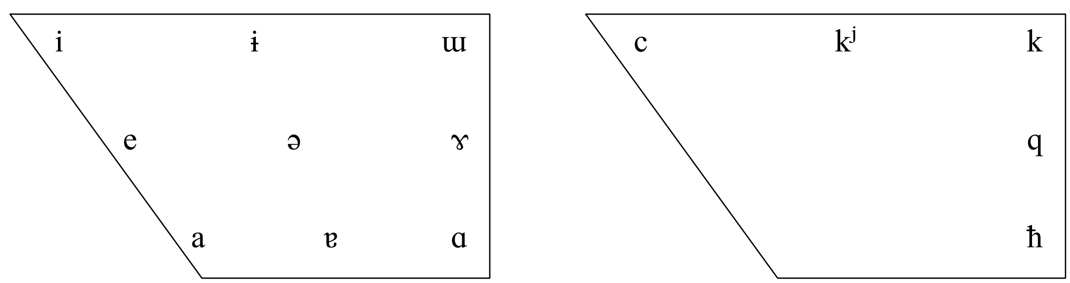
Note that there are nine possible combinations of these four features, but only five of these possibilities are exhausted by the dorsal places of articulation. The remaining four combinations all include the specification [−high, −back]. The exact nature of this pattern becomes clear when illustrated in relation to the corresponding vowels.

Table 38 Tongue body features for unrounded vowels

	i	ɨ	ɯ	e	ə	ɤ	a	ɐ	ɑ
high	+	+	+	−	−	−	−	−	−
low	−	−	−	−	−	−	+	+	+
front	+	−	−	+	−	−	+	−	−
back	−	−	+	−	−	+	−	−	+

The position of these vowels in the mouth is illustrated in the diagram to the left in Figure 49. The diagram to the right shows how the dorsal consonants correspond to the vowels based on their tongue body features.

Figure 49 Correspondences between unrounded vowels and dorsal consonants



Here we can see that the five dorsal consonants correspond with the high and back vowels, which is not unexpected, since the tongue body can only create a constriction against the palate or the pharyngeal wall. In other words, there is a constraint barring the featural combination *[−high, −back, +consonantal] due to the fact that the tongue body cannot reach the front the mouth. The diagrams in Figure 49 illustrate that there is a featural parallel between [dorsal] consonants and the relevant vowels. This type of parallel is expected if cardinal vowels are treated as simple [dorsal] articulations, but cannot be achieved unless palatal stops are also treated as [dorsal].[43]

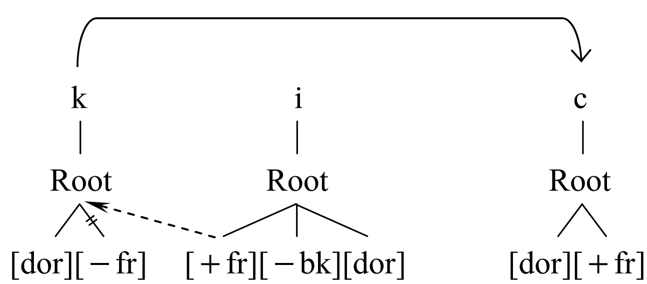
Viewing palatal stops as [dorsal] segments allows us to easily account for cases where they are derived from velar stops. An example of this is seen in the history of Icelandic, where velar stops became palatals before front vowels (Calabrese 2005).

Table 39 Icelandic velar fronting resulting in palatals

1.	k^{h}aːk^{h}a	‘cake’	2.	c^{h}iːlou	‘kilogram’
	k^{h}riːja	‘arctic tern’		c^{h}eiːla	‘cone’
	kouːmyr	‘palate’		cɪfta	‘marry’
	kliːma	‘wrestle’		ceiːsɪr	(name of a hot spring)

This can be accounted for by spreading the feature [+front] from the following front vowel to the velar stop *k*.

Figure 50 Velar fronting resulting in a palatal



[43] Speech sounds described as palatalized uvulars q^j and pharyngealized uvulars $q^{\text{ʕ}}$ exist in some Caucasian languages, such as Ubykh, Abaza and Bzyb. Colarusso (1988:272) accounts for these segments using the features [±advanced tongue root] and [±constricted pharynx], so these segments pose no problem for the view of dorsal consonants presented here.

Note that this is not a case of coronalization. I have proposed that coronalization is primarily an acoustic process, where the feature [+strident] is inserted into the feature matrix and creates a strident affricate. Since palatal stops are non-strident we do not expect them to result from an acoustic process such as coronalization, but rather from a purely articulatory process as illustrated here. By adding [±front] to the feature inventory we can adequately differentiate between velar stops and palatal stops without requiring a controversial feature such as [±depressed tip]. Perhaps this feature would be better put to use in a theory of phonetic features, such as that proposed by Ladefoged (1997), rather than in an abstract phonological representation. Nonetheless, I feel that the phenomenon of tongue tip depression is a line of research is worth pursuing in order to gain a greater understanding of palatal stops.

I suggest that palatal stops are able to undergo coronalization, much like palatalized velars. In §2.10 we saw Lee's (2000) argument that all cases of coronalization go through a palatal stage: *k → c → tʃ*. I propose instead that most cases of coronalization involve a more direct change k^j → *tʃ*, or even *k → tʃ*, and that an intermediate palatal stage is extremely rare. I do not discount this possibility altogether however, since palatal stops have the articulatory property which creates the acoustic conditions that lead to coronalization: a high front constriction in the stop release. The change *c → tʃ* did take place in a dialect of Bulgarian (Calabrese 2005:347), and I suggest that this is a case of coronalization much like the more common change *k → tʃ*.

Before we leave the subject of palatal stops, let us consider the phonological evidence surrounding these segments. Although they can be derived from velar stops, they can also result from the palatalization of dental and alveolar stops. This is seen in many Slavic languages (Kochetov 2002) and in the history Hungarian (Benko and Imre 1972, Collinder 1960). This development is especially interesting in the Slavic language family, where palatalization became contrastive among all stops, including the anterior coronal series (*t* vs. t^j). In Czech, Slovak, and dialects of Bulgarian and Russian the palatalized stop t^j developed into a palatal stop *c* (Kochetov 2002:23). This change seems to be the result of a desire to enhance the contrast between *t* and t^j. Much like coronalization, I suggest that this type of change is primarily acoustic in nature, although it is a case of enhanced contrast rather than mistaken identity. These cases indicate that there is perhaps justification for a process of *dorsalization* in addition to coronalization.

I have discussed the phonetic evidence regarding palatal stops, but I have avoided mentioning phonological patterns that include these segments. This is because palatal stops, like the palatal semi-vowel *j*, tend to pattern with coronal consonants. I argued that *j* sometimes patterns with coronals due to the fact that they share similar tongue body positions, and I assume that this also the case for palatal stops. However, it is also possible that in some cases speech segments labelled as palatal stops are in fact alveolopalatals. This is particularly true for Sanskrit, where the only available phonetic evidence comes from texts written by ancient grammarians. These early linguists made a meticulous record of the place of articulation of each series of Sanskrit consonants, including the following observation: "In the c-series contact is made with the middle of the tongue upon the palate" (Allen 1953:52). This statement has led modern linguists to believe that the c-series had a palatal place of articulation; however there is a possibility that this description could be referring to an alveolopalatal place of articulation instead.

The historical facts suggest that a palatal place of articulation was unlikely, since modern Sanskrit and its descendent languages all have palatoalveolars instead of palatals. Furthermore, all other Indo-Iranian languages show palatoalveolars for this same series, which was originally derived from velars through coronalization. In order to account for these facts it has been suggested that the Sanskrit c-series underwent the following set of changes: *k(i) → tʃ → c → tʃ*. While this succession of events is not completely untenable, it seems less than likely. I suggest instead that when the Indo-Iranian velars underwent coronalization they became alveolopalatals, and then eventually lowered to become palatoalveolars: *k(i) → tɕ → tʃ*. This process would have happened in all branches of Indo-Iranian, but the alveolopalatal stage may have lasted for a much longer period of time in Sanskrit than it did in the other descendent languages. If these so-called palatals were truly alveolopalatals then this explains why they patterned as coronals (Hall 1997:80).

Finally, let us consider the relationship between palatal stops and palatal fricatives. X-ray tracings indicate that palatal stops have a higher and more forward tongue body than their fricative counterparts (Ladefoged & Maddieson 1996:166). Similarly, Hall (1997) has made a distinction between palatal stops and fricatives based on their phonological behaviour. Under his analysis palatal fricatives, such as *ç,* are united with palatalized velar fricatives, such as x^j. I have adopted this innovation in my analysis of German coronalization in §5.1.1 above. More research needs to be done in order to clarify the relationship between palatal stops and palatal fricatives, and to determine whether or not there is a phonetic distinction between *ç* and x^j.

CHAPTER 6: CONCLUSION

This thesis has aimed to provide a formal phonological account of coronalization. A thorough review of previous theories of coronalization made it quite clear that a purely articulatory explanation of this phenomenon is incapable of accounting for the facts, so acoustic factors were considered as well. We then saw that there are some striking similarities between assibilation and coronalization, indicating that these processes are closely related. An account of coronalization that included both articulatory and acoustic factors was presented and then demonstrated using Romanian as a case study.

In the course of this thesis I have argued for a number of small changes to phonological theory, which I will recount here. It seems that in order to account for the phonological patterning of coronals we need to take their tongue body position into account. I argued that anterior coronals have [+low] tongue body position, and that palatoalveolars are [−high, −low]. In addition, I argued that there is no single feature responsible for palatalization, and that this process is instead caused by the featural combination [+high], [−low] and [−back]. I suggested that *j* should be treated as [dorsal] in order to maintain a close representational relationship between *i* and *j*. Some linguists have proposed adding [±front] to the feature inventory in order to account for the vowel systems of certain languages, and I have shown that this feature is also useful for distinguishing [dorsal] consonants.

One of the most important points of this thesis is that Vowel-Place Theory, a popular theory at the present time, cannot adequately account for coronalization, and that vowel-consonant alternations can be handled within a more traditional framework.

After closely investigating many accounts of coronalization, I have come to the conclusion that a more traditional view of phonological features, such as that found in Chomsky & Halle (1968) and Halle, Vaux & Wolfe (2000), is in fact more useful than some of the more innovative feature theories. This direction of argumentation is not at all a deliberate attempt to maintain or reinstate conservative views in feature theory; I have simply found that this set of features has the most explanatory power with regard to the problem at hand.

The main argument of this thesis is that a sequence *ki* has acoustic properties which induce the listener to insert the feature [+strident] into the feature matrix of the velar stop *k*. This additional feature may cause the velar stop to become a velar affricate *k͡s* or *k͡ʃ*, or to become a coronal affricate *tʃ* or *ts*. The choice between *tʃ* and *ts* is determined by whether or not the tongue height feature of the triggering vowel spreads to the new coronal affricate. If the tongue height feature does spread then we expect the palatoalveolar affricate *tʃ*, and if not then we expect *ts*.

The titles of some recent publications concerning coronalization suggest that this process is extremely important to our overall understanding of phonology. For example, a recent article had the title "Palatalization/Velar Softening: What It Is and What It Tells Us about the Nature of Language" (Halle 2005), and one of the chapters in Calabrese's (2005) book is titled "On Coronalization and Affrication in Palatalization Processes: An Inquiry Into the Nature of Sound Change". While I agree that being able to explain coronalization is important for improving our overall understanding of phonology, I disagree with the conclusion reached by Halle (2005) and Calabrese (2005) that coronalization is yet another case of articulatory assimilation. It seems that what coronalization tells us about the nature of language is that on occasion the listener, rather than the speaker, is responsible for phonological change (cf. Ohala 1981, 1993).

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