Friction between Phonetics and Phonology

The status of affricates

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Friction between Phonetics and Phonology
The status of affricates

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"As a rule," said Holmes, "the more bizarre a thing is the less mysterious it proves to be".

Sir Arthur Conan Doyle. *The Adventures of Sherlock Holmes, The Red-headed League*. (1891)

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Table of Contents

Acknowledgements **vii**

Chapter 1. Introduction **1**
1.1 Introduction 1
1.2 The phonetics of affricates 2
1.3 One or two phonemes? 5
1.4 The phonological structure of affricates 8
1.5 Research questions and methodology 9
1.6 Outline of the thesis 13

PART I: BACKGROUND

Chapter 2. The phonological debate **17**
2.1 Introduction 17
2.2 Affricates: stops with a release feature 17
2.2.1 Affricates as strident stops 17
2.2.2 Affricates as stops with a delayed release 18
2.3 Affricates: combinations of a plosive and a fricative 18
2.3.1 Multi-column complex segments 19
2.3.2 Contour segments 21
2.3.3 Complex segments 23
2.3.4 Aperture theory 27
2.3.5 Headedness among continuancy features 29
2.3.6 One or two nodes? 31
2.4 Affricates: simplex underlying stops 33
2.4.1 The nonavailability of [+continuant] 33
2.4.2 The return of the strident stop 35
2.4.3 Affricates do not exist 39
2.5 The contour segment revisited 44
2.6 Agreement and disagreement 45
2.7 Conclusion 46

PART II: TYPOLOGY

Chapter 3. Affricates in segment inventories **51**
3.1 Introduction 51
3.2 Preliminaries: typology and sampling 52
3.3 UPSID 54
3.4 From 1 to 24: the distribution of affricates in UPSID 56
3.5 Place of articulation 64
3.6 Voiceless vs. voiced 68
3.7 Sibilant vs. non-sibilant 72
3.7.1 Frequencies of occurrence 72
3.7.2 One or two sibilants 73
3.7.3 More than two sibilants 76
3.7.4 Contrastive parameters 79
3.7.5 Affricates and sibilant typology 82
3.8 Segmental attributes 85
3.9 Singleton vs. geminate 92
3.10 Feature Economy and Maximal Dispersion 96
3.11 Conclusion 99

Chapter 4. Theoretical implications of typological patterns **101**
4.1 Introduction 101
4.2 Validity of existing arguments 101
4.2.1 Place of articulation 101
4.2.2 Segmental modification 103
4.3 Applying a stop account to UPSID 1992 106
4.3.1 Stop accounts 106
4.3.2 Strident and lateral affricates 107
4.3.3 Non-strident and non-lateral affricates 109
4.4 Representational implications 118
4.4.1 Phonology vs. phonetics 118
4.4.2 Complex vs. simplex descriptions 119
4.4.3 Affricate geometry 120
4.5 Discussion and conclusion 125

Chapter 5. Affricates in the history of French **127**
5.1 Introduction 127
5.2 The rise and fall of affricates in French 127
5.2.1 Origins of affricates 127
5.2.1.1 Consonant coalescence 128
5.2.1.2 Intrusive stops 128
5.2.1.3 Palatalization 129
5.2.1.4 Glide strengthening 132
5.2.2 Deaffrication 133
5.3 Affrication and deaffrication: formal modelling 135
5.3.1 Preliminaries 135
5.3.2 Consonant coalescence 136
5.3.3 Intrusive stops 139
5.3.4 Palatalization before front vowels or the palatal glide 145
5.3.5 Velar palatalization before *a*: phonetics, phonology or both? 151
5.3.6 Glide strengthening 154
5.3.7 Deaffrication 160
5.4 Discussion and conclusion 162

PART III: A CORPUS STUDY OF MODERN FRENCH

Chapter 6. Data and methodology **167**
6.1 Introduction 167
6.2 Phenomena of study 168
6.2.1 Velar palatalization 168
6.2.2 Plosive affrication 170
6.3 Linguistic data 171
6.4 The PFC corpus 173
6.5 Selection of subcorpora and parameters of variation 175
6.5.1 Linguistic variation 175
6.5.2 Diatopic variation and selection of subcorpora 176
6.5.3 Diastratic and diaphasic variation 178
6.6 The PFC corpus: possibilities and limitations 180
6.7 Conclusion 181

Chapter 7. Velar fronting **183**
7.1 Introduction 183
7.2 The phonetics of velars 183
7.3 Method 184
7.3.1 Analysis 184
7.3.2 Material and measurements 188
7.4 Velars before front and back vowels 192
7.4.1 Linguistic factors 192
7.4.2 Sociolinguistic factors 197
7.4.3 Locus equation of the PFC velars 203
7.5 A closer look at *a* 205
7.5.1 /a/ vs. /ɑ/ 205
7.5.2 Velars before *a* 212
7.6 Discussion and conclusion 214

Chapter 8. Plosive releases **217**
8.1 Introduction 217
8.2 The French plosives 218
8.2.1 Frequencies of occurrence 218
8.2.2 Articulatory and acoustic characteristics 219
8.3 Material and measurements 221
8.4 Results 223
8.4.1 Word lists 223
8.4.1.1 Labials 223
8.4.1.2 Coronals 232
8.4.1.3 Velars 242
8.4.2 Read text: Puteaux-Courbevoie 247
8.4.2.1 Labials 248
8.4.2.2 Coronals 248
8.4.2.3 Velars 250
8.4.3 Summary 252
8.5 The sociophonetics of French plosives 253
8.5.1 Segmental factors 253
8.5.2 Sociophonetic factors 259
8.5.3 Summary and discussion 261
8.6 A few words on vowel devoicing 262
8.7 Discussion and conclusion 266

Chapter 9. Conclusion **269**
9.1 Introduction 269
9.2 A phonological class of affricates? 270
9.3 Palatalization and affrication in modern metropolitan French 273
9.4 The phonetics, phonology and sociolinguistics of affricates 274
9.5 Conclusion and perspectives 276

Appendices
Appendix A. UPSID languages with affricates 281
Appendix B. PFC reading tasks 297
Appendix C. Participants of the selected PFC surveys 301
Appendix D. Vowel space 307
Appendix E. Plosive + Vowel contexts 317

Bibliography **323**

Summary **335**
Samenvatting (Summary in Dutch) **341**

Curriculum Vitae **347**

1

Introduction

1.1 Introduction

As members of a specific speech community, we are exposed to massive amounts of oral speech every day: a continuous chain which we can in general very easily decompose into discrete units (sentences, words or even individual sounds). In order to be able to do so, we do not need to recognize the voice we hear, but we can perfectly understand speakers (speaking a language we are familiar with) whom we have never heard before. This is because we have representations of sounds and words at our disposal in our brains. The way in which sound is mentally represented by speakers is the main question for phonological science. In the past, a lot of progress has been made in this field, but there are still numerous issues to explore and numerous controversies to solve.

This thesis focuses on one of these controversies, namely the phonological representation of sounds with a complex articulation, like the one that we find at the beginning of English ***ch****ip* [tʃɪp] for instance, and which are labelled "affricates" in phonetics and phonology.[1] This introductory chapter serves to set out the problem that will be dealt with in this thesis, and to sketch the background against which the problem should be considered. First, we will have a closer look at the phonetic (i.e. the articulatory and acoustic) characteristics of affricates in section 1.2. Next, in sections 1.3 and 1.4 we will turn to their

[1] In the American tradition, affricates are represented by single symbols, e.g. [č] or [j] (cf. Bloomfield 1933). The alphabet of the International Phonetic Association (IPA), on the contrary, uses a combination of symbols, the first one representing the plosive part, the second one representing the fricative part, e.g. [tʃ], [dʒ]. For clarity's sake, both symbols may be tied by the diacritic [‿] (cf. Pullum & Ladusaw 1996). In this thesis, we will adopt the IPA transcription. The diacritic will only be used if confusion might arise between an affricate and a plosive-fricative cluster.

phonological properties and set out the exact nature of the controversy involved. A description of the research questions and methodology adopted will be given in section 1.5, and will be followed by a general outline of this thesis in section 1.6.

1.2 The phonetics of affricates

Consonants are commonly subdivided into several categories, depending on their degree of oral occlusion. First of all, consonants belonging to the category of "sonorants" are characterized by a constriction in the oral cavity which is sufficiently wide to allow the airstream to pass through without yielding friction. In this category, we find the nasals ([m], [n]), the liquids ([l], [r]) and the glides ([j], [w]). The second category of consonants groups the sounds that are produced with a tight constriction in the oral cavity: the "obstruents". To this category belong the plosives,[2] the fricatives and the affricates, all characterized by their own specific articulatory and acoustic aspects.

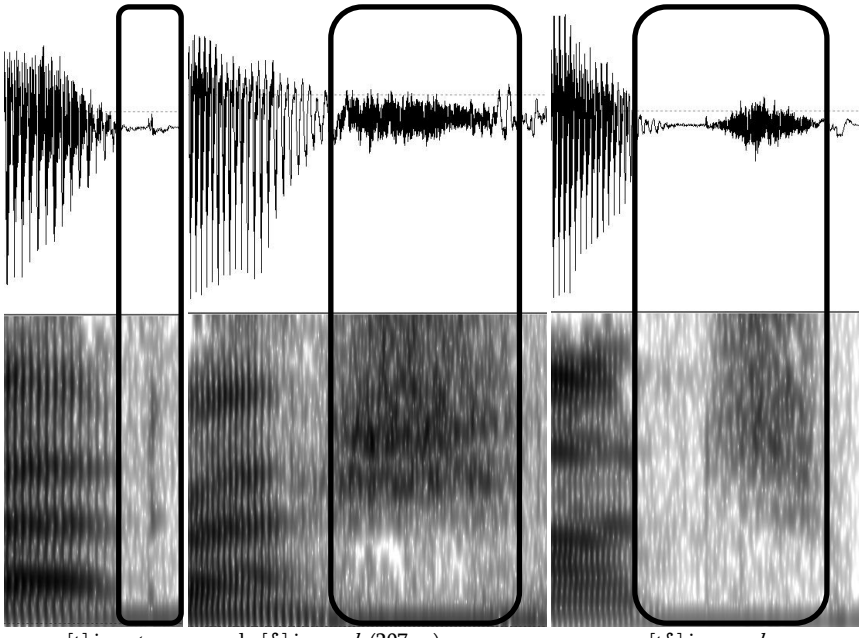
In the case of plosives, like [p], [t], [k] for instance, the air expelled from the lungs is blocked behind an occlusion made at some specific point in the oral cavity, and consequently, the oral air pressure increases. After the occlusion is removed, the air is audibly released. Acoustically, this release is accompanied by a popping sound, yielding the impression of an explosion. As far as fricatives (like [f], [s] or [x]) are concerned, no full closure is produced, but somewhere in the oral cavity the articulators involved are brought very close together, creating a very narrow channel. When air passes through, turbulence[3] is generated, which may additionally, depending on the place of articulation of the fricative, be coloured by obstacles like the teeth. This turbulence is perceived as frication noise by the human ear. The final group of sounds that is part of the category of obstruents are the affricates, from Latin *affricare*, meaning 'to rub against'. From an articulatory point of view, affricates are complex sounds, consisting of a

[2] In phonetic and phonological literature, the terms "stop" and "plosive" are not consistently used. Often, we find "stop" being used as a cover term for (non-affricated) plosives and affricates, yet other times, "plosive" is used as a label for the category including (non-affricated) stops and affricates. We will also use both terms interchangeably, but make sure that it is always clear which sounds are exactly referred to (i.e. only the plain segments, or both the plain segments and the affricates).

[3] The likelihood of turbulent airflow can be predicted by computing Reynold's number. If this number, which divides the product of the volume velocity and the diameter of the channel by a constant value (i.e. 0.14), exceeds a threshold (which is set at about 2000), turbulence is generated (cf. Catford 1977:39-42, Rietveld & van Heuven 2001:86).

plosive and a fricative part. Like plosives, the articulation of an affricate starts with the obstruction of air in the oral cavity. Contrary to plosives, however, the obstruction is not completely removed, but it is instead slowly turned into a constriction. The obstructed air therefore cannot escape freely, but has to pass through a narrow channel, yielding fricative noise. The plosive and fricative parts of the affricate generally have the same place of articulation, i.e. they are homorganic, as during the transition from the plosive into the fricative, only the degree of obstruction changes while the relative position of the articulators remains the same. The different realizations of the three obstruent sounds are visualized by the waves and spectrograms[4] in (1).

(1)



a. [t] in *rat*
closure: 31ms
release: 18ms

b. [ʃ] in *crash* (207ms)

c. [tʃ] in *march*
closure: 61ms
release: 89ms

The spectrograms show the different obstruents (framed) in word-final position. The plosive [t] is preceded by a short period of silence (on average between 50-

[4] The images represent fragments of the speech of 'General Australian speaker 2', reading the text 'Arthur the rat'. The recording can be downloaded for free from the digital audio archive of the alt.usage.english website (http://alt-usage-english.org).

150 ms, cf. Kent & Read 1992:110), an interval during which the air is trapped behind the occlusion. Subsequently, this air is released, yielding the brief explosion (the darker region in the frame, which generally does not take more than 40 ms (cf. Kent & Read 1992:110)). In the case of fricatives, as in (1b), two articulators are brought very close together, but, contrary to plosives, without making a full occlusion. When air passes through the narrow channel, friction is created. This friction is reflected by an a-periodic (in the case of voiceless fricatives) or quasi-periodic (in the case of voiced fricatives) wave, and corresponds to the darker parts in the spectrogram. The noise energy is generally more intense for the sibilant fricatives (like [s] or [ʃ]) in comparison with the non-sibilants (like [f] or [x]), because of the different nature of the constriction and the additional effect of the teeth in the case of sibilants (cf. Ladefoged 2005: 166-169). Finally, the affricate in (1c) combines the articulations of (1a) and (1b). The release is preceded by a silent interval during which air is obstructed in the oral cavity (the lighter grey area in the left-hand part of the frame), as in the case of plain plosives. Unlike plain plosives, however, this complete closure only changes into a narrow opening, and the release of the affricate therefore differs from the instantaneous release of the plain plosive in (1a). Instead, in (1c) we see a noisy signal as in (1b), with again the dark part in the spectrogram reflecting the turbulence that is generated. This turbulent portion is generally considerably shorter than the length of a fricative. As a matter of fact, because of its articulatory complexity (i.e. duality), the complete realization of an affricate takes longer than the realization of a plain plosive, but an affricate is in general clearly shorter than a cluster of a plosive followed by a fricative (cf. Kent & Read 1999:39, 129-130; Ladefoged 2005:60-61).

The articulatory and acoustic properties of affricates, phonetic, characteristics of affricates can be described in a very straightforward way, but their mental, or phonological, representation has always been, and still is, highly debated. Should the articulatory complex[5] sound be interpreted as one or as two segments, and how does this representation relate to the mental image of plain plosives and fricatives respectively? The phonological issues concerning affricates will be introduced in the following section.

[5] "Complex" meaning here a plosive-fricative transition within a single sound.

1.3 One or two phonemes?

Why should the sounds [tʃ] and [dʒ] in English *chip* [tʃɪp] and *judge* [dʒʌdʒ] or [pf] and [ts] in German[6] *Pferd* [pfe:ɐ̯t] ('horse') and *Zeit* [tsait] ('time') be considered single segments, but why should an – at first sight similar – plosive-fricative sequence [ts] in English *cats* [kæts] or in Dutch *fiets* [fits] ('bicycle'), for instance, be considered bisegmental? This is partially because of phonetics, but mainly, and most importantly, because of phonology.

In Trubetzkoy's *Grundzüge der Phonologie* (published posthumously in 1939), a separate section is dedicated to sounds involving a complex articulation and the question whether they should be interpreted as monophonematic or polyphonematic. Trubetzkoy posits a series of rules[7] (1969:56-59), listed and described in (2), with which a sound should comply in order to be analyzed as monophonematic.

(2)

Rule I	The constituent parts of the sound should not be distributed over two syllables.
Rule II	The combination of sounds should involve a homogeneous articulatory movement.
Rule III	The sound should not exceed the duration of the realization of other phonemes in that language.[8]
Rule IV	The sound should be treated as a single phoneme, i.e. it can occur in positions where clusters are excluded in that language.
Rule V	Treating the sound as monophonematic should lead to symmetry in the phonemic inventory.
Rule VI	The sound combination should be considered a single phoneme if it contains a constituent part that cannot be interpreted as a variant of another phoneme of the language.

If a sound fulfils the first three constraints, which are all purely phonetic or phonotactic in nature, the sound receives the status of a "potentially monophonematic" segment (1969:55). The sound has to be treated as an "actually

[6] Transcriptions from the *Wörterbuch Deutsch als Fremdsprache* (2000, New York/Berlin: De Gruyter) and *Van Dale Woordenboek Duits-Nederlands* (2012, Van Dale Online).

[7] "Rule" is the term used in the English translation (*Principles of Phonology*, by A.M. Baltaxe, 1969), it should not be confused with the generativists' use of this word.

[8] As far as rules I-III are concerned, Trubetzkoy notes that the first two are the most important ones. With respect to the third rule, he notes that: "[f]rom a practical point of view, this rule is less important than the two preceding rules. Nevertheless, it should be emphasized that the duration of […] affricates […] normally does not exceed that of the other "short" consonants. In any case, it never reaches the normal duration of sequences such as *ks* and *kš*" (1969:58).

monophonematic" segment, if it also meets the requirements of (one or more of the) rules IV-VI.

Trubetzkoy's rules did not turn out to be a satisfying method for the identification of the monophonematic and polyphonematic sound sequences. Although Martinet (1939) praises Trubetzkoy for establishing well-motivated, objective definitions of phonological notions such as "phoneme" and "markedness", he strongly criticizes his method for the identification of single phonemes and phoneme sequences. That is, in the first chapter of his book, Trubetzkoy uses the principle of "commutation" (i.e. 'interchangeability') to detect the phonemic or allophonic status of a sound in the first place. The principal shortcoming of Trubetzkoy's approach to discriminate between monophonematic and biphonematic sounds, according to Martinet, is then that it does not purely rely on this commutation. Instead, an alternative method is chosen, which suffers from insufficient grounding:

> "Nous trouvons […] un exposé très clair de la méthode qui doit nous servir à dégager l'unité phonologique de base nommée phonème. Cette méthode, qu'après MM. Hjelmslev et Uldall, nous pouvons désigner du terme simple de commutation, on pourrait s'attendre à la voir appliquée à la résolution du problème central: un ou deux phonèmes? Or, nous trouvons, au contraire, le problème envisagé sous un angle nouveau, et résolu, à notre sens, de façon peu satisfaisante, à l'aide de critères dont la valeur, en matière de phonologie, n'a pas été éprouvée précédemment".[9] (Martinet 1939:95)

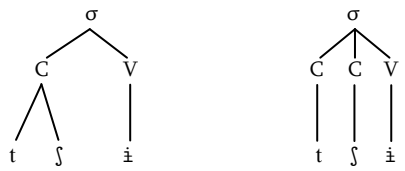
Martinet's criticism first of all relates to the three phonetic rules in (2), and he does away with all of them by stating that they are of no importance if there is no prior phonological relevance involved. The location of the syllable boundary in a group of sounds AB for instance (1939:100) is only relevant if in the same position the language contrasts A.B (the two separated by a syllable boundary) and AB (the two not separated by a syllable boundary). Moreover, the phonetic rules may also wrongly exclude groups of sounds from a monophonematic interpretation, for instance if the duration of an affricate reaches the length of a sequence of two phonemes, while phonologically still behaving as a single unit (1939:101). Martinet further discusses rules IV-VI, and argues that an analysis based on commutation offers a more adequate method for the interpretation of sound sequences. The monophonematic status of /tʃ/ in Castilian Spanish for

[9] We find a clear explanation of the method which serves to detect the phoneme, the basic phonological unit. We would expect this method, which we could after Hjelmslev and Uldall simply call "commutation", to be applied to the central problem: one or two phonemes? Yet, on the contrary, the problem is considered from a different point of view and solved, we think, in a very unsatisfying way, by means of criteria of which the phonological value has not been proven before.

instance is revealed by demonstrating that in this language [ʃ] never occurs in isolation but only in combination with a preceding [t]. [ʃ] can be replaced by another sound, e.g. *chato* [tʃ] ('flat') – *trato* [tr] ('manner'/'treaty'), but in the same environment, this is not possible with [t], as it would yield impossible forms.[10] Therefore, Martinet argues, /tʃ/ has to be interpreted as a single phoneme.

The formalization of the distinction between monophonematic and polyphonematic sounds, and hence also of the distinction between an affricate [tʃ] and a consonantal sequence [t][ʃ], was an important issue in the history of linguistic science, but once it was settled that articulatory complex sounds can behave phonologically as single units, this was considered a distinction that should be included in formal phonological models. In linear SPE phonology for instance (Chomsky & Halle 1968), the difference between an affricate [ts] and a cluster [t][s] was expressed by assigning only one feature matrix to the affricate, while the two sounds in the cluster each received a separate matrix (1968:335-340). Similarly, in the non-linear phonology of the 80s of the twentieth century, affricates were associated with a single consonantal timing slot (C), whereas the elements of a cluster were each linked to a separate consonantal timing unit, as shown for the Polish minimal pair *czy* ('whether') – *trzy* ('three') in (3) below (Clements & Keyser 1983:35).

(3)



Instead of focusing on the monophonematic versus polyphonematic interpretation of plosive-fricative sequences as such, it was the precise phonological content and structure of the sounds identified as monophonematic plosive-fricative combinations, i.e. affricates, that came to be questioned.

[10] In fact, the same argument applies to [tʃ] in English *chip* discussed earlier.

1.4 The phonological structure of affricates

During the second part of the twentieth century, the period of the formalization of distinctive feature theory, affricates were initially described as plosives with a specific release feature that distinguished them from non-affricated plosives. In the 1950s, Jakobson et al. (1952) described affricates as strident stops, and in SPE phonology (Chomsky & Halle 1968), affricates were described as plosives with a delayed release, contrary to plain plosives with an instantaneous release. Years later, by the end of the 1970s and mainly after the introduction of non-linear phonology, when different representational machinery became available, affricates received a more complex internal structure: the phonetic plosive and fricative components of the affricate were represented phonologically with both an independent non-continuant plosive part and a continuant fricative part (cf., among others, Sagey 1986, Hualde 1987, Lombardi 1990). As a matter of fact, such representations predict that affricates may behave as an individual class, but that they may also pattern with plosives and/or fricatives.

Initially, this balanced dual structure was considered more adequate than existing analyses where affricates were basically stops with some additional feature specifying their release. It soon turned out, however, that the predictions made by descriptions including autonomous plosive and fricative parts were too far-reaching for several languages. This led some phonologists to formulate language-specific conditions indicating when an affricate behaves like a plosive, like a fricative or like a separate group (cf. Hualde 1988). Others, on the contrary, totally abandoned the representations where the plosive and the fricative parts were included as independent elements, and instead returned to a more restrictive description, where the fricative part was no longer autonomous, but where affricates were described as stops with a strident release (cf. Rubach 1994). In more recent years, the debate has taken a different direction, by questioning the phonological relevance of the concept "affricate" as such. That is, the descriptions of affricates put forward until then all assumed the existence of a natural segment class of affricates, and affricates differed from plain plosives either by a specific release feature or by consisting of a combination of plosive and fricative manner features. As such, it was predicted that in some cases an affricate might show plosive-like behaviour, that in other cases it may show fricative-like behaviour, but that it might also behave differently from both plosives and fricatives. A number of analyses put forward by the turn of the century argued that the predictions made by these existing accounts were too strong (e.g. LaCharité 1993, Clements 1999, Kehrein 2002). They instead claimed

that affricates are essentially equal to non-affricated plosives. If affricates behave differently from plosives, this is because of independently motivated features, like place of articulation for instance, but not because they are "affricates".

The disagreement that arose in the early 1990s, when the first doubts concerning the contour representation of affricates were expressed, still persists, and to this day different views coexist (cf. Lin 2011). Some descriptions still analyse affricates as underlying plosive-fricative combinations, others describe affricates as stops with a distinctive release and yet others deny any formal difference between plain stops and affricated stops. The persistence of disagreement on the phonological representation of affricates is mainly caused by the fact that most accounts rely on only a single or a restricted number of language(s). This yields a fragmentary picture of the cross-linguistic behaviour of these sounds, and it is not necessarily based on a collection of languages which is properly balanced. Moreover, the small number of studies that rely on a larger number of languages are partially contradictory and did not lead to consensus.

1.5 Research questions and methodology

In the chapters that follow, we will search for an adequate phonological representation of affricates. The first crucial issue that needs to be settled is whether affricates are of phonological relevance in the sense that they can constitute a natural segment class. Are there sound inventories with contrasts that can only be described by assigning affricates a representation which is distinct from both plosives and fricatives, or are there phonological processes showing that affricates behave differently from both plosives and fricatives? If this appears to be the case, there must be something in the underlying representation of affricates that distinguishes them from the other two categories of obstruents. If no such exclusive patterning or behaviour can be revealed, it needs to be determined which description is required to account for the plosive-fricative-affricate contrasts languages may display. A concomitant aspect that needs to be considered is whether the representation of affricates is universally fixed, or whether it is language-specific.[11] That is, it may be the case that affricates behave like stops in one language, while they clearly behave like phonological plosive-fricative combinations in another language.

[11] Like laterals, which may be [-continuant] in some languages but [+continuant] in others (cf. Gussenhoven & Jacobs 2005:64).

The question of the phonological status of affricates cannot be disconnected from the phonetic aspects of these sounds. This does not only concern the way in which the underlying representation relates to the concrete realization, but also the fact whether there are some specific phonetic conditions for affricates to show up, even if they turn out to be phonologically irrelevant.

We will look for an answer to these questions by investigating affricates from different perspectives. As we have seen, the absence of agreement on their phonological representation is mainly due to the fact that the existing studies are language-specific, so that, together, they do not reflect a representative sample of languages. Moreover, the contrastive studies that exist have come up with different conclusions.

In order to add to the existing studies and to clarify the existing controversies, the first component of our investigation is a typological approach. In this typological part, a properly balanced survey of languages will be studied, i.e. the most recent version of the *UCLA Phoneme Segment Inventory Database* (UPSID 1992). On the basis of these inventories, we will examine the synchronic typological characteristics of affricates and consider their position with respect to plosives and fricatives. Furthermore, we will determine to what extent this genetically-balanced sample provides evidence or counterevidence for the existing arguments and proposals.

The UPSID sample gives a static view on the position of affricates and, as such, it is not informative with respect to the patterning of affricates in phonological processes in the different languages. As it is not possible here to examine the phonological processes in all the languages involved, we will limit the discussion of the process-related behaviour of affricates to the historical phonology of French.[12] In the light of the debate on the representation of affricates, the French language is highly interesting and relevant. In the course of the evolution from Latin to modern French, several processes led to the creation of affricates, which were all lost eventually. One of these processes is velar palatalization, where a velar is fronted, changes into a velar with a secondary palatal articulation [kʲ] and then turns into a coronal affricate [ts] or [tʃ]. Velar palatalization is a common source of affricates cross-linguistically speaking, and it created a considerable number of these sounds in the historical phonology of

[12] At first sight, this choice may seem an arbitrary one, which would result in adding yet again a single-language description to the fragmentary existing picture. It should be stressed that this is not the case as French occupies a special position in the debate, and moreover, the French facts will be discussed in the light of the results of the UPSID sample.

French (*centum* [k] > [kʲ] > [ts] > [s] *cent* [sã], 'hundred'). French is exceptional, however, in showing this development also before the low vowel *a* (*carrum* [k] > [kʲ] > [tʃ] > [ʃ], *char* [ʃaʁ], 'cart'). By examining the different affrication processes and the subsequent reduction of these sounds in French, we will consider whether the behaviour of affricates in this language demands a treatment as (plain) stops or as complex plosive-fricative segments.

The second major component of this study is an investigation of allophonic palatalization and affrication in modern French, as it will constitute a valuable addition to the typological discussion and an essential source of evidence for the phonetic emergence of affricates. Synchronically, French is interesting first of all in showing allophonic affrication. The Canadian French varieties are well-known for the assibilation of coronal plosives followed by a high front vowel, turning [t] and [d] into [ts] and [dz] respectively, as in *petit* [pətsi] ('small/little'), *type* [tsip] ('type') or *durer* [dzyʁe] ('to take/to last') for instance (cf. Walker 1984). Even though hardly documented for metropolitan, European, French (cf. Malécot 1977), this phenomenon does occur in France as well, but it is less salient and less systematic than in the Canadian varieties. The synchronic part of our study will focus on the quality of the plosive releases in several French varieties spoken in France. On the basis of recordings of different surveys of one of the most recent oral language databases, the corpus *Phonologie du français contemporain* (PFC), we aim to retrieve the exact circumstances where assibilation of plosives occurs, and to determine the spread of the phenomenon with respect to several sociolinguistic factors.

Modern French is not only intriguing because of plosive assibilation. It is well-known that French velars take a more fronted realization when followed by a front vowel, as in the relative pronoun/interrogative *qui* for instance, which is commonly realized with a fronted plosive.[13] Interestingly, Buckley (2003) notes that this fronting not only occurs before the high front vowels, but also before *a* (e.g. *quatre* 'four' [k] > [kʲatʁ(ə)]), mirroring the historical development. The degree of fronting of velars in the different vocalic contexts is therefore particularly worth investigating. Again on the basis of the spoken language

[13] In order to illustrate this phenomenon, Martinet (1965:39) uses the difference between *kilo* and *courage*: "En français, le début de *kilo* et celui de *courage* s'articulent de façon très différente, le premier vers l'avant de la bouche contre le palais dur, le second vers l'arrière contre le voile du palais" [In French, the beginning of *kilo* ('kilo') and the beginning of *courage* ('courage') have a very different articulation, the former in the anterior region of the oral cavity with the tongue against the hard palate, and the latter in the posterior region with the tongue against the velum].

material in the PFC corpus, we will examine the linguistic circumstances of velar fronting, and discuss how it is spread across the French speech community. Moreover, the examination of the velar release before the low vowel *a* might be a valuable source of evidence for the historical change, as the quality of the modern vowel (fronted, raised, central or back?) may reflect the quality of the vowel when the historical development took place.

By combining different sources, we will obtain evidence from a complementary collection of data. The study of the UPSID inventories will add first of all to the small number of contrastive studies, and moreover, it will provide both a check and an update of the (restricted) existing typological findings, which are partially contradictory. We will add to the existing data of segmental processes involving affricates by studying the historical phonology of French, which is especially worth investigating because of the emergence of these sounds in a cross-linguistically exceptional context.

The corpus study of modern French will give a description of the actual characteristics and spread of velar fronting and plosive assibilation in France, which are still unknown. At the same time, the study of the synchronic phenomena may yield (additional) insight into the historical changes, and it will also further our understanding of the creation of affricates and the relation between their phonetic characteristics and their phonological behaviour. An overview of the research questions addressed in this thesis is given in (4).

(4) **What is the phonetic and phonological status of affricates?**

I. Does a universal phonological class of affricates exist?
- If so, how are affricates specified at the underlying level? Is this underlying representation a universal one?
- If not, which description is required in order to predict exactly the contrasts and natural segment classes that are attested, to the exclusion of the ones that are not?

II. What are the characteristics of allophonic velar palatalization and plosive affrication in modern metropolitan French?
- To what extent are both processes active in France?
- What are the linguistic and sociolinguistic factors involved in both phenomena?

1.6 Outline of the thesis

This chapter serves as a general introduction to the topic of this thesis, but has provided only a very concise background of the actual phonological debate. Chapter 2 will therefore first of all present a more detailed overview of the different analyses of affricates that have been proposed in the phonological literature. It will consider both the points of agreement and disagreement, as well as the arguments that have been provided in favour of, or against, the different representations. Next, we will consider affricates from different perspectives in order to solve the existing controversies. Chapter 3 will deal with the typological characteristics of affricates by examining the synchronic sound inventories of the UPISD survey. The theoretical implications of these typological patterns will be discussed in chapter 4. In chapter 5, we will turn to the examination of affricates in the historical phonology of French. Chapters 6, 7 and 8 will provide a corpus study of velar fronting and the quality of release of French plosives in several regions in France. We will conclude in chapter 9 by summarizing our main findings and by proposing a formal representation of the affricate.

Part I:
Background

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2

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The Phonological Debate

2.1 Introduction

The representation of affricates has been subject to a series of revisions throughout the history of phonological theory. As to date, uncertainty remains and phonologists still disagree on a considerable number of issues.

This chapter serves to illustrate the debate related to the phonological representation of this specific category of sounds, by focusing on the developments in the twentieth and twenty-first century. First, we will provide a more or less chronological overview of the principal formal descriptions of affricates that have been proposed in phonological literature. Afterwards, we will contrast the different views and consider the major points of agreement and dissent.

2.2 Affricates: stops with a release feature

2.2.1 Affricates as strident stops

One of the first coherent inventories of distinctive features was proposed in Jakobson et al. (1952). In this framework, which is primarily acoustically-based, contrasts are described in terms of opposites, such as “consonantal” vs. “non-consonantal” or “interrupted” vs. “continuant”. Affricates are basically considered stops, but differ from plain stops by their release. This difference is captured by the feature pair “strident” and “mellow”: given that the release of an affricate is accompanied by fricative noise, contrary to normal plosives, the former are described as strident stops, whereas the latter are labelled non-strident or mellow (1952:24).

2.2.2 Affricates as stops with a delayed release

With the publication of the *Sound Pattern of English* (Chomsky & Halle 1968), henceforth SPE, a revised set of distinctive features was introduced. This collection of (mostly articulation-based) features is assumed to be universal, each segment consisting of a matrix with a specific combination of features.

Just as in Jakobson et al. (1952) the distinctive features in the phonological matrices are assumed to be binary, although a slightly different notation is used in SPE (i.e. positive and negative values of a given feature instead of two separate designations to refer to the two poles). The dichotomy between strident and mellow was transformed into [+strident] and [-strident] respectively. More importantly, however, SPE revised the actual description of affricates proposed by Jakobson et al. (1968:318-322). That is, although in Chomsky & Halle's description affricates are also conceived of as plosives with a distinctive release, they do not describe the difference between plosives and affricates primarily in terms of stridency. Their main reason for the rejection of the strident stop approach was the fact that there exist not only strident affricates, but also non-strident ones, such as [tθ] and [pf]. In order to account for both strident affricates and their non-strident counterparts, a new distinctive feature was introduced: [±delayed release]. This articulatory-based feature, reflecting the way in which the obstructed air is released, is available only to the [-continuant] sounds, i.e. sounds that are articulated with a complete closure of the oral cavity. It differentiates plosives, which have an instantaneous release of their obstruction (and which are as such [-delayed release]), from affricates that are characterized by a delay in the release of the obstructed air, because of the fricative constriction (and which are consequently specified as [+delayed release]). Within this revised feature configuration, the acoustically-defined feature [±strident], a feature only relevant to continuant obstruents and affricates, may still be needed in the representation of affricates, but it serves a different function than under the approach proposed by Jakobson et al. (1952). That is, instead of separating affricates from plosives, [±strident] may be distinctive *within* the category of affricates, and distinguish between strident and non-strident affricates (1968:321-322).

2.3 Affricates: combinations of a plosive and a fricative

After a means was found to define both strident and non-strident affricates uniformly, a series of other problematic issues was noted in the years following

the introduction of SPE. The representation of affricates as plosives with an additional feature specifying the release (either strident or delayed) appeared to be inappropriate, given that it could not directly account for cases where affricates pattern with fricatives. This led phonologists to treat affricates as complex entities, assigning them both a plosive and fricative part at the underlying level.

2.3.1 Multi-column complex segments

The idea of affricates as plosive-fricative combinations was first introduced by Hoard (1975), at a time when linear SPE phonology was still the commonly adopted framework. Hoard shows that the representation of affricates as stops with a delayed release cannot account in a straightforward way for processes where plosives and fricatives merge into an affricate, or cases where an affricate is reduced to a fricative. In Puget Salish for instance (Hoard 1975:34), sequences of a plosive and a fricative are fused into an affricate when they are concatenated during the derivation (e.g. /t/ + /s/ → [ts], and /d/ + /s/ → [dz]).[14] The effect of this rule is observable, among others, in contexts where the possessive marker of the third person singular – underlying /s/ – is attached to a noun ending in a dental plosive, as shown in (5).

(5)	a. ʔálʔal	'house'	/ʔálʔal/ + /s/	ʔálʔals	'his house'
	b. ʔə́ɬəd	'food'	/ʔə́ɬəd /+ /s/	ʔə́ɬə[dz]	'his food'

On the basis of the feature [±delayed release] the change in (5b) does not follow as a natural consequence. As Hoard (1975:34-35) argues, the formalism does not express why two sounds which are both [-delayed release] should result in a single sound bearing a positive value for this same feature, cf. (6).

(6)
$$\begin{matrix} /d/ & /s/ & & /dz/ \\ \begin{bmatrix} -\text{cont} \\ -\text{del rel} \end{bmatrix} & \begin{bmatrix} +\text{cont} \\ -\text{del rel} \end{bmatrix} & \longrightarrow & \begin{bmatrix} -\text{cont} \\ +\text{del rel} \end{bmatrix} \end{matrix}$$

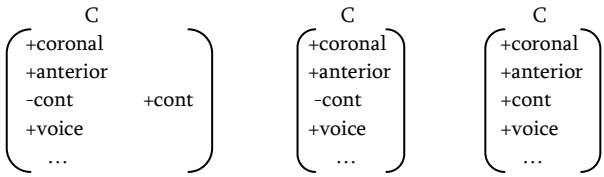
A similar observation holds for processes where affricates are reduced to fricatives. Hoard refers to an example from the Quileute language, where the affricate [tʃ] is reduced to [ʃ] if followed by a velar plosive (1975:36). If affricates were stops with a delayed release, deletion of the plosive element would involve the erasure of the entire affricate. An insertion rule would then be required to

[14] As Hoard (1975:34) states, the plosive-fricative combination that arises through suffixation is clearly distinct from the bisegmental plosive-fricative clusters in the language.

account for the resulting fricative. Again, it would not follow automatically why an affricate would be reduced to a fricative as far as its phonological content is concerned.

Rather, in order to account directly for processes of affricate creation and reduction, Hoard proposes a complex analysis of affricates, including a specification for both [-continuant] and [+continuant] at the same time. The change of a plosive-fricative sequence into an affricate can then be expressed as the fusion of a [-continuant] and a [+continuant] segment into a single one, preserving both features: [-continuant, +continuant]. The reduction of an affricate to a fricative follows from the deletion of the [-continuant] part, leaving the [+continuant] unaffected. Graphically, affricates are represented as "multi-column complex segments" (Hoard 1975:36), that is, segments with a single feature matrix consisting of two columns (7a).

(7) a. Affricate [dz] b. Consonant cluster [d][z]



Except for the contradictory feature, the specifications in the first column of the affricate are copied to the second column. Affricates differ from consonant clusters (7b) by the fact that the segments in a cluster each have a separate feature matrix, whereas affricates consist of only one consonantal matrix with two columns of features.

The notion of affricates as underlying combinations of plosives and fricatives survived into the following decade. The rise of non-linear phonology and feature geometry, however, entailed several challenges for the representation of affricates that did not yet play a role in the strictly linear SPE framework. The main points that required to be determined were the mutual order of the two (contradictory) continuancy features and their position in the hierarchical feature tree, aspects which would appear to bring about a considerable amount of discussion.

2.3.2 Contour segments

Sagey (1986) proposes a non-linear model of phonological representation, in which she also deals with the representation of segments consisting of multiple articulations, like affricates, prenasalized stops and complex place segments. Before considering the formal modelling of these segments, she first of all insists upon the fact that these kinds of sounds, even though they have a complex phonetic realization, all should be treated as single segments as far as their phonological behaviour is concerned. She refers to languages with a templatic morphology (like a number of Arabic dialects), where the underlying material has to be associated to fixed templates consisting of consonantal and vocalic slots. In these languages, the different compound segments are linked in their entirety to a single C-slot on the template, contrary to consonant clusters which occupy multiple slots.

Additional evidence is found in segmental reduplication processes. In such processes, affricates and complex place segments appear to be fully copied, whereas consonantal clusters are only partially reduplicated, as in Ewe for instance where reduplication serves to change a verb into an adjective or noun (Sagey 1986:85-86):

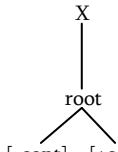
(8)	fo	'to beat'	fofo	'beating'
	fle	'to buy'	feflee	'bought'
	tsi	'to grow'	tsitsii	'grown up'
	gbla	'to exert oneself'	gbagblam	'exerting oneself'

However, even though the complex sounds are all treated as single units, an important subdivision comes into play with respect to the underlying structure of the features capturing the complex articulation. Sagey introduces the concepts of "contour segment" and "complex segment" (1986:92-130). Both consist of multiple articulations linked to a single timing slot. The crucial difference between the two types resides in the fact that the multiple articulations are ordered phonologically in the case of contour segments, whereas this order of articulations – even though required phonetically – is absent at the phonological level in the case of complex segments. Within this dichotomy, Sagey describes affricates as contour segments, branching for the feature [±continuant].[15] The

[15] Not every possible combination of features may occur in a contour or complex segment, as only a number of types of these structures are actually attested. As far as the contour segments are concerned, Sagey stipulates that: "Contour segments may branch for terminal features only. No branching class nodes are allowed" (1986:50). Complex segments, on the other hand, are subject to a different restriction: "[…] the class of possible complex segments in human language is explained by

sequence of the features is assumed to be similar to their order in the phonetic realization:

(9)



(Sagey 1986:96)

The main reason for Sagey to consider affricates contour segments instead of complex segments is that affricates show "edge effects":

> "Affricates are made up of sequences of two articulations: stop + fricative. They behave as stops with respect to phonological rules sensitive to their left edges. […] On the other hand, affricates behave as fricatives with respect to phonological rules sensitive to their right edges". (1986:93-94)

Complex segments, on the other hand, do not behave as a strict linear sequence of features with respect to phonological rules in which they are involved:

> "Unlike contour segments, complex segments involve articulations which are not phonologically ordered. Even when phonetically the articulations may be (or seem to be) ordered, phonologically they are unordered. A labiovelar like [kp] will behave phonologically as both labial and velar with respect to processes both on the left and on the right". (1986:99)

These edge effects of affricates are illustrated, among others, by the processes of stop voicing in Zoque and [ɪ]-insertion in English (1986:93-95). In Zoque, non-continuants are voiced if they are preceded by a nasal. Both plosives and affricates are subject to this rule:

(10) **[-cont] → [+voice] / [+nasal] ___**

/N-pama/	[mbama]	'my clothing'
/N-tʃoˀngoya/	[ñdʒoˀngoya]	'my rabbit'

---

the fact that speech is produced using several independently functioning articulators in the vocal tract" (1986:58-59). Complex segments are then claimed to consist of a combination of two different articulators, dominated by a single place node (e.g. labial + coronal, labial + velar, coronal + velar etc.).

On the basis of the contour representation, it is indeed predicted that affricates are involved in the voicing process, given that the [-continuant] part of the affricate is immediately adjacent to the nasal consonant, creating the required context for the rule to apply.

The alignment of the fricative part at the rightmost edge of the affricate at the underlying level follows, among others, from the plural formation in English. If the noun stem ends in a strident fricative, [ɪ] is inserted between the stem-final fricative and the plural suffix /z/.

(11) **Ø → [ɪ] / [+cont, +strident] ___ [+cont, +strident]**

/bæk + z/	[bæks]	'back'
/bʌs + z/	[bʌsɪz]	'bus'
/dɪʃ + z/	[dɪʃɪz]	'dishes'
/bædʒ + z/	[bædʒɪz]	'badge'
/tʃɜ:(r)tʃ + z/	[tʃɜ:(r)tʃɪz]	'church'

The rule in (11) concerns both strident fricatives and affricates. According to Sagey, this can be directly accounted for if a linear sequence of continuancy features is assumed at the underlying level. The rightmost specification of the affricate is then immediately adjacent to the plural suffix, which corresponds to the sequence of features required for the rule to apply.

2.3.3 Complex segments

Initially, Hualde (1987) also adhered to a contour segment approach for the description of affricates in Basque. He stated nevertheless, that affricates do not necessarily show the edge effects presumed by Sagey (1986), given that in Basque affricates appear to be involved in a stop deletion rule, deleting the first plosive in a sequence (1987:77-80):

(12) **[-cont] → Ø/ ___ [-cont]**

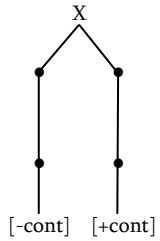
<tz>: voiceless dorso-alveolar affricate
<z>: voiceless dorso-alveolar fricative

bat + batean	bapatean	'at once (one in one)'
bat + gar	bakar	'single, only one'
bat + paratu	baparatu	'put one'
bat + kurri	bakurri	'run one'
hitz + tegi	hiztegi	'dictionary'
haritz + mendi	harizmendi	'oak mountain'

Under Sagey's hypothesis of two clearly ordered feature specifications for [±continuant], the stop deletion rule is expected to be blocked for affricates. That is, by means of a strict contour analysis, the two [-continuant] parts (of the affricate and the following plosive, respectively) are not adjacent, but separated by the [+continuant] specification at the rightmost edge of the affricate.

According to Hualde, the application of stop deletion to affricate-plosive sequences in Basque can be accounted for by the fact that phonological rules may apply at different levels of the hierarchical feature structure. In this respect, he refers to the scansion levels distinguished by Archangeli & Pulleyblank (1987), who propose two possible levels at which adjacency of features may be defined (cf. (13) below). The highest level of structure for consonants is the skeletal tier, representing the timing-slots of the segments; the lowest level of structure to which a phonological rule may refer is the feature tier, which dominates the individual distinctive features. If adjacency is defined at the skeletal tier, the rule in question acts at the "maximal scansion level"; if, however, adjacency is defined at the lowest level of structure, the rule performs a "minimal scansion" (cf. Archangeli & Pulleyblank 1987:19-29).

(13)



maximal scansion level

minimal scansion level

(cf. Hualde 1987:83)

In order to account for the apparent anti-edge effect of affricates in Basque stop deletion, Hualde assumes adjacency to be defined at the skeletal tier (maximal scansion) and not at the level of the individual features (minimal scansion). This means that, in the case of an affricate-stop sequence, the rule still has access to a succession of two segments bearing a specification for [-continuant]. Since it operates at a higher level, the intrinsic order of continuancy features defined at the lower level of the affricate does not play any role. Consequently, it is predicted that affricates take part in stop deletion, as indeed appears to be the case.

In 1988, however, Hualde revised the description he proposed a year earlier, replacing the contour segment account by a complex segment analysis. The main reason for Hualde to drift away from a strict order of continuancy

features at the underlying level resided in the fact that the anti-edge effects proved to be more complex than he had initially assumed. That is, next to the instances of "overapplication" (as in the case of Basque stop deletion), a second type of anti-edge effect was attested (cf. Hualde 1988:144):

(14) "Overapplication": A rule makes reference to either value of [±continuant]. The value in question is on the wrong side of the affricate, but the rule nevertheless applies.

"Underapplication": A rule makes reference to either value of [±continuant]. The value in question is on the appropriate side of the affricate, but the rule nevertheless fails to apply.

In Basque, the second type of anti-edge effect appeared to occur as well. An instance of underapplication in this language can be found in the process of stop voicing (cf. Hualde 1988:146). This change takes place in verbal inflection, where, if preceded by a sonorant noncontinuant segment, stop-initial suffixes take a voiced realization, whereas suffixes having an affricate in initial position do not:

(15) **[-cont] → [+voice] / [-cont, +son] ___**

a.	/ken-tu/	[kendu]	'take away' (perfective)
	/lan-tu/	[landu]	'labor' (perfective)
b.	/ken-tsen/	[kentsen]	'take away' (imperfective)
	/lan-tsen/	[lantsen]	'labor' (imperfective)

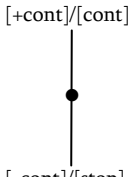
Even though the contour segment analysis is able to account for the edge effects and the cases of overapplication (when adjacency is defined at the maximal scansion level), it fails to describe the cases of underapplication. That is, the strict ordering of features would predict the rule to apply, given that the structural description of the rule is met (both at the minimal and maximal scansion level), and [ts] is expected to change into [dz].[16] In order to be able to account for the patterning of affricates in Basque, Hualde assumes that affricates are still specified for both [-continuant] and [+continuant], but instead of describing them as contour segments, he considers affricates to be complex segments with

[16] As Hualde (1988:147) notes, the absence of voicing is not related to the fact that the voiced affricate [dz] does not exist in the majority of Basque dialects, because in the dialects that do have [ts] and [dz] in their inventories, the rule in (15) fails to apply as well.

two unordered feature values underlyingly.[17] In order to indicate which rules involving [±continuant] apply to affricates, and which ones do not, each phonological rule is accompanied by a parameter that specifies whether it applies to affricates or not. In the case of stop deletion, this setting is "inclusive", meaning that affricates will be subject to it; whereas the parameter is "exclusive" for the stop voicing, as such leaving affricates unaffected (1988:156).

Lombardi (1990) provides arguments that also favour an absence of order at the underlying level. Like Hualde, Lombardi mentions the anti-edge effects, which cannot be accounted for if a predetermined order of features is assumed at the phonological level. A second problematic aspect of an intrinsic order of continuancy features resides in the nature of phonological representations as such. That is, since the phonological representation is minimal and contains only those specifications that are contrastive, adopting a strict order [-continuant, +continuant] (or [stop, continuant], by means of univalent features)[18] underlyingly implies that the order is contrastive and that the opposite order [+continuant, -continuant] exists as well. However, such segments are not attested (1990:375-376). With Hualde (1988), Lombardi assumes that the specifications for the feature [continuant] are underlyingly unordered, which is visualized as follows:

(16)



(Lombardi 1990:381)

Contrary to Hualde, Lombardi does not adopt a parameter indicating for each rule involving [±continuant] whether affricates are involved or not. Rather, a closer examination of Hualde's data showed that by means of additional features which specify the place of articulation more precisely (like [±distributed]), the

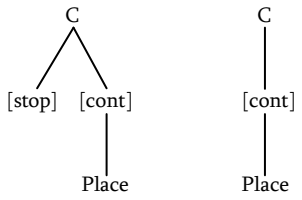
[17] Recall that in Sagey (1986) terminal features, like [±continuant], could only occur in a contour segment but not in a complex segment. This latter configuration was restricted to segments involving multiple articulator nodes under a single Place node.

[18] Lombardi (1990:378-379) remarks that adopting a binary feature [±continuant] implies that the two opposite values of this feature are on the same tier. It is not directly obvious then why the features would be unordered. Rather, under a more restrictive approach based on the monovalent features [stop] and [continuant], the absence of order of features follows automatically, given that two different features are never on the same tier.

groups involved in the different processes can be correctly described (1990:416-417).

The analysis presented in van de Weijer (1996) essentially corresponds to the ones presented by Hualde and Lombardi, and it provides a number of additional arguments in favour of a complex segment description of affricates. First of all, van de Weijer notes that if affricates have a secondary articulation, this articulation typically appears to occur also on the plosives or the fricatives of the language (albeit more often on plosives, given that secondary articulations generally tend to occur more often in this category). If affricates are both [stop] and [continuant] underlyingly, the observed patterns come as a natural result (1996:137-138). Furthermore, affricates tend to occur at the same places of articulation as the fricatives of a language. Basque, for instance, has fricatives at three places in the coronal range, with affricates at corresponding places of articulation. These patterns are assumed to be caused by the fact that affricates and fricatives share [continuant] with an identical Place feature attached to it (1996:138-139), as shown in (17).

(17)



a. *Affricates* b. *Fricatives* (van de Weijer 1996:139)

2.3.4 Aperture theory

The analysis put forward by Steriade (1994) varies on the theme of affricates as plosive-fricative combinations, while it makes at the same time a number of different predictions than the complex analyses described above. Her account is based on the different degrees of aperture (A) that characterize the release of obstruents. Three levels are distinguished (1994:207):

(18)

A_0:	minimal aperture, corresponding to a complete closure.
A_f:	intermediate aperture, reflecting an opening which is sufficiently narrow to produce turbulent airflow (i.e. a fricative release).
A_{max}:	maximal aperture, indicating an unhindered release of obstructed air.

By means of this three-way distinction, stops, fricatives and affricates are described as follows:

(19)

Stop:	A_0 A_{max}
Affricate:	A_0 A_f
Fricative:	A_f

Steriade aims to account for the fact that, from a typological point of view, plosive obstruents (i.e. stops and affricates) appear to have clustering possibilities (like nasalization and glottalization) that fricative obstruents have not. She captures this asymmetry by assuming that both stops and affricates (referred to as "released plosives" (1994:203, 210)), have two aperture nodes, the first one representing the closure and the second one the release. Features can then be attached to one or to both A position(s), yielding a possible four-way contrast, as shown for nasalization of stops in (20) below (C = Closure, R = Release):

(20)

Oral	**Prenasalized**	**Postnasalized**	**Fully nasalized**
	[nasal]	[nasal]	[nasal]
C R	C R	C R	C R

In this approach, affricates consist of a plosive closure followed by an intermediate aperture characteristic for fricatives, a description that more or less corresponds to the other complex analyses adopting continuancy features. However, the account relying on aperture nodes entails different implications with respect to the patterning of affricates with plain plosives and fricatives, respectively. That is, Steriade first of all considers the release specification of plosives to be phonologically irrelevant, and as such she does not distinguish between plain plosives and affricates: "Since the presence of release is not distinctive for the plosives of any language, I will assume that releases are projected from underlying representations in which the stops are mere closures" (1994:208).

Rather, in order to distinguish between plain stops and affricates, features specifying the place of articulation are required. This claim is based on two pairs of oppositions which are commonly attested across languages, and which occur in English for instance: /t/-/tʃ/ and /s/-/ʃ/. Generally, the opposition between the latter minimal pair is considered to involve a place contrast. According to Steriade, it would be unclear then why the former opposition should require a

description which is primarily based on release features instead of place specifications (1994:209-210).

At a given moment, though, the simple closures are turned into released plosives by means of a process of "release projection" (1994:208), providing the A node for the release:

(21) Release projection:
$A_0 \rightarrow A_0\ A_{max}$

Subsequently, after a release node has been added, the A_{max} is changed into an A_f node in the case of affricates: "[…] the approximant releases of normal stops turn into the distinctive releases that characterize affricates: a plain stop ($A_0\ A_{max}$) becomes an affricate ($A_0\ A_f$)" (1994:209). Steriade does not specify at which moment this transformation takes place, but even though stops and affricates are indistinguishable in the early stages of the derivation, at some point (albeit relatively 'late') the quality of the release becomes relevant, creating a distinction between stops and affricates.

Steriade herself does not address the patterning of affricates with fricatives nor the implications of the presence of the aperture nodes for phonological processes, but it has been put forward by Clements (1999:274) that this representation still predicts that affricates pattern with fricatives with respect to their right edge. That is, despite the fact that affricates and stops both consist of two A nodes representing the closure and the release respectively, there is, nevertheless, at a given moment an ordered sequence with a plosive element on the left edge and a fricative part on the right edge of the branching structure.

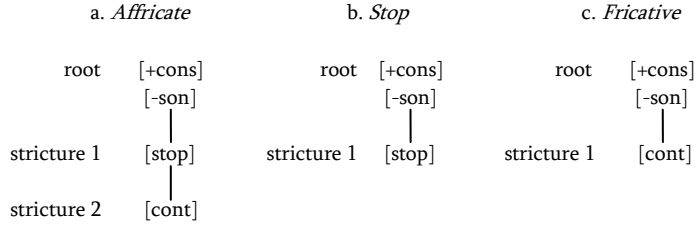
2.3.5 Headedness among continuancy features

The branching structures described so far share the fact that the plosive and fricative parts of the affricate are considered equally important. However, in Schafer (1995), it is argued that affricates basically behave as stops. In order to account for this patterning, Schafer claims that affricates should not be described underlyingly as feature complexes with two independent specifications for continuancy, but rather as segments with an internal hierarchy of stricture values.[19] This structure follows from the "Head Feature Principle", which stipulates that if two values of the same feature set are present within the same configuration (in this case two continuancy/stricture features in a single segment), one of them constitutes the head (1995:63). In this representation of

[19] Schafer adopts, like Lombardi (1990) the monovalent features [stop] and [continuant].

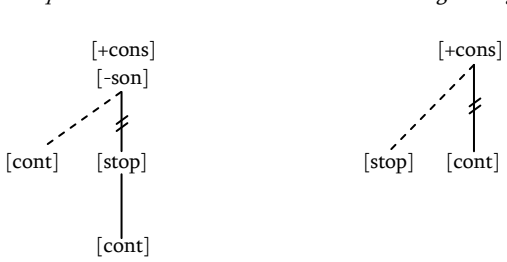
the affricate (1995:61), the feature [continuant] is dependent on [stop]. Like non-affricated stops, affricates have a primary stricture [stop]. Fricatives and affricates share a [continuant] stricture, albeit that it is a primary stricture for the former but only a secondary stricture for the latter.

(22)



This analysis is based on processes like spirantization and fricative strengthening for instance. As far as spirantization is concerned (cf. 23a), both stops and affricates change into fricatives, which is described as the association of [continuant] (either by insertion or by spreading from an adjacent segment, cf. 1995:66-67):

(23)



The insertion of the feature [continuant] on the primary stricture tier causes the delinking of the previous stricture [stop] as well as of the secondary stricture it dominated. As such, the root tier is preserved, whereas the hierarchical relation of stricture features changes into a simplex one, only consisting of a fricative part.

In strengthening processes, on the other hand, fricatives change into a stop or an affricate (cf. 23b). This is described by means of the insertion of a [stop] feature at the primary level of stricture (1995:73-74). Again, this insertion causes the delinking of the previous stricture, in this case [continuant]. Schafer assumes that the reassociation of delinked material to their original stricture tier is prohibited by a universal principle. Language-specific principles then

determine whether the delinked stricture feature(s) may be relinked to a different stricture tier or not. The possibility of relinking means, in the case of fricative strengthening, that the delinked [continuant] part may be reassociated as a secondary stricture, yielding an affricate (cf. (22a)). If, however, the language prohibits reassociation of delinked material at any stricture level, the floating feature [continuant] is erased, and fricative strengthening will result in a stop.

2.3.6 One or two nodes?

The question that prevails in the different accounts adopting either a contour or a complex segment approach concerns the formal modelling of the plosive and fricative parts of the affricate in such a way that both the edge effects and anti-edge effects can be accounted for. However, there is a second issue that plays a role in these analyses, not related to the mutual order of the continuancy features, but to the way these features are attached to the feature tree. The different descriptions assume the feature [±continuant] to be linked to the supralaryngeal node or directly to the root node, depending on the version of feature geometry adopted by the author. Some variation can be found, though, with respect to the number of either of these nodes that should be postulated underlyingly in the case of an affricate.

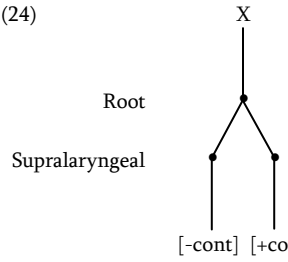
Sagey (1986) assumes that the [-continuant] and [+continuant] features of an affricate are dominated by the same root node. This assumption is again based on the behaviour of complex and contour segments in reduplication processes (cf. (8)) and in languages with root-and-pattern morphology. If affricates consisted of two root nodes, they would be expected to behave differently with respect to these phenomena. Furthermore, there is a theoretical restriction that comes into play. As mentioned earlier, in order to delimit the number of possible contour segments, Sagey stipulates that only terminal features may branch, whereas class nodes may not. Consequently, a contour segment consisting of two root nodes is not well-formed.

In Hualde (1987/1988/1991) an alternative view is adopted, and both continuancy features are dominated by a separate node.[20] Hualde claims that a single-node analysis cannot account for Basque stop deletion (cf. (12)). That is, if [-continuant] and [+continuant] were both dominated by the same node, it would be impossible to describe in a uniform way why simplex stops are entirely

[20] In Hualde (1987/1988) a representation is presented where the continuancy features are linked to two supralaryngeal nodes, dominated by a single root node. A reanalysis of his data leads Hualde to revise this analysis, by postulating two root nodes, each of them directly dominating one of the continuancy features (1991:124-138).

deleted, while affricates are changed into a fricative: delinking of the node dominating [±continuant] would entail the delinking of all features dependent on that node. Therefore, Hualde assumes that the [-continuant] and [+continuant] parts are each dominated by a separate node, as visualized in (24). Stop deletion then involves the deletion of the node dominating [-continuant], leaving the node dominating [+continuant] unaffected.

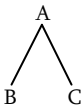
(24)



(cf. Hualde 1987:80)

A theoretical postulate for a two-root analysis is put forward by Clements & Hume (1995). In their outline of contour segments, they refer to the "No Branching Constraint". This constraint, given in (25), forbids branching of features under a single class node.

(25) The No Branching Constraint:
"Configurations of the form



are ill-formed, where A is any class node (including the root node), A immediately dominates B and C, and B and C are on the same tier". (1995:255)

With respect to the contour representation[21] of affricates, the No Branching Constraint states that the features [-continuant] and [+continuant] may not be dominated by a single root node, and must therefore each be dominated by an individual node, resulting in a two-root segment.

Contrary to the two-root analyses, Lombardi (1990) and van de Weijer (1992/1996) assume the two unordered continuancy features to be linked to the same root node. Lombardi's major objection against the postulation of two root nodes within the feature configuration of affricates is that it does not account for

[21] The No Branching Constraint does not concern the number of root nodes in a *complex* segment, given that the two unordered continuancy features are on different tiers.

the fact that the plosive and fricative parts of the affricate always share the same (primary) place feature: in principle every combination of place features would be possible. Next to the problems related to root-and-pattern morphology, as already addressed by Sagey (1986), van de Weijer (1992:133) additionally remarks that if a two-root analysis of affricates were adopted, there would be nothing inherent in the model that limits branching to the features [continuant] or [nasal]. That is, it would also be possible to posit for instance branching [voice] or [sonorant] under the nodes, as such predicting numerous segments that do not exist.

2.4 Affricates: simplex underlying stops

The idea of the affricate as an underlying plosive-fricative combination (either unordered or with a linear or hierarchical order of continuancy features) was commonly adopted since its introduction in 1975, but it fell into disregard in the 1990s. By then, it appeared that there also exist languages where affricates behave *exclusively* as stops, while the complex and contour segment approaches predict that they are in principle as likely to pattern with plosives as with fricatives.

Although a number of complex analyses, especially Steriade (1994) and Schafer (1995) already more or less alluded to a description of affricates as stops, they nevertheless assumed the presence of a fricative specification at some point in the phonological derivation, which still implied the patterning of affricates with fricatives to a certain extent. The apparent lack of consistent motivation for the presence of [+continuant] (or an equivalent feature) in the underlying representation of an affricate gave rise to a series of formalizations that characterized affricates basically as [-continuant] sounds. The debate then mainly concentrated on the exact specification of these simplex segments at the underlying level.

2.4.1 The nonavailability of [+continuant]

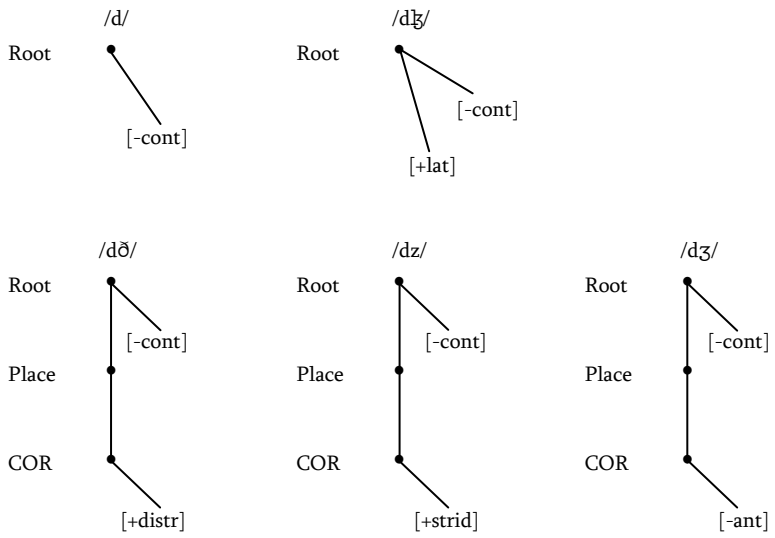
Shaw (1991) aims to establish a formalization of consonant harmony processes that directly captures the various typological characteristics of the phenomenon. Adopting the principle of "Radical Underspecification",[22] defended by among

[22] "Radical Underspecification" assumes that phonological representations may only contain unpredictable specifications. This means, more concretely, that next to the redundant features, also one value (either the + or -) of each feature is absent at the lexical level. The absent feature value, just

others Archangeli (1988), Shaw stipulates that as far as consonants are concerned, the only available specification for continuancy at the lexical level is [-continuant]. This assumption obviously entails important consequences for the representation of fricatives and affricates. As far as the fricatives are concerned, Shaw considers them to be unspecified for continuancy underlyingly. With respect to affricates, the absence of [+continuant] at the lexical level means that the branching structure consisting of [-continuant] and [+continuant] – a view that was still commonly adopted at the time – is excluded. Rather, both plain stops and affricates are principally specified as [-continuant]. Stops and affricates can then be distinguished from one another "primarily in terms of the feature specification that identifies the distinctive nature of the fricative release" (1991:147). The exact underlying feature specification of affricates (accompanying [-continuant]) depends on the contrasts that occur in a language, and it may as such differ from one language to another.

In Tahltan (1991:144-152) for instance, three series of coronals are involved in a process of coronal harmony. The coronal series that are not subject to the assimilation process, i.e. the simple stops and lateral affricates, are assumed to be underspecified for [coronal] underlyingly. The three affricate series involved in the harmony process are distinguished by the features [+distributed], [+strident] and [-anterior] respectively.

(26)



like the redundant features, will then be inserted at a later stage of the derivation by a default rule (cf. Archangeli 1988:192-193).

Even though the exact representation of affricates may vary from one language to another, the crucial point to retain is that Shaw proposes an analysis where affricates are primarily stops ([-continuant]), with an additional feature specification that can distinguish them from simple plosives. This is an important deviation from the contour segment and complex segment analyses, which were mainly not questioned until then. Furthermore, the representations in (26) also show that Shaw does not assume some specific feature that may define an individual category of affricates to the exclusion of stops. That is, by means of features like [+delayed release] or the contour/complex segment accounts, all affricates could be distinguished from normal stops. In Shaw's description, on the contrary, affricates do not share some specific feature which serves such a function; the only feature affricates have in common is [-continuant], which they also share with normal stops.

2.4.2 The return of the strident stop

It has been argued in Rubach (1994) that the patterning of affricates in Polish disfavours the presence of a fricative specification at the underlying level. Rubach discusses a number of segmental processes, each of them presenting either counterevidence to the contour segment analysis (referred to as the "Ordered Segment Hypothesis" (1994:119)) or to both the contour analysis and the complex segment account (referred to as the "Unordered Segment Hypothesis" (1994:119)).

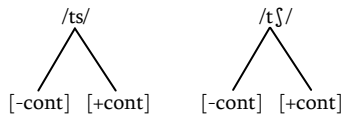
The process causing difficulties for both the complex segment and contour analyses of affricates is fricative assimilation (1994:134-137), which involves the assimilation of the continuants /s/, /z/ to the following alveopalatal or postalveolar noncontinuant segment. The process fails to apply to affricates:

(27)	pańs̲ki /s/	'sir' (Adj.)	pańs̲zcz̲yzna [ʃtʃ]	'serfdom'
	staroświec̲ki /ts/	'old-fashioned'	staroświecc̲zyzna [tstʃ]	'old-fashioned things'
	oset – /ostɕe/	'thistle'	ośc̲ie [ɕtɕ]	'thistle (loc. sg.)'
	ocet – /otstɕe/	'vinegar'	occ̲ie [tstɕ]	'vinegar (loc. sg)'

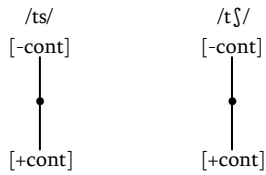
The examples in (27) show that /s/ is assimilated to [ʃ] before [tʃ], and to [ɕ] if followed by [tɕ], whereas the affricate /ts/ remains unaffected in the same contexts. Rubach argues that if affricates were combinations of plosives and fricatives in terms of continuancy features, this behaviour would not be expected. That is, under the "Ordered Component Hypothesis" (28a), the [+continuant] value is aligned at the rightmost edge of the affricate, and is thus immediately adjacent to the [-continuant] value of the following segment, which

corresponds to the context where fricative assimilation applies. More or less the same holds when an absence of ordering of continuancy specifications is assumed (28b). Even though the values are on separate tiers, there still is a [+continuant] value (from the first affricate) next to a [-continuant] specification (of the following segment), as is required for the assimilation process to take place.

(28) a. Ordered Component Hypothesis



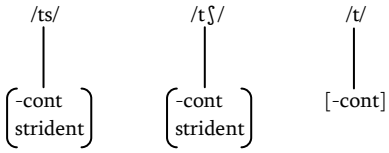
b. Unordered Component Hypothesis



(cf. Rubach 1994:122)

Since both types of multiple-component hypotheses make false predictions, Rubach does not include a [+continuant] specification in the underlying representation of Polish affricates. Instead, he adopts a non-branching description, only containing [-continuant]. In order to distinguish affricates from stops, Rubach makes use of the stridency feature, and as such, he more or less returns to the strident stop approach originally proposed by Jakobson et al. (1952).[23]

(29) Strident Stop Analysis



(cf. Rubach 1994:137)

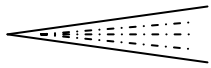
[23] The only difference between the two analyses resides in the fact that the feature [strident] was assumed to be binary in the framework of Jakobson et al. (that is, an opposition *strident-mellow*, which boils down to [+strident] and [-strident] respectively), whereas the feature is monovalent in Rubach's account.

The description of affricates as strident stops (cf. (29)) predicts that they pattern with the class of [-continuant] segments, and on the basis of their specification for stridency, affricates and strident fricatives are expected to behave alike. As Rubach argues, the strident stop analysis is able to account for the behaviour of affricates with respect to fricative assimilation: there is an underlying sequence of [-continuant] followed by another [-continuant], and as the requirements of the structural description of the rule are not met, the process fails to apply.

Clements (1999) and Kim (2001) also argue against the presence of [+continuant] in the phonological feature configuration of affricates. Their reasoning closely corresponds to the analysis presented by Rubach a few years earlier, and they also make use of the feature [strident]. Furthermore, next to a phonological motivation, the characterization of affricates as strident stops also receives phonetic grounding. Both Clements (1999:285-292) and Kim (2001:93-96) observe that affrication of a plosive like [t] (yielding [ts]) is likely to occur before a high vocalic element. In order to produce the dental plosive [t], the closure is made by raising the tongue to the upper teeth or the alveolar ridge. During the transition from [t] to the high vowel [i], for instance, the mouth remains relatively closed. The air has to be released through a narrow channel, causing strident airflow (30a). The result is an assibilated plosive or affricate [ts]. On the contrary, affrication is unlikely before a low vowel like [a]. In this context, the passage through which the air is released is relatively wide, yielding less or no turbulent airflow (30b).

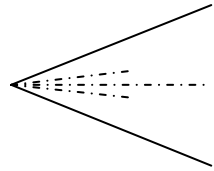
(30) Degree of oral cavity opening

a.



[t] [i]

b.



[t] [a]

(After: Clements 1999:287, Kim 2001:95)

It is noted, however, that the underlying representation of affricates like [ts] as strident stops is phonetically uninterpretable, given that there cannot be a complete closure of the oral cavity and a strident release at the same time. When it comes to the articulation of an affricate, linear sequencing of the underlying

specifications is required. Clements refers to this difference between phonetics and phonology as a "principled phonology-phonetics mismatch" (1999:272-292):

> "[…] the fact that affricates consist of single segments in the phonology and two segments in the phonetics constitutes a residual case of phonology-phonetics mismatch which cannot be resolved by any further reallocation of phonetic material to phonological segments. In this case, however, the mismatch is a principled one, motivated […] by the fact that the features [-continuant, +strident] cannot be produced simultaneously […]. It is just this inherent conflict in feature definitions which […] requires the incompatible features to be phonetically sequenced". (1999:272)

Furthermore, Clements takes into consideration the non-strident affricates, which were not addressed by Rubach (1994), given that Polish only has strident affricates. Clements characterizes strident affricates as [-continuant, +strident], whereas non-strident affricates bear a negative value for stridency: [-continuant, -strident]. As far as these two features are concerned, a plosive like [t] and a non-strident affricate like [tθ] thus get the same underlying specification. The segments [t] and [tθ] can then be distinguished from one another by the feature [±distributed], which refers to the relative surface of the tongue needed for the articulation of the sound in question: [t] being [-distributed], [tθ] being [+distributed]. The feature [±distributed] may also be distinctive within the category of strident affricates and differentiate [ts] ([-distributed]) from [tʃ] ([+distributed]). By means of the three features [±continuant], [±strident] and [±distributed] it is possible to describe the four-way contrast /t - tθ - ts - tʃ/ as follows:

(31)

/t/	/tθ/	/ts/	/tʃ/
-cont	-cont	-cont	-cont
-strident	-strident	+strident	+strident
-distributed	+distributed	-distributed	+distributed

Although the four sounds can be distinguished from one another, the descriptions in (31) nevertheless entail an important implication. That is, in Jakobson et al. (1952) the feature [±strident] was used to distinguish affricates from plain plosives. However, this is not possible in the inventory in (31) given that the features [±continuant] and [±strident] alone cannot provide the affricates [tθ], [ts] and [tʃ] with a uniform description. This is exactly the principal claim made in Clements (1999). Affricates should not be distinguished from stops by means of a contour representation or by means of some universal feature, given that this would largely overgenerate the number of contrasts among stops and

affricates attested in the world's languages. Rather, Clements assumes that "affricates are always distinguishable from non-affricated stops in terms of independently motivated features such as [strident], [distributed], [anterior] and the like" (1999:272-273).[24] To put it differently, the different contrasts are described by specific features, capturing a specific aspect in which the affricated stop differs from the plain plosive.

2.4.3 Affricates do not exist

The most radical accounts of affricates deny the phonological existence of this category of sounds altogether. LaCharité (1993) was in fact the first one to explicitly ban the concept "affricate" from phonology. On the basis of a sample of 322[25] languages, she proposes the principle of "Stop Affricate Dependency" (1993:75): affricates and stops often show a complementary distribution of place of articulation. Only in the coronal range stops and affricates systematically occur at the same place of articulation, but these contrasts can be adequately captured by means of the feature [strident]. Unfortunately though,[26] this analysis has been virtually gone unnoticed in the analyses that appeared afterwards.

The account put forward by Kehrein (2002), which is based on 281 languages, also favours a description of affricates as simplex stops. Like the other stop accounts, Kehrein argues against the presence of [+continuant] (or an equivalent) in the underlying representation of an affricate, by denying the existence of a natural class containing both affricates and the entire category of fricatives. However, Kehrein even goes one step further, by explicitly questioning the justification for a separate phonological class of affricates. Without knowing it himself, his account thus closely resembles the account proposed by LaCharité some ten years earlier. On the basis of the data considered, Kehrein deduces a definition of affricates which differs substantially from the traditional one. It stipulates that the sounds that commonly have been labelled "affricates" cannot be distinguished from stops as far as their underlying representation is concerned, a conceptualization which he calls the "Generalized Stop Approach" (2002:5). At the phonological level, stops can either be simple, or they can have a supplementary specification for their Manner of articulation: [lateral], [nasal] or [strident]. The segments traditionally referred to as

[24] Reflecting his principle of "Plosive-Affricate Complementarity" (1999:277).

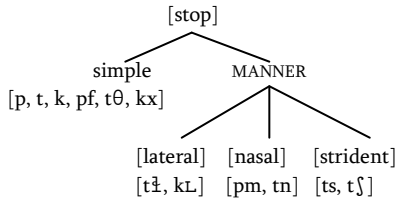
[25] The inventories were mainly taken from Maddieson (1984), to which several other languages were added (1993:76). LaCharité's sample contains both languages with and without affricates.

[26] Probably because a digital version of this PhD dissertation only became available very recently.

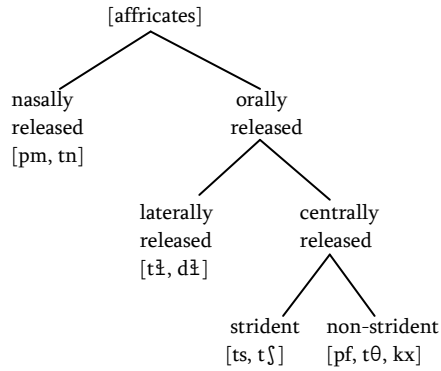
"affricates" can then be found among the simple stops (e.g. [tθ]), the lateral stops (e.g. [tɬ]) and the strident stops (e.g. [ts]), cf. (32a).

Affricates may show up, though, at the surface level. From a phonetic point of view, affricates are considered to be a clearly defined subcategory of stops: "Like stops, they consist of a closure followed by a release phase, but the release of affricates carries additional supralaryngeal properties" (2002:5). Furthermore, this conceptualization of affricates is rather comprehensive in comparison with the commonly used definition (i.e. sounds consisting of a plosive closure followed by a fricative release), and next to strident, non-strident and lateral affricates, also nasally released stops are subsumed under the same header (cf. (32b)).

(32) a. **Phonological level** (2002:8)



b. **Phonetic level** (2002:6)



Phonetic affrication of underlying stops may have different origins. First of all, the stops with a supplementary Manner specification at the phonological level, like [lateral], [nasal] or [strident] are subject to "Manner Driven Affrication". Given that the [-continuant] part, and the specific release cannot be realized simultaneously, they have to be ordered linearly; as it is impossible, for instance, to obstruct the air and produce a strident release at the same time (which therefore requires "phonetic sequencing" (2002:9)).

The other phonetic affrication processes concern the affricates belonging to the category of simple stops, i.e. stops that are deprived from an additional Manner specification underlyingly. Three possibilities are distinguished. The first one is speaker-dependent or contextually-determined affrication of underlying stops. As Kehrein notes, from a phonetic perspective, this kind of affrication is a natural result "since the difference between a sound perceived as a stop and one perceived as a non-strident affricate is gradient rather than categorical" (2002:22).

(33)

Language	**Stop**	**Affricate**	**Affricate context**
Kunimaipa	/p, k/	[pɸ, kx]	#__; __#
Diyari	/t̪/	[t̪θ̪]	free
Aleut	/q/	[qχ]	free

A second affrication process involving simple stops is "Laryngeally Driven Affrication". It applies to stops with a contrastive laryngeal specification, mostly aspiration. Instances of such affrication may be found, among others, in Tahltan which contrasts /kʷ/-/kʷʰ/, and /q/-/qʰ/. In order to enhance the contrast, the laryngeally specified phonemes appear to be realized as affricated segments: [kxʷʰ] and [qχʰ], respectively.

The final instance of affrication of simple stops is "Place Driven Affrication". It is applied to increase the perceptibility of plosive phonemes in the same range of articulation (dissimilation). Irish, for instance, has a phonemic distinction between the dorsal palatal plosive /c/ and the dorsal velar plosive /k/. In order to increase the perceptibility of this distinction, the palatal stop changes into an affricate, which creates the contrast [cç] – [k] at the surface level (2002:23).

According to Kehrein, the major drawback of previous analyses resides in the fact that they all depart from the assumption that affricates constitute a separate natural segment class. These "affricate-approaches" (2002:11-12) all claim that, from a phonological point of view, affricates can be distinguished from stops either by a branching structure or by a specific release feature. Consequently, it is incorrectly predicted that *all* affricates contrast with stops, and that affricates form a natural segments class on their own and with plosives or fricatives respectively. Rather, Kehrein argues that the Generalized Stop Approach only captures the contrasts attested in languages, whereas it excludes non-occurring ones (cf. 2002:6-7).

The Generalized Stop Approach predicts first of all that affricates as such do not form a natural class (34a), and neither do affricates and fricatives (34b). Affricates and stops, however, do (34c). Within this comprehensive category of underlying stops, the entire group of Manner-specified stops constitutes a natural segment class on its own (34d) and they may thus contrast with the simple stops, /t/ vs. /ts, tɬ, tn/ for instance. The phonetic non-strident affricates never contrast with stops at the exact same place of articulation, and therefore, both /t/ and /tθ/ belong to the category of simple stops (34e).

As far as the Manner-specified stops are concerned, all sounds specified as either [strident], [lateral] or [nasal] form a separate phonological category. It is here that stridently, laterally or nasally released stops may pattern with strident fricatives, laterals and nasals respectively (34f). Finally, the [strident], [lateral] and [nasal] stops may each form a natural segment class on their own (34g), on the basis of both [-continuant] (which excludes them from [+continuant] sounds having the same Manner-specification) and the specific Manner feature (opposing them to simple stops and segments with a different Manner feature).

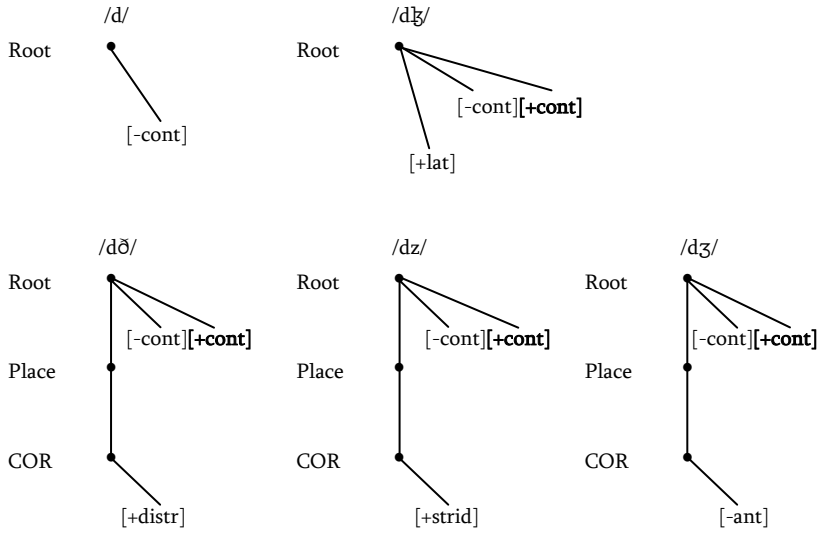
(34) a. *[pf, tθ, qχ, kx, ts, tɬ, tn]
b. *[pf, tθ, ts, kx, f, θ, s, x]
c. [p, t, k, pf, tθ, qχ, kx, ts, tɬ, tn]
d. [ts, tɬ, tn]
e. [t, p, tθ, pf]
f. [ts, tʃ, s, ʃ]
[tɬ, ɬ, l]
[tn, n]
g. [ts, tʃ]
[tɬ, kʟ]
[pm, tn, kɳ]

Kehrein notes that some of the previous analyses more or less went in the same direction as the Generalized Stop Approach, in particular Clements (1999). According to Kehrein, however, his account is more extensive than Clements' in two respects (2002:15). First of all, the Generalized Stop Approach directly takes into account both lateral and nasal affricates, and second, it provides a more elaborate view on phonetic affrication.

Besides, Shaw (1991) and Steriade (1994) also assumed that affricates are underlyingly identical to stops – either by means of the feature [stop] (Shaw) or the stricture feature A_0 (Steriade) –, and they did not postulate some additional feature which served to define affricates as being phonologically distinct from

stops. Still, as Kehrein notes, at some point in the phonological derivation, both accounts assume that the underlying (affricate) stops change into a complex stricture segment, and as such they come to consider affricates as phonologically relevant entities. Consequently, even though affricates are primarily conceived of as stops in both accounts,[27] they still incorrectly predict that affricates exist at some level in the phonology of a language and that they may pattern with fricatives. Kehrein notes that Shaw's analysis comes closer to the Generalized Stop Approach than Steriade's, given that the initial stop account is turned into an affricate approach at a later stage in the derivation in Shaw's analysis than in Steriade's account. That is, Shaw assumes [+continuant] to be absent at the lexical level, which means that it is inserted at the postlexical level by a default rule (cf. Kehrein 2002:14). Consequently, the structures in (26) are transformed into the following ones:

(35)



[27] Kehrein classifies Steriade's analysis as a stop account, whereas Clements treats it like a contour analysis. Apparently, this is caused by the fact that Steriade herself does not explicitly define at which point in the phonological derivation the A_0 changes into a stricture contour A_0 A_F. As such, Kehrein focuses primarily on the stop aspect of her description, whereas Clements stresses the contouring.

Given that both Steriade's and Shaw's analyses make claims which lie in between the ones made by the affricate approaches and the Generalized Stop Approach, Kehrein classifies them as "split-approaches" (2002:13-15).

2.5 The contour segment revisited

Even though the different stop approaches were claimed to be more advantageous than the branching-structure analyses in a number of respects, their introduction did not bring about a total neglect of the latter. Rather, there appeared to be languages for which the stop descriptions proved to be inadequate.

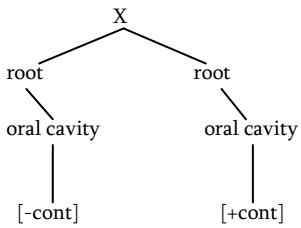
In Jacobs & van Gerwen (2006) glide strengthening processes in the historical phonology of French and Spanish are discussed. Around the fifth century, the palatal glide [j] (from Latin origin) and the labial glide [w] (from Germanic origin) were strengthened, generally in syllable-initial position. In a first stage, [j] changed into [dʒ], whereas [w] became [gw] (2006:80-83):

(36)

	Latin	*Gallo-Romance*	*Early Ibero-Romance*	
[j]	[jam]	[dʒam]	[dʒam]	'already'
[w]	[want]	[gwant]	[gwante]	'glove'

Given that these strengthening processes took place during the same period, Jacobs & van Gerwen argue that they should receive a unified description. They therefore adopt an approach where a [-continuant] value is added to the glide ([+continuant]), as such resulting in an underlying sequence [-continuant, +continuant]. By adopting the "No Branching Constraint" (Clements & Hume 1995, cf. (25)), affricates are described as contour segments consisting of two root nodes, as visualized in (37).

(37) [dʒ] – [gw]



(Jacobs & van Gerwen 2006:85)

This representation directly accounts for the subsequent development of the strengthened glides – which takes different forms according to the surrounding segmental context – in both French and Spanish. That is, the [-continuant, +continuant] sequences were either left unaffected or the changes targeted only one of the [continuant] branches.

Moreover, it is explicitly argued that a description of affricates as strident stops could not account for the changes observed. First of all, if the transformation of glides into complex segments were described in terms of stridency, the description would fail to provide a unified explanation for the change, given that only [dʒ] may be characterized as [+strident], whereas [gw] may not. Second, the strengthening processes took place before all vowels, independently of their place of articulation. Therefore, the insertion of the feature [+strident] (which is often associated with stop-high vowel sequences, as shown by Clements 1999 and Kim 2001) does not make sense from a phonetic point of view either. Third, if insertion of the feature [+strident] were assumed, it would still not yield the correct outcomes. That is, by adding this specification to the feature configuration of the continuant, non-strident glide, it is not clear how this would result in an affricate [dʒ], and additional machinery would be required in order to account for the insertion of the [-continuant] part and to assure the correct place of articulation.

Furthermore, Jacobs & van Gerwen touch on an aspect vital to the actual debate on the phonological representation of affricates. An important proposition put forward in their analysis is that the underlying representation of affricates may not be a universally fixed one. Rather, it may differ from one language to another. A concomitant question which is raised then concerns the fact whether this representation is fixed in a specific language or whether it may differ within one and the same language, according to the way the affricate originates (2006:92-93).

2.6 Agreement and disagreement

While it is generally acknowledged that affricates are single segments, phonetically consisting of a linearly ordered sequence of a plosive and a fricative, it follows from the above overview that their phonological representation remains a controversial issue. The different views put forward in the history of phonological theory may roughly be divided into two conflicting groups. The first one advocates a description of affricates as underlying stops, whereas the

second one describes them as branching structures containing both a plosive and a fricative part (either ordered or unordered).

However, the subdivision of the divergent views proposed in phonological literature is not as neat as all that, and within both extremes a more subtle distinction is required. Among the stop analyses, disagreement persists on the question whether affricates are underlyingly identical to stops, or whether they can be distinguished by some specific release feature; and if so, which release feature has to be adopted. Furthermore, if it is assumed that affricates are identical to stops, it has to be considered whether contouring nevertheless takes place somewhere in the phonology (e.g. Shaw 1991; Steriade 1994) or whether they remain stops throughout the phonological derivation (e.g. LaCharité 1993; Clements 1999; Kehrein 2002).

The adherents of a branching structure analysis also still have several issues to settle. First of all, it remains undecided whether the continuancy features are ordered linearly at the underlying level (Sagey 1986; Hualde 1987; Jacobs & van Gerwen 2006), whether they remain unordered (Hualde 1988; Lombardi 1990; van de Weijer 1992, 1996) or whether they rather appear in a head-dependency relationship (Schafer 1995). Second, it has to be decided how the plosive and fricative parts are represented: by means of the binary feature [±continuant] (e.g. Hoard 1975; Sagey 1986); the monovalent features [stop] and [continuant] (e.g. Lombardi 1990; van de Weijer 1992, 1996); or by the stricture features A_0 and A_f (Steriade 1994). A third aspect that gives rise to discussion is the number of nodes directly dominating the continuancy features in the branching structure, i.e. are the stop and the fricative parts each linked to a separate root or supralaryngeal node (e.g. Hualde 1987; Jacobs & van Gerwen 2006), or do they both belong to the same node (e.g. Sagey 1986; Lombardi 1990; van de Weijer 1992, 1996)?

2.7 Conclusion

This chapter has provided an overview of the major formal descriptions of affricates that have been proposed in the literature. Initially, affricates were seen as stops with a distinctive release, captured by a specific feature like [+delayed release]. Afterwards, affricates came to be analyzed as complex (i.e. branching) entities, consisting of both an independent plosive and fricative part. In recent years, however, the phonological complexity of affricates has been questioned, and several accounts favoured a bare stop description of these phonetically

complex sounds. Moreover, also the status of affricates as an autonomous phonological category has been challenged.

Even though there is currently a strong tendency to consider affricates simplex stops, disagreement nevertheless persists on a number of aspects. The crucial factor in the absence of disagreement on the phonological representation of affricates appears to be the fact that most of the existing studies are mainly based on a single language or only a small number of languages. This yields a fragmentary picture of the cross-linguistic behaviour of affricates, which is, moreover, not based on a properly-balanced sample of languages. Interestingly enough, the studies based on a larger set of languages, mainly van de Weijer (1996) and LaCharité (1993)/Kehrein (2002), come to different conclusions.

In order to add to the existing analyses, and to provide a counter-check of van de Weijer's and LaCharité's/Kehrein's contradictory claims, we will have a closer look at the patterning of affricates in a representative survey of languages in the following chapter.

Part II:
Typology

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3

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Affricates in Segment Inventories

3.1 Introduction

As shown in the previous chapter, the uncertainty about the phonological representation of affricates is due to the fact that most existing analyses are language-specific, which yields a fragmentary picture of the cross-linguistic patterning of these sounds. The number of existing typological studies of affricates is extremely limited and they have resulted in contradictory findings.[28] An additional problem is that it is often not entirely clear on which languages these typological studies are exactly based or how the sample of languages has been selected. Consequently, it is not clear whether the studies rely on a properly balanced collection of languages that reliably mirrors the world's languages, or whether it is rather opportunistically sampled.

In this chapter, we will provide a synchronic typological study of affricates, on the basis of the sound systems in UPSID 1992, which is one of the largest databases of segment inventories currently available, and which has been compiled in such a way that it closely reflects the inventories of the world's languages. The studies of van de Weijer (1996), LaCharité (1993), Clements (1999) and Kehrein (2002) were (partially) based on the first version of UPSID (1984), but came to different conclusions. The second version of UPSID has undergone several important changes by including languages of linguistic areas that were too poorly represented and furthermore, the data of the languages that were already included have been thoroughly checked. As such, it can be examined whether the changes in UPSID entail modifications of the descriptions based on UPSID 1984, and the data can be updated.

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[28] Van de Weijer (1996) vs. LaCharité (1993), Clements (1999) and Kehrein (2002).

This chapter is organized as follows. First of all, we will briefly introduce the notions of typology and sampling in section 3.2. Next, in section 3.3 we will present and discuss the design of the UPSID 1992 corpus. Subsequently, the distribution of affricates in this database will be described and discussed in sections 3.4 up to 3.9, focusing on different aspects like frequencies of occurrence, voicing, place of articulation and secondary articulations. In 3.10, we will briefly consider to what extent the behaviour of affricates fits the conflicting principles of maximal dispersion and feature economy, which have been put forward as organizational mechanisms underlying sound inventories. Finally, before moving on to the next chapter, where the implications of the typology for the representation of affricates will be discussed, we will briefly recapitulate our main findings in section 3.11.

3.2 Preliminaries: typology and sampling

The ultimate aim of language typology is to provide a classificatory description of some linguistic phenomenon, both of its universal characteristics and its diversity, and to account for the observed patterns. In the ideal case, a typological study should consider all existing languages, but in practice this is obviously an impossible requirement. First of all, the exact number of languages spoken in the world cannot be determined exactly. Languages are not clearly delimited entities and are constantly evolving, which makes it often difficult to draw a sharp division between a language and a variety of the same language. Moreover, numerous languages are nowadays well described and documented, but not all languages spoken today are actually known. Second, there are several practical limitations (lack of time and/or sufficient material) that make it impossible to examine all languages that exist nowadays, let alone also the ones that ever existed.

Still, in order to obtain a reliable description and to develop a solid linguistic theory of a specific phenomenon, linguists want to describe and account for (un)attested patterns, and ultimately, they want their conclusions or findings to be representative for the languages in the world.[29] Therefore, like any

[29] A language database has to be primarily *descriptively* representative, i.e. it should include at least one instance of the different systems that occur in the world's languages. Therefore, the sample should be sufficiently large to assure that the likelihood that all possibilities are included is quite high. When this descriptive requirement is met, the sample can always be extended in such a way

other study inferring generalizations on an entire population on the basis of a random selection, the sample of languages needs to be selected in such a way that it reflects the variety of languages that can be found in the world. In this respect, a number of sampling procedures have been proposed (cf. Dryer 1989, Whaley 1997).

A first possible option is to create a "proportionally representative sample" (Dryer 1989:258). In such a sample, each language family or linguistic area is represented by the same percentage. Consequently, in absolute numbers, larger language families or areas will be represented by a larger number of languages than smaller ones. The major advantage of this technique is that the sample quite closely reflects the relative number of the world's languages with or without a specific characteristic. However, these relative frequencies are not very reliable estimators of the actual tendencies of the existing languages towards particular structures. That is, the high frequency of a given pattern is not necessarily linguistically determined: it might be the case that patterns are similar or dissimilar just by chance. Furthermore, the size of a language or language family is mainly determined by social and historical factors. The frequencies observed in a proportionally representative sample (where larger language families outnumber smaller language families by definition) may therefore be influenced by the dominance of some larger language families, at the same time obscuring the characteristics of smaller ones, and as such bias the image.

The preferential structures across language families or linguistic areas can be revealed more directly if a sample of "independent languages" (Dryer 1989:261) is used. This kind of sample uniquely contains languages that are only remotely related or that are not related genetically or geographically at all. The advantage of this sampling technique is that, even though chance may still play a role, the risk of influencing the observations by recurring patterns in larger families can be controlled for, since the sample does not contain a direct member of the same language group. Therefore, these samples are most suitable for statistical testing on linguistic preferences.

The language sample which will be used in this chapter is a genetically-based sample of independent languages. The following section will describe the design of this database and motivate the choice for this particular corpus.

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that it becomes more or less *statistically* representative, which makes it possible to examine relative frequencies of occurrence.

3.3 UPSID

The most recently released version of UPSID (*UCLA Phonological Segment Inventory Database,* cf. Maddieson & Precoda 1990) lists the segment inventories of 451 languages (estimated at 6-7% of the world's languages). One of the main goals underlying the design of UPSID was to create a collection of languages representative of the languages in the world, and which could therefore be used as a reliable source for statistical testing. UPSID is a genetically-based collection of languages, for which Maddieson (1980a) provided the following motivation:

> "A genetic basis for the sample is selected in preference to any other since it is the only classification which is, in principle, not arbitrarily determined by the criteria chosen for the classification, but instead aims to represent real historical relationships". (1980a:7)

The genetic classification underlying UPSID consists of eleven major language classes and an additional number of smaller groups. These categories are subdivided into (several) intermediate levels, in such a way that the languages in each sublevel evolved independently from the languages in the other sublevels of the same family for more than 1000 years. In case a single subgroup consisted of several languages (i.e. which evolved less than 1000 years independently from each other), only one language was included in the sample. The choice for this language depended on the availability and quality of the required data. By means of this sampling procedure, the entire range of language families is covered, while the risk of including multiple varieties of one and the same language is avoided as much as possible.

After the languages were selected, their segment inventories were determined by carefully checking the consulted sources. A standardized procedure for the interpretation of phoneme inventories was used, in order to make the compilation procedure as uniform as possible (cf. Maddieson 1980a/b; 1984, 1986; 1991, Maddieson & Precoda 1990).[30] In the actual database entries, each phoneme is represented by its most frequent allophonic variant (i.e. the most frequently occurring token in the language), and furthermore, sounds that only occur in loanwords, but that are no productive phonemes in the language have not been included in the inventories.

[30] For a more detailed review of the selection procedure and the actual content of the first version of UPSID, the reader is referred to Basbøll (1985).

In this chapter, we will make use of UPSID for the following reasons. First of all, since only one language has been sampled from a group which is considered to be sufficiently distant historically, the obtained data will not be influenced by closely related varieties of the same language. Two genetically related languages included in UPSID may still be similar in several respects, but given their historical distance, the similarity is due to chance, or a certain characteristic has proven stable over time. UPSID will therefore provide a close approximation of the way affricates are actually structured in the segment inventories of the world's languages. Second, as noted by Clements (2003b), UPSID is the largest database of segments currently available. As it is digitally accessible,[31] it is possible to perform directed searches, and data can be easily extracted.

Needless to say, the specific design of UPSID also entails a number of disadvantages. Even though these disadvantages do not outweigh the advantages, let us nevertheless briefly mention them. First of all, although the data in UPSID may approximate the structure of segment inventories of the world's languages quite closely, it is impossible to conclude anything on the relative frequencies of particular segments, given that it is not proportionally balanced. Besides, since only one language is selected from each remote subgroup, it could be the case that, by chance, the language with or without affricates happened to be sampled. Yet, in our case, information on relative frequencies is only of limited use. We are not primarily interested in bare numbers of occurrence of affricate sounds, but rather in the way languages with affricates actually structure their inventories, and whether they assign an allophonic or a phonemic status to these sounds.

Moreover, as noted by Clements (2003a/b), a true genetically balanced sample can never be created. Even though the criterion for subgrouping has been set at 1000-1500 years of independent development, larger language families are likely to have more members that meet this requirement than smaller ones, and consequently, the former will be represented by a larger number of languages than the latter with few subgroups. Indirectly, language family size may thus play a role, although it is not directly reflected in the sampling quota.

Finally, it should be kept in mind that the use of a survey of languages in general involves a number of limitations (cf. Clements 2003b). During the

[31] The software package *UPSID-pc* can be downloaded freely from: http://www.linguistics.ucla.edu/faciliti/sales/software.htm, and a web-based interface, developed by Henning Reetz, is available at: http://web.phonetik.uni-frankfurt.de/upsid.html.

collection of data, miscopyings may occur, and furthermore, multiple investigators are involved in the compilation process, which may give rise to differences in transcription of a given sound.

The version of UPSID that will be used in this study is the latest one, which dates from 1992. It has been expanded and corrected with respect to the previously released version (containing 317 languages, and which is described in Maddieson 1984). The analysis of van de Weijer (1996) and in part LaCharité's (1993) and Kehrein's (2002) studies are based on the original corpus, UPSID 1984. Although largely based on the same data, these analyses come to different and even conflicting conclusions, as we have seen in the preceding chapter. By using UPSID 1992, our typological study of affricates, which will cover the remainder of this chapter, will also be an update of the data presented by van de Weijer, LaCharité and Kehrein.

3.4 From 1 to 24: the distribution of affricates in UPSID

The inventories of 302 languages in UPSID contain at least one affricate segment,[32] which corresponds to 66.96% of all languages in the database. Among these 302 languages, the smallest number of affricates a language contains is 1 (77 languages), the highest number 24 (1 language). A complete overview of the distribution is provided in (38) below.

[32] A detailed overview of these 302 languages is given in Appendix A.

(38) **Distribution of affricates**

Number of affricates	*Number of languages*[33]	*% of languages with affricates*	*Cumulative % of languages with affricates*
1	77	25.50%	25.50%
2	104	34.44%	59.93%
3	33	10.93%	70.86%
4	42	13.91%	84.77%
5	5	1.66%	86.42%
6	21	6.95%	93.38%
7	3	0.99%	94.37%
8	2	0.66%	95.03%
9	5	1.66%	96.69%
10	1	0.33%	97.02%
11	1	0.33%	97.35%
12	3	0.99%	98.34%
13	1	0.33%	98.68%
14	3	0.99%	99.67%
…	0	0%	99.67%
24	1	0.33%	100%
Total: 921 $\bar{X}$: 3.05	302	100%	

As far as the distribution of the number of affricates between the two extremes is concerned, the overview shows that 59.93% of the languages have up to 2 affricates, and 93.38% of the languages have between 1 and 6 affricates. The number of languages with a total number of affricates between 7 and 14 is only marginal, and equally striking is the considerable gap between languages having 14 affricates and the one with 24 of these sounds.

[33] As far as the distribution of the affricates across the different language families is concerned, the languages with the higher number of affricates appear to occur especially among the Caucasian, Khoisan and North and South American families. However, the number of affricates in a language belonging to one of these families may differ considerably. The Caucasian languages that are included in the UPSID sample all have affricates, varying from 5 (Kabardian) to 24 (Archi). The languages from the Khoisan family that have been sampled also all have affricates, with a range from 2 (Nama) to 14 (!Xu). The total number of languages included from the North and South American families (i.e. 56 and 66 respectively) is quite large because of the numerous subgroupings. About 96% of the North American and 82% of the South American languages have at least one affricate in their inventory, the language with the highest number of affricates is Acoma (9 affricates) for the North American languages, and Jaqaru (also 9 affricates) for the South American languages. These numbers may be an indication of the variety in the number of affricates found in the world's languages, but because of the nature of the UPSID sample, i.e. one language from each subgrouping, they cannot be seen to reflect the *absolute* dispersion of numbers of affricates within a family.

One might wonder whether the fact that a language has affricates (and if yes, how many) is dependent on the size of the segment inventory of the language. Correlating[34] the number of consonantal segments with the number of affricates (0-24) for all 451 languages in the survey yields a correlation coefficient r of 0.716, which is significant at the α 0.01 level. Computing the same correlation for only the 302 languages with affricates gives a correlation coefficient r of 0.746, which is also significant at an α level of 0.01. We may therefore conclude that the larger the consonant inventory of the language, the more likely it is to have affricates, and the more likely it is to have more of them.

Consonant inventory size is, however, no absolute estimator of the number of affricates a language may have. The squared correlation coefficients (r = 0.716, r^2 = 0.513 and r = 0.746, r^2 = 0.556) show that the variation in the number of affricates is only by about 50% (i.e. 51% and 56% respectively) dependent on the total number of consonantal segments in the language. In fact, these statistical outcomes are not surprising. To a certain extent there is of course a relation between the number of affricates and the total number of consonants, as it is generally acknowledged that languages gradually build their segment inventories, and that languages with smaller inventories are less likely to have particular segments than others. However, this is only part of the story, as reality is more complex. The exact principles that underlie the structure of segment inventories are still subject to debate. One view defends the principle of "maximal dispersion" of contrasts, which stipulates that sounds in a given inventory should be as dispersed as possible, in order to facilitate the perception of the different sounds of that particular inventory (cf. for instance Liljencrants & Lindblom 1972, Lindblom 1986, Lindblom & Maddieson 1988). This view was initially used to account for vowel patterns, but afterwards, it became used to account for consonantal patterns as well. Scholars who adhere to the second, opposite, view argue that sound systems are subject to "feature economy" (cf. Martinet 1955, Clements 2003a/b). According to this principle, which in fact dates back to the structuralists, "languages tend to maximize the combinatory possibilities of a few distinctive features to generate a much larger number of phonemes. In other words, features used once in a system tend to be used again" (Clements 2003a:371). Although such an approach to sound systems is primarily phonologically-based, Martinet (1955) explicitly points out that the possibilities are bound by phonetic considerations, which strongly try to avoid articulatory complexity and which strive to optimize perceptual salience. There is still

[34] Pearson correlation in SPSS.

discussion about the exact principle(s) underlying segment inventories, but it goes without saying that the presence of affricates will also depend on the structure of the segment inventory and the contrasts exploited by the language. We will return to this matter in more detail below.

After having presented the number of affricates in different languages, let us now, for reasons of illustration, briefly consider the frequencies of the different affricates in UPSID. In (39), the ten most frequently occurring affricates are listed.[35]

As we have seen in sections 3.2 and 3.3, UPSID is not proportionally balanced, and therefore the numbers in (39) do not necessarily reflect the relative frequencies of these affricates in the world's languages. The overview of the most frequent affricates does give a good indication of the way languages tend to build up their (affricate) inventories, though. The data in (39) first of all show the dominance of coronal, sibilant, affricates. The most frequently occurring affricate is the voiceless palatoalveolar /tʃ/, followed by voiceless /ts/ (either dental, alveolar or unspecified dento-alveolar). It can also be deduced from (39) that the difference between the frequencies of the voiceless affricates in 1. and 2. and their voiced counterparts in 3. and 4. respectively is quite large. Furthermore, it is striking that sibilant affricates with a modifier like aspiration or prenasalization tend to occur phonemically relatively often, and again, the voiceless versions seem to be the preferred ones.

[35] For clarity's sake, we did not count affricates with attributes (like aspiration or a secondary articulation) and plain affricates of the same type together, since there are languages that use these characteristics distinctively. The relation between the plain affricates and the ones with an additional attribute will be considered in detail below.

(39) **The top 10 affricates**

	Affricate	*Number of occurrences*	*% of UPSID languages with affricates*
1.	tʃ	188	62.25%
2.	ts[36]	123	40.73%
3.	dʒ	113	37.41%
4.	dz	54	17.88%
5.	ts'	52	17.22%
6.	tʃʰ	51	16.89%
7.	tsʰ	50	16.56%
8.	tʃ'	44	14.57%
9.	tɬ'	20	6.62%
10.	ʈʂ	16	5.30%

The numbers in (39) represent absolute frequencies, but as such they do not show whether languages have a preference for a particular segment if they only have a single affricate in their inventories, or to put it differently, with which affricate languages typically 'start'. The overview in (40) shows the different possibilities exploited by the UPSID languages with one affricate.

[36] In UPSID, the anterior coronal affricates (both the voiced and the voiceless ones) are subdivided into three subcategories: dental, alveolar and dento-alveolar (i.e. unspecified). However, none of the languages in UPSID is described as having an affricate contrast involving all these three possibilities. Moreover, the distinction between dental, alveolar and dento-alveolar affricates is rather subtle, and has therefore not been interpreted in an absolute way by researchers using UPSID or its predecessor (i.e. the Stanford Phonology Archive). As noted by Nartey (1979), it seems likely that these sounds have not been described in a uniform way in the sources on which the sample is based. Maddieson (1984) merged the three categories in his data "[…] partly because they are frequently not reliably distinguished in the sources and partly because a contrast between these places is unusual" (1984:31-32). For these reasons, we also collapsed the different places of articulation in (39). Incidentally, though, a language may be described as having a contrast between two places of articulation in the dental/alveolar range (as in Tzeltal, which contrasts dental and alveolar sibilant affricates). If the distinction becomes relevant in the light of the place contrasts among plosives and/or fricatives in a particular language, we will make a distinction between the different places of articulation in the anterior coronal domain.

In addition, it should also be noted that a three-way coronal contrast (e.g. one apical and two laminals, or two apicals and one laminal) is excluded by a geometry assuming a Coronal place node dominating the binary features [±anterior] and [±distributed]. With respect to the [+anterior] coronals, these features predict an apical-laminal contrast. A contrast between two apicals or two laminals is not predicted to occur, as this would yield an identical feature representation [COR, +anterior, -distributed] for the two apicals or [COR, +anterior, +distributed] for the two laminals.

(40) **Languages with 1 affricate**

Affricate	*Number of languages*	
tʃ	34	(44.16%)
dʒ	12	(15.58%)
ts	12	(15.58%)
dz	5	(6.49%)
tʂ	5	(6.49%)
tʃʰ	2	(2.60%)
cç	2	(2.60%)
qχ	2	(2.60%)
t̪ʃ̪[37]	1	(1.30%)
tɸ	1	(1.30%)
kx	1	(1.30%)
Total	77	

Again, a quite skewed picture arises. On the basis of (39), the high number of languages with /tʃ/ as their only affricate is expected. Strikingly, there is also a considerable number of languages that rather opt for its voiced counterpart /dʒ/, or for a voiceless affricate, but a more anterior one: /ts/. There is a mid-category of languages that prefer a voiced version of this latter (dental/alveolar) affricate, or even a voiceless retroflex /tʂ/. Among the lower numbers, we find languages with affricates at more posterior places of articulation: the palatals /tɸ, cç/, the velar /kx/ and the uvular /qχ/. Besides, instead of resorting to the more remote places of articulation, the lowest frequencies also contain a language with the nonsibilant coronal /t̪ʃ̪/ as its only affricate, and two languages that do not opt for a plain affricate but rather for an aspirated one, which turns out to be palatoalveolar /tʃʰ/.

Let us now turn to the other extreme: Archi, the language with the highest number of affricates in the survey. Archi is a Caucasian language spoken in southern Dagestan, and has a total of 81 consonantal segments (glides and glottal stop included), of which 24 are affricates. Its consonantal segment inventory, as described in UPSID 1992 is given in (41).

[37] Notation from Maddieson (1984): voiceless alveolar nonsibilant affricate.

(41) Archi (Caucasian)

bilabial	dento-alv.		pal.alv.	palatal	velar	lab.-velar	uvular	pharyngeal	glottal
									ʔ
b pː pʰ pʼ	d tː tʰ tʼ dʷ tʷʰ				g kː kʰ kʼ gʷ kʷː kʷʼ kʷʰ				
	tsʰ tsʼ tsʼː tsʷʼ tsʷʰ	tɬʰ tɬʼ tɬʷʼ tɬʷʰ	tʃʰ tʃʼ tʃʼː tʃʷʼ tʃʷʰ				qχ qχʼ qχʼː qχʷ qχʷʼ qχˤ qχˤː qχˤʼ qχʷˤ qχʷˤʼ		
	s z sː sʷ zʷ sʷː	ɬ ɮ ɬː ɬʷ ɬʷː	ʃ ʒ ʃː ʃʷ ʒʷ ʃʷː				χ ʁ χː χʷ ʁʷ χʷː χˤ ʁˤ χˤː χʷˤ ʁʷˤ χʷˤː	ħ ʕ	h
m	n r l			j		w			

Affricates in Archi are produced at three different places of articulation, and they may be dento-alveolar, palatoalveolar and uvular. Besides, Archi has both sibilant and non-sibilant affricates, the non-sibilant tokens slightly outnumbering the sibilant ones (i.e. 14 non-sibilant against 10 sibilant ones). The striking aspect of this inventory is that Archi only uses three places of articulation and no voicing contrast for affricates, but that it nevertheless contains 24 affricates. Also, as can be observed in (41), this language only has one short, plain affricate, the uvular /qχ/. The other affricates all have additional features like aspiration, lengthening and/or a secondary articulation, which are especially exploited among the uvular tokens.

If we compare the distribution of the affricates with the distribution of the plosives and fricatives, we see first of all that as far as their place of articulation is concerned, affricates occur in two regions (palatoalveolar and uvular) where no plain plosives are attested. Fricatives, on the contrary, occur at all three places where affricates are produced. Second, as far as the large number of segmental attributes of the Archi affricates is concerned, we see that the length contrast is also present among both the plosives and fricatives, ejectivity and aspiration are shared with the plosives, and the secondary affricate articulations labialization and pharyngealization occur on both plosives and fricatives and only fricatives, respectively. Finally, unlike both plosives and fricatives, however, Archi only has voiceless affricates.

As such, the Archi case nicely illustrates that affricates share some of their features with plosives and/or fricatives, but that yet in other respects, they may be different from or complementary to either of these two groups.

Now, why do we typically find the patterns we have seen in this section? Taking into account that there is a potentially high number of possible contrasts, one could wonder why there seems to be such a tendency towards particular structures. The bare numbers in (38)-(40) have only limited informational value if we do not consider the position that the affricates occupy within the phoneme inventories of these languages, as we have done for Archi in (41). The following sections will be concerned with the distribution of affricates in the inventories of the UPSID languages, by separately considering aspects like place of articulation, voicing, secondary articulations and laryngeal modification, which we have only briefly addressed above. Moreover, for each of these aspects, it will be considered to what extent the behaviour of affricates corresponds to that of plosives and/or fricatives.

3.5 Place of articulation

The number of different places of articulation where affricates are attested in the languages of UPSID goes up to nine, if we do not merge the dental, alveolar and unspecified dento-alveolar places of articulation. None of the languages in UPSID, however, has a contrast among all of these places of articulation: the highest number of different places of articulation where affricates (irrespective of their laryngeal settings) occur within a single language is four. For plosives and fricatives this maximum is six and eight, respectively.[38] (42) lists the number of languages with affricates at the different places of articulation.

(42)

Places of articulation for affricates	*Number of languages*
Labiodental	6
Dental/Alveolar/Dento-alveolar	161
Palatoalveolar	222
Retroflex	21
Palatal	19
Velar	5
Uvular	5

As already briefly noted earlier, the preferred place of articulation for affricates appears to be the palatoalveolar region, as 222 languages in the UPSID sample have at least one affricate of this type. The second most frequently exploited place of articulation is the anterior coronal area, where 161 languages have affricates. All the other places of articulation where affricates are attested are considerably less frequently used. 21 languages have retroflex affricates, and the inventories of 19 languages contain palatal tokens. The labial affricates are even less frequent, and occur in only 6 languages.[39] Strikingly, these are all labiodentals: no UPSID language has bilabial affricates. The velar and uvular affricates are the least frequently used, and both occur in only 5 languages.[40]

How does place of articulation of affricates relate to the place of articulation of the other obstruents? (43) gives an overview of the attested patterns.

---

[38] Following Maddieson (1984:31), we excluded the glottal plosive [ʔ] and the pharyngeal and glottal fricatives [ħ, ʕ, h, ɦ] because of their specific characteristics that distinguish them considerably from other obstruents.

[39] Aghem, Beembe, German, Kotoko, Mambila, Teke.

[40] The velar affricates occur in Avar, Chipewyan, Nama, Nganasan and Zulu. The uvular affricates are reported for Archi, Avar, Kabardian, Nez Perce and Wolof.

(43) **Correspondence of Place of articulation** (A = affricates, P = plosives, F = fricatives)

A	+	+	+	+	+	+	+	+
P	+	-	+	-	+/-	-	+/-	+/-
F	+	+	-	-	+/-	+/-	-	+/-
	11.26%	51%	3.97%	25.50%	1.66%	5.96%	0.33%	0.33%

In 11.26% of the languages, the affricates all have both a corresponding plosive and fricative at the same place(s) of articulation. 51% of the languages display a full correspondence of place of articulation between affricates and fricatives, but not between affricates and plosives. In only 3.97% of the languages, the affricates only have a plosive counterpart, and in 25.50% of the cases, the affricate has neither a corresponding plosive nor a corresponding fricative. Among the remaining languages, there are cases where some of the affricates of the language occur at the same place of articulation as plosives, whereas the other ones occur at the same place as fricatives (1.66%), and cases where affricates share at least one place of articulation with only fricatives (5.96%), only plosives (0.33%) or with both (0.33%), but where the other affricate(s) of the language occur at places of articulation where neither plosives nor fricatives are attested in that language. Examples of the observed patterns are given in (44).

(44) **a.** *Affricates have both a plosive and a fricative at the corresponding place of articulation (11.26%).*

p	t	t̪[41]	k
			kʲ
			kʷ
ᵐb	ⁿd	ⁿd̪	ᵑg
	ts	tʃ	
	s	ʃ	

ꞵ

Amuzgo (North American)

b. *Affricates have a fricative at a corresponding place of articulation, but no plosive (51%).*

p		t	k
b		d	
		tʃ	ʈʂ
		ʃ	ʂ

ꞵ ð̪

Tacana (South American)

[41] Palatoalveolar stops, transcribed as [t̪ – d̪] by Maddieson (1984).

c. *Affricates have a plosive at a corresponding place of articulation, but no fricative (3.97%).*

p	t̪	t	k
p̪	t̪	t̪	k̪[42]
		ts	
		t̪s̪	
	s̪		

Javanese (Austro-Tai)

d. *Place of articulation in affricates is not mirrored by plosives or fricatives (25.50%).*

p	t		c	k
		t̠ʂ		
	s	ʃ		
				ɣ

Khanty (Ural-Altaic)

e. *Place of articulation in affricates partially parallels plosives, partially fricatives (1.66%).*

p	t		k
			k^w
	t’		k’
			$k^{w’}$
	ts	tʃ	
	ts’	tʃ’	
	θ	ʃ	
	ß		

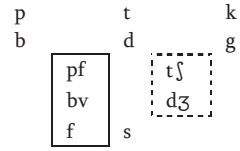
Huasteco (North American)

f. *Affricates partially share their places of articulation with plosives/fricatives, partially they do not (6.62%).*

p	t			c	k	q
p^h	t^h			c^h	k^h	q^h
p’	t’			c’	k’	q’
	ts	tʃ	t̠ʂ			
	ts^h	$tʃ^h$	$t̠ʂ^h$			
	ts’	tʃ’	t̠ʂ’			
	s	ʃ			x	

Jaqaru (South American)

[42] Plosives with a breathy release.



Teke (Niger-Kordofanian)

These numbers indicate that languages may very well have different obstruents at the same place(s) of articulation. Conversely, an affricate may also occur at a specific place of articulation where no plosives or fricatives are attested in a particular language. Table (45) gives an overview of the attested plosives, fricatives and affricates at the different places of articulation. For simplicity's sake, only the voiceless tokens are given.

(45) **Place of articulation of obstruents**

BILAB.	LABIO-DENTAL	DENTAL/ALVEOLAR			PAL. ALVEOLAR	RETROFLEX	PALATAL		VELAR	UVULAR
p	-	t	t	t	t	ʈ	c	c	k	q
-	pf	ts	tθ	tɬ	tʃ	ʈʂ	cç	tɕ	kx	qχ
ɸ	f	s	θ	ɬ	ʃ	ʂ	ç	ɕ	x	χ

Except for the bilabial category, affricates are attested at all places of articulation. When considering the gaps in the bilabial and labiodental category, it is tempting to conclude that there is a complementary distribution between the two: labial plosives are bilabials and labial affricates are labiodentals. However, such a positional trade-off is not immediately apparent in the other cases. Indeed, languages may have plosives where no affricates occur, or the other way round, but yet in other cases, languages may contain up to three obstruents of the same category.[43]

[43] This is common for the dentals/alveolars, palatoalveolars, retroflexes and the sibilant palatals. For the non-sibilant palatal, velar and uvular affricates, these two-way stop-affricate or three-way stop-affricate-fricative patterns are very infrequent. With respect to these patterns, Kehrein (2002) argues that such contrasts involving plain plosives and affricates are in fact nonexistent, and he presents a reanalysis of these cases. We will discuss these issues in the next chapter.

3.6 Voiceless vs. voiced

In UPSID the number of voiceless affricates is higher than the number of voiced ones (cf. (39) above). More precisely, the database contains 688 voiceless affricates against 233 voiced tokens. One of the obvious conclusions to be drawn is that not all languages that have a given voiceless affricate also have its voiced equivalent. The list in (39) did not show, however, what the voicing patterns of affricates across languages exactly look like: to what extent do languages tend to have voicing symmetry among affricates, or to what extent do they prefer to have only a voiceless or voiced affricate? Moreover, how is symmetry or asymmetry of voicing spread across the different places of articulation where an affricate may occur? The distribution of voicing patterns for the different places of articulation where affricates are attested, is illustrated in (46). In order to better differentiate between the different types of dental/alveolar affricates, the sibilants, non-sibilants and laterals have been included as individual categories.

(46)

Labiodental: 6 languages
Only voiced: 2
Only voiceless: 3
Voiced+voiceless: 1

Dental/alveolar (sib): 149 languages
Only voiced: 6
Only voiceless: 92
Voiced+voiceless: 51

(Alveo)palatal:[44] 7 languages
Only voiced: 0
Only voiceless: 5
Voiced+voiceless: 2

Dental/alveolar (non-sib/non-lat): 5 languages
Only voiced: 0
Only voiceless: 4
Voiced+voiceless: 1

Lateral: 24 languages
Only voiced: 0
Only voiceless: 16
Voiced+voiceless: 8

Palatoalveolar: 222 languages
Only voiced: 13
Only voiceless: 102
Voiced+voiceless: 107

[44] In UPSID 1992 this category is labelled "palatal sibilant affricate", and transcribed as [tɕ]/[dʑ] by Maddieson (1984). In order to avoid confusion between these palatal sibilant affricates and their non-sibilant pendants [cç]/[ɟʝ], we will refer to the former as "alveopalatals" and to the latter as "palatal" affricates.

Palatal (non-sib): 12 languages
Only voiced: 0
Only voiceless: 4
Voiced+voiceless: 8

Retroflex: 21 languages
Only voiced: 0
Only voiceless: 16
Voiced+voiceless: 5

Velar: 4 languages
Only voiced: 0
Only voiceless: 4
Voiced+voiceless: 0

Uvular: 5 languages
Only voiced: 0
Only voiceless: 5
Voiced+voiceless: 0

Irrespective of their place of articulation, languages seem to prefer voiceless affricates. For several categories in (46), the number of languages having only the voiceless version of a particular affricate considerably exceeds the number of languages having a symmetrical voicing contrast, and moreover, the number of languages having only the voiced token of that particular category is only marginal. This holds for the dental/alveolar sibilant affricates, and even though restricted in number, it may also hold for the alveopalatal, retroflex and anterior non-sibilant affricates. For the palatoalveolars, the discrepancy between the number of languages having only a voiceless affricate and the number of languages having both a voiced and voiceless version of a given affricate is smaller, but again, the number of languages having only a voiced affricate is substantially lower. As far as the velar and uvular categories are concerned, no languages in UPSID only have a voiced variant or a symmetrical voicing contrast. Instead, only the voiceless affricates are attested at these places of articulation.

With respect to the remaining categories, the picture is slightly different. In the case of the non-sibilant palatal affricates, the number of languages having a symmetrical voicing contrast is somewhat higher than the number of languages having only a voiceless affricate, but again, no language only has a voiced palatal affricate. Finally, even though small in number, the distribution of the labiodentals shows a pattern which is more balanced, but in line with the preceding observations, the number of voiced affricates does not exceed the number of voiceless ones.

Let us now compare the patterns of voicing among plosives, fricatives and affricates in the UPSID languages. The value for the feature [±voice] of affricates proves to parallel closely the specification of plosives for this feature. In 74.83% of the cases, the [voice] setting(s) of the affricate is also present in both fricatives and plosives, and in 23.51% of the languages, the [voice] specification for

affricates can be found among the plosives but not among the fricatives. Only in 0.66% (2 of the 302 languages) is the [voice] value of the affricate(s) also used by the fricatives, but not by the plosives of the language. As for the remaining languages, in two of them (0.66%), the voicing pattern of affricates partially corresponds to the voicing pattern of plosives and/or fricatives, but there is also a [voice] value that is neither present in the fricatives nor the plosives. Finally, only one language (0.33%) displays a pattern that does not correspond to the [voice] settings of plosives and fricatives. The different patterns are illustrated in (47).

(47) **a.** [voice] *value of affricates shared with both plosives and fricatives (74.83%).*

p	t[45]	k
b	d	g
ɓ	ɗ	

ts	tʃ	
dz	dʒ	

f	s	ʃ	x
v	z	ʒ	ɣ

Margi (Afro-Asiatic)

p		t	k	q
b		d	g	

ts	tʃ		

f	θ̪	s	ʃ	x
v		z	ʒ	

Bashkir (Ural-Altaic)

b. [voice] *of affricates parallels* [voice] *of plosives, but not of fricatives (23.51%).*

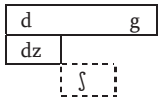
p	t	k
b	d	g

ts
dz

f	s

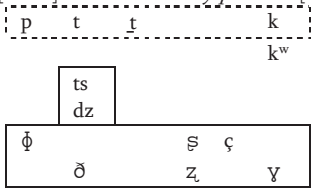
Chamorro (Austro-Tai)

[45] Margi has (unspecified) dento-alveolar stops and alveolar fricatives and affricates.



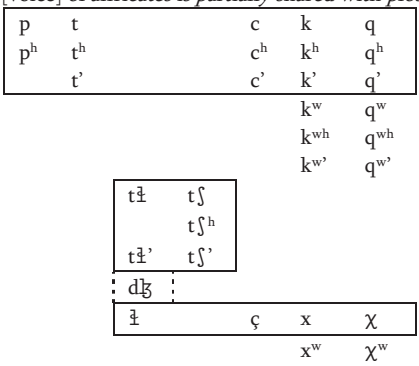
Cherokee (North American)

c. [voice] *of affricates fully parallels* [voice] *of fricatives, but not of plosives (0.66%).*



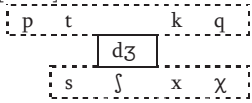
Highland Chinantec (North American)

d. [voice] *of affricates is partially shared with plosives and/or fricatives, partially not (0.66%).*



Haida (Na-Dene)

e. [voice] *of affricates differs from* [voice] *of plosives and fricatives (0.33%).*



Achumawi (North American)

Ohala (1997b) has provided a phonetic explanation for the cross-linguistic dominance of voiceless obstruents. As he states, the crucial condition for voicing to occur, next to the appropriate degree of adduction of the vocal folds, is to maximize the difference between the sub- and supraglottal pressure, which practically boils down to keep the oral air pressure as low as possible (1997b:93).

For plosives, pressure is accumulated in the oral cavity during the obstruction phase while this cannot be easily compensated for by an increase of subglottal pressure, which makes it difficult to maintain vocal fold vibration. For fricatives voicing is even more difficult. During the realization of a fricative, air escapes through a narrow constriction, thus reducing the air pressure in the oral cavity, but in order to produce optimal frication, the oral air pressure needs to be as high as possible. Therefore "[…] voiced fricatives face an inherent problem: for voicing the P_{oral} should be as low as possible, whereas for frication, it should be as high as possible. Obviously, one can't satisfy both demands optimally" (1997b:93). Even though Ohala does not directly address voicing in affricates, his reasoning could be extended to these sounds. As a matter of fact, affricates encounter the problems of voicing in plosives and fricatives at the same time: the oral air pressure during the obstruction phase has to be sufficiently low to produce voicing, but sufficiently high in order to ensure sufficient velocity for the fricative release. Moreover, the experimental study of Zygis & Fuchs (2008) has shown that next to the articulatory complexity, the length of affricates, which is relatively long in comparison with plosives and fricatives (cf. chapter 1), is also a complicating factor, as the transglottal pressure difference has to be maintained longer.

3.7 Sibilant vs. non-sibilant

3.7.1 Frequencies of occurrence

Affricates not only display a clear distributional pattern as far as place of articulation and voicing are concerned, also if we draw a distinction between sibilant[46] and non-sibilant affricates a skewed picture arises, as the numbers in (48) clearly demonstrate:

(48)	Sibilant affricates:	806 occurrences, distributed over 291 languages.
	Non-sibilant affricates:	115 occurrences, distributed over 51 languages. (of which 51 lateral, and 64 non-lateral)

[46] "Sibilance" is defined by Maddieson (1984) as "an acoustic property, referring to a noise spectrum with comparatively strong energy at high frequencies" (1984:42), and includes the anterior coronals [s, z], the palatals [ɕ, ʑ], palatoalveolars [ʃ, ʒ], and retroflexes [ʂ, ʐ]. For more detailed acoustic descriptions of sibilant sounds cf., among others, Kent & Read (1992), Ladefoged (2005).

These numbers show a strong preference for sibilant affricates over non-sibilant ones. Among the sibilant affricates, the voiceless palatoalveolar /tʃ/ is the most frequent one, followed by the dental/alveolar /ts/ (cf. (39) above).

At first glance, this observation seems contradictory to the sibilant patterns for fricatives. That is, as commonly noted, and confirmed by the UPSID languages (cf. Maddieson 1984:41-58), if a language has at least one fricative sibilant, it typically has /s/, and if it has a contrast between anterior and postalveolar fricatives, it typically also has /ʃ/. Yet, the sibilant patterns of the languages in UPSID show that languages with a larger number of sibilants do not tend to build their set of sibilants out of *only* fricatives or *only* affricates. 415 UPSID languages (=92.02%) have at least one sibilant in their inventory. For 123 languages, the sibilant(s) is (or are) only of fricative nature, while 17 languages only have affricate sibilants. In the majority of languages (i.e. 275), fricative and affricate sibilants occur simultaneously. One might wonder whether in these latter cases, there is an interaction between fricatives and affricates. Do fricative and affricate sibilants complement each other as for instance voicing or place of articulation is concerned,[47] or is there no interaction between the two with respect to the dispersion of sibilant structures?

3.7.2 One or two sibilants

In the majority of languages with only one sibilant, this sibilant is a fricative (65 out of 71), which is mostly /s/. Only 6 languages have an affricate as their only sibilant, which are, strikingly, all palatoalveolars /tʃ, dʒ/ (mostly voiceless).

Among the 83 languages with two sibilants, a more balanced pattern arises. Table (49) gives an overview of the patterns attested in these languages.

[47] For instance, does /tʃ/ only occur if the language already has fricative /s/ or even /ʃ/?

(49)

Two-sibilant patterns		Number of languages
I. *2 fricatives*		40
Voice difference	28	
Place difference	10	
Modification difference[48]	2	
II. *1 fricative, 1 affricate*		33
Direct equivalents	6	
Voice difference	3	
Place difference	19	
Modification difference	1	
Voice + Place difference	2	
Voice + Modification difference	-	
Place + Modification difference	2	
III. *2 affricates*		10
Voice difference	6	
Place difference	2	
Modification difference	2	

As follows from the numbers in (49), two main tendencies exist. The first dominant pattern consists of sets of two sibilant fricatives, which in most cases differ for voicing, and in a smaller number of cases the two (voiceless) fricatives have different places of articulation. Occasionally, the sibilant fricatives differ with respect to some segmental attribute, and next to a plain sibilant fricative, the language also contains its modified counterpart, like a laryngealized or labialized fricative. Again, there appears to be a strong dominance of anterior sibilant fricatives.

The second dominant pattern displayed by languages with two sibilants does not consist of languages having only two *affricates*, but rather of languages having one affricate and one fricative sibilant. Three observations can be made with respect to this series. The most frequently recurring pattern is the one containing a fricative and an affricate that are not produced in the same articulatory range. In the majority of these cases, languages have an anterior coronal (dental/alveolar) fricative and a palatoalveolar affricate. In a small number of cases, these place contrasts involve retroflex or alveopalatal fricatives and affricates.

Next to these place oppositions between fricatives and affricates, quite some languages with a two-sibilant fricative-affricate pattern have a direct

[48] "Modification" subsumes all kinds of segmental attributes like secondary articulations, aspiration or ejectivity for instance. Segmental modification will be discussed in detail in section 3.8.

affricate equivalent of their sibilant fricative. In all six cases, the sibilants are the anterior coronals /s/ and /ts/. Other recurrent pairs consist of a voiceless fricative and a voiced affricate, either within or outside the same range of articulation. The different two-sibilant fricative-affricate patterns are illustrated in (50).

(50) **a.** *Place of articulation difference*

s – tʃ
e.g. Ainu (Ural-Altaic), Asmat (Papuan), Picuris (North American), Yaqui (Uto-Aztecan)

ʂ – tʃ
Movima (South American)

s – tʂ
Pohnpeian (Austro-Tai)

b. *Same place of articulation*

s – ts
Guahibo (South American), Huave (North American), Rukai (Austro-Tai)

ʃ – tʃ
Japreria (South American)

c. *Voiceless fricative – voiced affricate*[49]

s – dʒ
Dogon (Niger-Kordofanian)

s – dz
Yareba (Papuan)

Strikingly, as we have already briefly noted above, languages do not tend to have two affricates as their only sibilants (only 10 out of 88 languages with two sibilants). If such a pattern does occur, languages either opt for (i) two affricates that differ for voicing but that share their place of articulation (mostly palatoalveolars); (ii) for a plain and a modified affricate; or (iii) for two affricates with different places of articulation, as shown by the examples in (51).

[49] The reverse structure, i.e. voiced fricative-voiceless affricate, does not occur.

(51)

a. *Voicing difference*	**b.** *Plain vs. modified*	**c.** *Place difference*
tʃ – dʒ	ts – ts^{h}	ts – tʃ
Ache	Iate	Yagua
(South American)	(South American)	(South American)

3.7.3 More than two sibilants

As the number of sibilants in a language increases, the same tendencies seem to recur. Even though theoretically possible, languages do not prefer to have fricatives as their only sibilants, and languages avoid having only sibilant affricates even more. That is, no language with four sibilants or more only has sibilant affricates, and if a language has between three and six sibilants, sets containing only sibilant fricatives only occasionally occur. If a language has seven or more sibilants, it always includes both fricatives and affricates. A summary of the attested patterns is given in (52).

(52)

3 sibilants	**Number of languages**		**4 sibilants**	**Number of languages**	
I. *Only fricatives*		4	**I.** *Only fricatives*		11
Voice difference	-		Voice difference	-	
Place difference	-		Place difference	-	
Length difference	-		Length difference	-	
Modification difference	-		Modification difference	-	
Voice + Place	1		Voice + Place	9	
Voice + Modification	1		Voice + Modification	1	
Place + Modification	1		Place + Modification	-	
Voice + Place + Modification	1		Voice + Place + Modification	1	
II. *Fricatives and affricates*		62	**II.** *Fricatives and affricates*		51
Voice difference	5		Voice difference	2	
Place difference	12		Place difference	9	
Length difference	0		Length difference	-	
Modification difference	10		Modification difference	1	
Voice + Place	24		Voice + Place	20	
Voice + Modification	2		Voice + Modification	6	
Place + Modification	8		Place + Modification	3	
Voice + Place + Modification	1		Voice + Place + Modification	9	
Place + Modification + Length	-		Place + Modification + Length	1	
III. *Only affricates*		1	**III.** *Only affricates*		0
Voice difference	-				
Place difference	-				
Length difference	-				
Modification difference	1				

5 sibilants	**Number of languages**		**6 sibilants**	**Number of languages**	
I. *Only fricatives*		1	**I.** *Only fricatives*		1
Voice difference	-		Voice difference	-	
Place difference	-		Place difference	-	
Length difference	-		Length difference	-	
Modification difference			Modification difference		
Voice + Place + Modification	1		Voice + Place + Modification	1	
II. *Fricatives and affricates*		27	**II.** *Fricatives and affricates*		39
Voice difference	-		Voice difference	-	
Place difference	-		Place difference	3	
Length difference	-		Length difference	-	
Modification difference	-		Modification difference	-	
Voice + Place	11		Voice + Place	16	
Voice + Modification	7		Voice + Modification	-	
Place + Modification	3		Place + Modification	12	
Voice + Place + Modification	6		Voice + Place + Modification	8	
III. *Only affricates*		0	**III.** *Only affricates*		0

7 sibilants	**Number of languages**		**8 sibilants**	**Number of languages**	
I. *Only fricatives*		0	**I.** *Only fricatives*		0
II. *Fricatives and affricates*		19	**II.** *Fricatives and affricates*		17
Voice difference	-		Voice difference	-	
Place difference	-		Place difference	-	
Length difference	-		Length difference	-	
Modification difference	-		Modification difference	-	
Voice + Place	5		Voice + Place	4	
Voice + Modification	-		Voice + Modification	-	
Place + Modification	2		Place + Modification	-	
Voice + Place + Modification	11		Voice + Place + Modification	13	
Place + Modification + Length	1		Place + Modification + Length	-	
III. *Only affricates*		0	**III.** *Only affricates*		0

9 sibilants	**Number of languages**		**10 sibilants**	**Number of languages**	
I. *Only fricatives*		0	**I.** *Only fricative*		0
II. *Fricatives and affricates*		5	**II.** *Fricatives and affricates*		8
Voice difference	-		Voice difference	-	
Place difference	-		Place difference	-	
Length difference	-		Length difference	-	
Modification difference	-		Modification difference	-	
Voice + Place	-		Voice + Place	1	
Voice + Modification	-		Voice + Modification	-	
Place + Modification	2		Place + Modification	-	
Voice + Place + Modification	3		Voice + Place + Modification	7	
III. *Only affricates*		0	**III.** *Only affricates*		0

>10 sibilants	**Number of languages**	
I. *Only fricatives*		0
II. *Fricatives and affricates*		14
Voice difference	-	
Place difference	-	
Length difference	-	
Modification difference	-	
Voice + Place	-	
Voice + Modification	-	
Place + Modification	1	
Voice + Place + Modification	13	
III. *Only affricates*		0

Several additional observations have to made with respect to the above overview. First of all, throughout the entire range of sibilant patterns, the voiceless sibilants predominate. Second, in line with what we have already seen before, languages appear to restrict the number of different places of articulation. Even though a language could in principle include all places of articulation where sibilants may occur, languages tend to limit these positional differences to two or three different (major) places of articulation, and they rather use additional strategies like voicing oppositions, secondary articulations, and in some cases length oppositions.

3.7.4 Contrastive parameters

The overview in (52) shows that sibilant inventories not only often consist of both fricatives and affricates, but that they often also involve multiple distinctive parameters. Strikingly, these parameters could, if used exhaustively, generate more sibilants than actually present in the language. For a sibilant set consisting of four segments (affricates and fricatives), for instance, one feature (e.g. [place] or [voice]) would suffice; an eight-sibilant set could be created on the basis of two features (e.g. [place] and [voice]), as illustrated by the languages in (53).

(53) **a.** s ʃ
ts tʃ
Campa
(South American)

b. s z
ts dz
Greek
(Indo-European)

c. s ʃ
z ʒ
ts tʃ
dz dʒ
Margi
(Afro-Asiatic)

In reality, such patterns turn out to be rare. Especially when the number of sibilants increases, languages do not tend to have patterns which are as symmetrical or as economical as the ones in (53). In the majority of languages, there is some symmetry among sibilant fricatives and affricates, but only to a certain extent. First of all, it may be the case that the number of affricate sibilants is equal to the number of fricative sibilants, but that the two categories do not display the same differences. Irish (54a), for instance, has a place contrast among fricatives, whereas affricates differ with respect to voicing. Another pattern that arises contrasts fricatives for place of articulation or voicing, whereas affricates differ for some segmental modifier (54b and 54c). Moreover, it may also be the case that the differences among fricatives and affricates parallel each other to a certain extent, while both groups also show a different contrast, as illustrated by Hindi-Urdu and Tigré in (55).

(54) **a.** s ʃ
tʃ
dʒ
Irish
(Indo-European)

b. s̪ ʃ
tʃ
tʃʰ
Phlong
(Sino-Tibetan)

c. s z
ts
ts'
Kiowa
(North American)

(55) **a.**

s	ʃ		
z	ʒ		
	tʃ	tʃʰ	
	dʒ	dʒʰ	

Hindi-Urdu
(Indo-European)

b.

s	z	ʃ	ʒ
		tʃ	dʒ
ts’		tʃ’	

Tigré
(Afro-Asiatic)

In the majority of sibilant patterns consisting of fricatives and affricates, the number of affricate and fricative sibilants are not equal. Either the number of affricate sibilants exceeds the number of sibilant fricatives, or the other way round. These cases are very informative with respect to the preferential structures of affricates and fricatives respectively, as perfect symmetry is excluded by definition. Generally speaking, also in these cases there is a strong tendency noticeable for fricatives to have a dental/alveolar segment, whereas affricates are more inclined towards palatoalveolars. The tendencies we have seen up to now are thus confirmed, but let us nevertheless have a closer look at the patterns that emerge.

First of all, in cases where a language contrasts both dental/alveolar and palatoalveolar fricatives, but only has one affricate, this affricate is again typically a palatoalveolar /tʃ/ (or /dʒ/), as in Hixkaryana for instance (56a). Moreover, if a language has more than one affricate, it is not automatically the case that every fricative sibilant has an affricate counterpart, as in Sedang (56b) where instead of having /ts/ – /tʃ/ symmetrically to /s/ – /ʃ/, there is a voicing opposition among palatoalveolars, or as in Yakut (56c) where only the palatoalveolar fricatives have an affricate pendant.

(56) **a.**

s	ʃ
	tʃ

Hixkaryana
(South American)

b.

s	ʃ
	tʃ
	ⁿdʒ

Sedang
(Austro-Asiatic)

c.

s̪	ʃ
z̪	ʒ
	tʃ
	dʒ

Yakut
(Ural-Altaic)

The other way round, as we have already seen above, languages do not necessarily need to have a given fricative for its affricate counterpart to occur in the first place. This is shown by Iban or Itonama for instance (cf. (57)): languages that lack palatoalveolar fricatives, but that nevertheless have palatoalveolar

affricates. Fricatives and affricates may therefore very well complement each other as far as place of articulation is concerned.

(57) **a.** s
tʃ
dʒ
Iban (Austro-Tai)

b. s
tʃ
tʃ'
Itonama (South American)

Itonama in (57b) shows another recurrent pattern. If a language has more than one affricate, and either only dental/alveolar fricatives or both anterior and postalveolar sibilant fricatives, languages might add affricates first by using segmental attributes (like aspiration or ejectivity) rather than having an affricate equivalent of the different fricatives, as illustrated by the languages in (58). Again, note the dominance of the palatoalveolar affricates.

(58) **a.** s z ʃ ʒ
s' ʃ'
tʃ
tʃ'
tʃʰ
Dakota (North American)

b. s
tʃ tʃʰ
dʒ dʒʰ
Mundari (Austro-Asiatic)

c. s tʃ dʒ
ts' tʃ'
Wintu (North American)

Summarizing so far, the UPSID inventories show that languages are most inclined towards voiceless sibilants and that they typically do not exploit the full range of possible places of articulation. Besides, in a large majority of cases, sibilant patterns consist of both fricatives and affricates. The smaller inventories may contain only fricatives or only affricates, but especially the latter scenario is very infrequent, and the larger the number of sibilants, the more likely it is to find inventories containing both sibilant fricatives and affricates. Moreover, full symmetry between sibilant fricatives and affricates turns out to be rare, and decreases when the number of sibilants increases. Rather, fricatives and affricates (partially) differ for voicing, place of articulation or attributes like secondary

articulations. Typically, the larger the sibilant inventory, the more different parameters are used, and interestingly, this is often a larger number of parameters than theoretically required to generate a given number of sibilants. It thus appears that distributional symmetry among sibilants is somehow blocked and that other, additional, principles govern the contrasts among the two categories of sibilants. We will return to this below.

3.7.5 Affricates and sibilant typology

It has been commonly noted in typological descriptions (Hockett 1955, Fromkin & Rodman 1974, Bright 1978, Maddieson 1984) that languages with sibilants are most likely to have an /s/, which is not only the most common sibilant, but also the most frequently occurring fricative in general. What has gone unnoticed in these studies, however, is how affricate sibilants fit into this picture. As shown above, affricates and fricatives display a different preferential pattern as far as place of articulation is concerned. The UPSID data clearly confirm this preference for the languages with only one sibilant: if it is a fricative, then it is a /s/ or /z/, if it is an affricate, it is most likely a /tʃ/. Also among the languages with larger sibilant sets the same preferences are strongly manifested.

While most existing analyses only focused on typological patterns of fricatives as such, a number of studies also took phonetic aspects into consideration to explain the attested patterns. In order to shed more light on the existing insights and the position of affricates in sibilant sets, we will more thoroughly discuss the phonetically-based study of Padgett & Zygis (2003), and consider to what extent the UPSID 1992 data are compatible with their claims.

To account for the distribution of sibilant fricatives, Padgett & Zygis (2003) propose a phonetic approach, including articulatory, acoustic and perceptual aspects, taking diachronic data from Polish as a starting point.[50] Center of Gravity (COG)[51] measurements of the different sibilants show that /s/ has a very high COG value in comparison with postalveolar sibilants. For the different

[50] Between the thirteenth and the sixteenth century, Polish contrasted dental/alveolar /s/, alveopalatal /ɕ/ (which originated from palatalized dentals) and palatalized palatoalveolars /ʃʲ/. Around the sixteenth century, the palatalized palatoalveolar series changed into retroflexes, a change which seems unmotivated at first sight.

[51] Center of Gravity: "a weighted average frequency, where frequencies at which a fricative has more intensity count more" (Padgett & Zygis 2003:161). In this way, the acoustic resemblances and differences of the different fricatives can be more easily expressed.

postalveolar sibilants, /ɕ, ʃ, ʂ/, the values are relatively close together and even partially overlapping. Given this overlap of the COG values of /ɕ/ and /ʃ/, and of /ʃ/ and /ʂ/ respectively, Padgett & Zygis claim that it is likely that such contrasts are disfavoured, because the sounds are easily confusable.[52] Additionally, from an articulatory point of view, it is argued that /ʃ/ is the least marked postalveolar sibilant, whereas /ɕ/ and /ʂ/ are more marked as they require more articulatory effort: the former because of its inherent palatalization and the latter because of its retroflexion.

The prediction of these acoustic and articulatory characteristics then is that if a language has two sibilants, it either has /s/ and /ʃ/, or if it only has two postalveolar sibilants, it is most likely to have /ɕ/ and /ʂ/. The first pattern contains two articulatory unmarked sibilants which are acoustically not overlapping. The second pattern consists of the two postalveolar sibilants that are the most dispersed in the acoustic domain, and therefore perceptually preferred.[53]

Padgett & Zygis' proposal indeed accounts for the majority of sibilant patterns in UPSID. However, they focus on sibilants in general and they do not draw a clear distinction between sibilant fricatives and sibilant affricates and the relation between the two, as their primary goal is to account for the changes affecting the Polish sibilants. The UPSID data described in the previous sections therefore add to Padgett & Zygis' findings, but also reveal a number of aspects where their analysis requires some refinement.

First of all, Padgett & Zygis state that /s/ is the unmarked anterior sibilant, whereas /s/ – /ʃ/ is the unmarked contrast containing an anterior and a postalveolar sibilant. For fricatives, this is clearly the case. For affricates, however, the pattern is somewhat different. If a language has affricates as its only sibilants, these are typically palatoalveolars, and only exceptionally anterior affricates. This is something we would not expect if we were to take Padgett &

[52] Still, even though this line of reasoning could account for the Polish sound change in the sixteenth century, it is not clear why /ɕ/ originated in the thirteenth century in the first place, as it yielded a perceptually non-optimal contrast.

[53] Their account is modelled in the framework of Dispersion Theory, which is a constraint-based approach like standard Optimality Theory, but which has the deviant requirement that output forms must not be evaluated in isolation, but with respect to other forms that are contrastive in the language. The interaction between SPACE constraints (which specify the degree of perceptual distinctiveness), and *MERGE (which penalizes the collapse of contrasts), determines the actual sibilant contrasts in a language.

Zygis' account very strictly, and it would predict [ts] to be the most frequently occurring sibilant affricate. Moreover, taking into account the sibilant patterns of all the UPSID languages, it seems a *general* tendency of affricates to manifest themselves primarily as palatoalveolars. This general difference in preferential patterns of affricate and fricative sibilants, however, does not follow from Padgett & Zygis' analysis either. Should there be a separate markedness hierarchy for fricative and affricate sibilants? Or is /tʃ/ simply the articulatory preferred affricate? Based on the assumption that sound patterns are articulatory but especially perceptually determined, as in the account under discussion, /tʃ/ might be the perceptually preferred affricate (whereas /s/ is the preferred fricative).[54]

A second aspect that does not follow automatically from Padgett & Zygis' formalization concerns the more fine-grained patterns, in which also contrasts of segmental modification are involved. Dispersion Theory only stipulates which place contrasts are favoured in a given perceptual space, but it is not clear how contrasts with some modifier fit into this picture. Is a postalveolar contrast like /(t)ʃ/ – /(t)ʃʰ/ or /(t)ʃ/ – /(t)ʃ'/ for instance more or less perceptually favoured than /(t)ɕ/ – /(t̠)ʂ/ or /(t)ɕ/ – /(t)ʃ/? The two former patterns, which make use of modifiers instead of place distinctions for a postalveolar contrast, occur far more frequently in the UPSID sample. If typological patterns should indeed be interpreted as perceptual preferences, as Padgett & Zygis do, it would mean that patterns of segmental modification are perceptually the more robust ones. This sounds questionable however, since the distinction between /tʃ/ and /tʃʰ/ or /tʃ'/ seems more subtle than a (postalveolar) place distinction. Obviously, experimental evidence is required. Furthermore, the alveopalatal sibilants /tɕ, dʑ/ are generally relatively rarely exploited by the UPSID languages.[55] In line with the previous observation, however, if a language contrasts two or more postalveolar sibilants it is expected, on the basis of the proposed markedness hierarchy, that this sound would occur more frequently (more or less the same holds for the retroflexes, although they are somewhat more frequent than the alveopalatals). In reality, however, languages rather use other contrasts like voicing or (a series of) segmental modifications. Next to markedness principles,

[54] These fricative and affricate markedness hierarchies must interact, since sibilant patterns may consist of both fricatives and affricates.

[55] It should be kept in mind though that [tʃ] and [tɕ] are perceptually very close together and therefore, it is likely that they have not always been reliably described in the sources on which UPSID is based (cf. Maddieson 1984, Padgett & Zygis 2003 and Clements 2003b).

other mechanisms also seem to be involved here, like the parallel patterning of affricates with respect to other parameters.

This section has discussed the sibilant patterns of the languages in UPSID. We have considered the position of affricates with respect to fricatives, and the different parameters that come into play in sibilant patterns. It has turned out that affricates and fricatives clearly have different preferential structures, and we have addressed several aspects that provide new insight into the structuring of sibilants in languages.

Up to now, we have already seen several times that languages resort to segmental attributes like secondary articulations or aspiration, instead of exhausting all theoretically possible place or voicing contrasts. In the next section we will focus on the behaviour of affricates with respect to these segmental attributes.

3.8 Segmental attributes

In the preceding sections, the terms "modified affricate" and "segmental modification" have already been used several times to refer to characteristics like secondary articulations, aspiration or ejectivity for instance, but without providing a clear definition of this notion. We will adopt the definition provided by Hinskens & van de Weijer (2003a/b), who used "segmental modification" (MOD) as a cover term for a series of segmental attributes, listed in (59).

(59) **Segmental Modification**

Secondary articulation (oral)
labialization
palatalization
velarization
uvularization
pharyngealization

Phonation types (laryngeal)
(pre-)aspiration
breathy voice
with breathy release
laryngealization
ejectivity
glottalization

Nasality
(pre-)nasalization

(Hinskens & van de Weijer 2003a:1046)

188 of the 302 languages with affricates exhibit at least one instance of segmental modification among their obstruents. As far as the distribution across the three different obstruent categories is concerned, a fragmented, but again skewed pattern is derived from the data. Table (60) provides an overview of the attested patterns. An asterisk indicates that this type of obstruent is not involved.

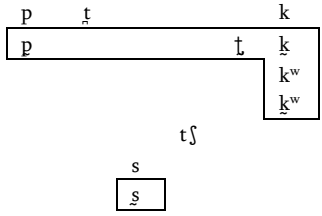
(60) **Patterns of segmental modification**

	Obstruents involved			*Number of languages*
a.	*Mod. I*	*Mod. II*	*Mod. III*	59 (31.38%)
	Plosives	Plosives	Fricatives	
	Fricatives	*Fricatives	*Plosives	
	*Affricates	*Affricates	*Affricates	
b.	Plosives			109 (57.98%)
	Affricates			
	*Fricatives (or only partially)			
c.	Plosives			9 (4.79%)
	Fricatives			
	Affricates			
d.	*Mod. I*	*Mod. II*		1 (0.53%)
	Fricatives	Plosives		
	Affricates	Affricates		
	*Plosives	*Fricatives		
e.	*Mod. I*	*Mod. II*	*Mod. III*	2 (1.06%)
	Affricates	Affricates	Affricates	
	Plosives	Fricatives	*Plosives	
	*Fricatives	*Plosives	*Fricatives	
f.	*Mod. I*	*Mod. II*		3 (1.60%)
	Plosives	Affricates		
	Affricates	*Plosives		
	*Fricatives	*Fricatives		
g.	Affricates			5 (2.66%)
	* Plosives			
	* Fricatives			

In 59 languages, the modifications show two or three different behaviours. Some of the modifiers occur among both plosives and fricatives, some only among plosives and/or others only among fricatives. In these languages, the modifiers never occur among the affricates. As for the remaining 129 languages, different

scenarios emerge. The segmental modifier(s) on affricates can most often also all be found on plosives, but not, or only partially, on fricatives (109 languages). In 9 languages, the modified affricates have an equivalent among both fricatives and plosives. Next, there is 1 language where a part of the modifiers on the affricates of the language can be found on the fricatives (but not on the plosives), whereas the other modifiers on affricates, on the contrary, do occur among the plosives (but not among the fricatives) of the language. Interestingly, the patterns of MOD derived from the UPSID data do not involve instances where all the modifiers found on affricates in a particular language are *only* mirrored by the fricative series but not by the plosives. Equally striking are the cases where a part of the modifiers of affricates also occurs only on plosives, another part only on fricatives, but where there is also a third[56] type which only occurs on affricates (2 languages). Moreover, in 3 languages, a part of the modifiers on affricates is also present on the plosives in that language, but not on the fricatives, whereas the other part of the modifiers only occurs in combination with affricates, but not with plosives and fricatives. Finally, in 5 languages, the modifier of affricates cannot be retrieved among both the plosive and fricative series of the language. Examples of each of the patterns are given in (61).

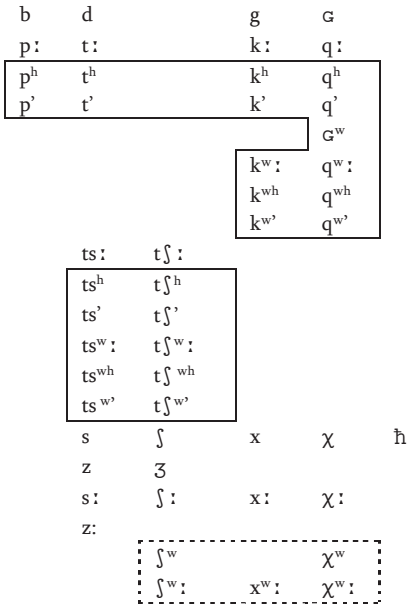
(61) **a.** *Modification of plosives and fricatives, not of affricates (31.38%).*



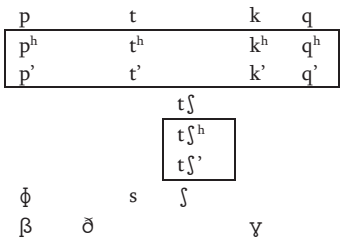
Siona (South American)

[56] Combining the modification types of plosives and fricatives, for instance palatalization and aspiration.

b. *All the modifiers on affricates are also used by plosives, sometimes partially by fricatives (57.98%).*

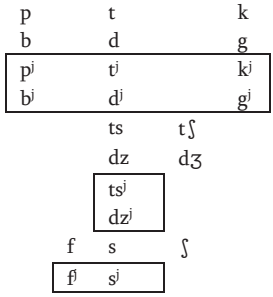


Lak (Caucasian)



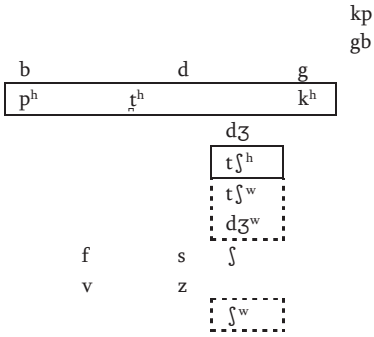
Quechua (South American)

c. *The modified affricates have both a plosive and fricative equivalent (4.79%).*



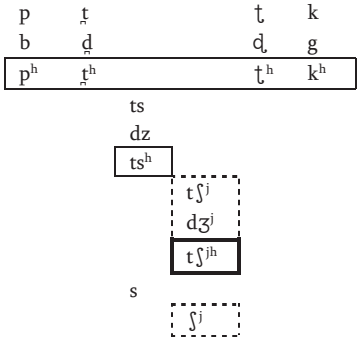
Saami (Ural-Altaic)

d. *A part of the modifiers on affricates is also used by plosives, the other part by fricatives (0.53%).*



Gã (Niger-Kordofanian)

e. *The modifiers on affricates are partially present among plosives and fricatives, partially not (1.06%).*



Kashmiri (Indo-European)

f. *The modifiers on affricates are partially present among plosives, partially not (1.60%).*

p	t		k
	t’		k’
			k^{w}
			k^{w}’
	$t^{\gamma w}$		
t̪θ̪	ts	tʃ	
	tɬ		
t̪θ̪^{h}	ts^{h}	tʃ^{h}	kx^{h}
	tɬ^{h}		
			kx^{wh}
t̪θ̪’	ts’	tʃ’	
	tɬ’		
θ	s	ʃ	x
ð	z		ɣ
			x^{w}
			ɣ^{w}

Chipewyan (Na-Dene)

g. *Modification type only occurs on affricates (2.66%).*

p	t		k
p^{j}			
ts^{h}	tʃ^{h}	ʈʂ^{h}	
	tʃ^{jh}		
s	ʃ		x
β		ʐ	ɣ

Amuesha (South American)

The above overview does not show whether there are modifiers that are more likely to combine with plosives, fricatives and/or affricates, and which would directly explain the patterns in (60). The overviews in (62) list the number of languages with a specific modifier on the different types of obstruents. (62a) is based on all 451 languages in UPSID, (62b) only shows the MOD patterns found in the 302 languages that have affricates.

(62)a. **Modification among obstruents: all UPSID languages**

Modifier	*Affricate*	*Fricative*	*Plosive*	*Total*
Labialization	8	36	76	120
Palatalization	6	17	30	53
Velarization	1	2	3	6
Pharyngealization	1	6	5	12
Aspiration	78	3	115	196
Pre-aspiration	1	1	1	3
Breathy voice	11	2	12	25
Laryngealization[57]	4	6	22	32
Ejectivity	59	10	68	137
Nasalization	0	0	0	0
Pre-nasalization	18	7	53	78
Total	187	90	385	662

b. **Modification among obstruents: UPSID languages with affricates**

Modifier	*Affricate*	*Fricative*	*Plosive*	*Total*
Labialization	8	31	58	97
Palatalization	6	15	24	45
Velarization	1	2	3	6
Pharyngealization	1	4	3	8
Aspiration	78	2	97	177
Pre-aspiration	1	1	1	3
Breathy voice	11	1	12	24
Laryngealization	4	5	18	27
Ejectivity	59	7	63	129
Nasalization	0	0	0	0
Pre-nasalization	18	4	26	48
Total	187	72	305	564

In absolute numbers, the non-affricated plosives most often occur with some kind of segmental modifier, followed by the affricates and finally by the fricatives. The differences between plosives and affricates on the one hand, and plosives/affricates and fricatives on the other are substantial. A comparison between the two tables shows that these differences between affricates and the two other obstruent categories are *not* brought about by a disproportionate number of modifiers on plosives and fricatives in the languages without affricates, as the distributions in the two tables show a similar pattern. The tables

[57] The UPSID search engine classifies the glottalized and uvularized segments among the laryngealized sounds.

also show that there is no modifier that exclusively combines with a particular category of obstruents. Still, aspiration, ejectivity, breathy release and prenasalization combine most often with the non-continuant obstruents, whereas the secondary articulations seem more frequent among the non-affricate obstruents.[58]

This section has considered the different segmental modification patterns in the UPSID languages, and the behaviour of affricates with respect to this phenomenon. Affricates often show the same modification patterns as plosives, but there are also several cases where affricates share their modifiers with fricatives, or where affricates display a type of modification that exclusively occurs on the affricates of the language but not on the other obstruents.

The following section will focus on the final characteristic of affricates that will be considered in this chapter: the distribution of singleton and geminate affricates.

3.9 Singleton vs. geminate

Of the 921 affricates occurring in UPSID, 902 tokens are short (97.9%), and only 19 affricates are described as phonemically long (2.1%). The geminate affricates occur in 4 languages, and these languages also all have one or more singleton affricates. Strikingly however, the patterns of the short and long affricates do not always turn out to be symmetrical as far as their place of articulation is concerned. 2 of the 4 languages with geminate affricates have a singleton equivalent at the same place of articulation. The other 2 languages, however, have some place symmetry among short and long affricates, but yet the other affricates of the language have no corresponding singleton or corresponding geminate counterpart.

Archi and Lak belong to the first group, with short and long affricates at the same place of articulation. Avar and Wichita, on the contrary, belong to the second category. Avar has affricates at four places of articulation (dento-alveolar, palatoalveolar, velar and uvular), but only the dento-alveolars and palatoalveolars occur both as singletons and geminates. The velar and uvular affricates only occur as geminates. Conversely, Wichita has affricates at two

[58] It is not unlikely that affricates avoid secondary articulations because their articulation already is relatively complex in comparison with plain plosives and fricatives.

places of articulation: its dento-alveolars occur as short as well as long, whereas its retroflex affricate is a singleton without a geminate counterpart.

Geminate affricates thus appear to be very infrequent in the full set of affricate phonemes. Let us next, as for the other characteristics described in the preceding sections, consider the status of geminate affricates with respect to geminate and singleton plosives and fricatives. (63) shows the co-occurrence, or the absence thereof, of geminate affricates, plosives and fricatives.

(63) **Long affricates: presence and absence of long plosives and fricatives**

Language	*Only long affricates*	*Long affricates + long plosives*	*Long affricates + long fricatives*	*Long affricates, long plosives + long fricatives*
Archi (Caucasian)				✓
Avar (Caucasian)			✓	
Lak (Caucasian)				✓
Wichita (N. American)			✓	

Just like no language appears to have only geminate affricates to the exclusion of singleton affricates, no language only has geminate affricates to the exclusion of long plosives and/or fricatives. That is, if a language has long affricates, it also shows a length contrast in some other category of obstruents. Archi and Lak have long affricates, and both long plosives and fricatives, Avar and Wichita, on the other hand, have long affricates and fricatives, but no long plosives. Conversely, one might wonder whether the 302 languages with affricates may have a length contrast among plosives and/or fricatives, but not among affricates. Indeed, this may be the case, as shown in (64).

(64) **(Co-)occurrence of long affricates, long plosives and long fricatives**

Language	*Only long plosives*	*Only long fricatives*	*Only long affricates*	*Long plosives + long fricatives, short affricates*	*Long affricates + long plosives, short fricatives*	*Long affricates + long fricatives, short plosives*	*Long affricates, long plosives + long fricatives*
Archi (Caucasian)							✓
Avar (Caucasian)						✓	
Inuit (Eskimo-Aleut)		✓					
Iraqw (Afro-Asiatic)		✓					
Lak (Caucasian)							✓
Trumai (S. American)		✓					
Wichita (N. American)						✓	
Wolof (Niger-Kordofanian)	✓						
	1	3	0	0	0	2	2

Among the 302 languages with affricates, there are 3 languages with long plosives. 1 of them has no long affricates or fricatives, the other 2 also have both geminate affricates and fricatives. There is a total of 7 languages with long fricatives. 3 of these languages only have long fricatives and no long plosives or affricates; 2 languages have long fricatives and long affricates but no long stops, and the remaining 2 languages contain geminate variants of all three obstruent types. Languages may thus have a length contrast among other obstruents without showing a length difference for affricates.

What does gemination of obstruents, and especially affricates, involve? In UPSID, the geminate nature of sounds is indicated by the addition of the diacritic **:** at the right-hand side of the transcription, as is common practice in phonetics and phonology. Lengthening of plosives entails an extension of the closure phase,

and in the case of fricatives the duration of the constriction increases. For affricates, it is commonly noted that gemination generally involves a lengthening of the plosive part, i.e. [tt͡ʃ] (cf., among others, Laver 1994). Gemination by a lengthening of the fricative part is not non-existent, but extremely rare, and it appears to be accompanied by some degree of lengthening of the closure part. Laver (1994:439) also explicitly differentiates gemination of affricates from affricate repetition. In gemination, the plosive or incidentally the fricative part of the affricate lengthens, whereas in repetition the entire affricate is doubled, e.g. [t͡ʃt͡ʃ]. This distinction seems a sensible one, as in these latter cases there is not a lengthening of a part of the articulation of the affricate, but the entire articulation is repeated. Lengthening of normal stops and fricatives also means a lengthening of the plosive closure or the fricative release, but it never involves a repetitive sequence of two complete articulations. Let us now return to the UPSID languages. For 3 of the 4 languages with geminate affricates (i.e. Archi, Lak, Wichita), it is indeed the plosive part that lengthens. For Avar, on the contrary, the information file accompanying the segment inventory states that geminate affricates in this language rather involve an important lengthening of their fricative portion.[59]

As a matter of fact, phonetically speaking, it is not that surprising that geminate fricatives outnumber geminate stops and affricates cross-linguistically. Lengthening the full closure of stops and affricates is less straightforward from both an articulatorily and aerodynamic point of view. In the case of fricatives, there is a continuous airstream that can be extended more easily. Apparently, the plosive part of the articulation of the affricate is most dominant in the large majority of languages; otherwise, we would expect a higher number of geminate affricates with a lengthened fricative portion.

The distribution of quantitative contrasts among obstruents is the last of the different parameters discussed in the description of the UPSID affricates. Before moving on to the implications of the typological patterns for the phonological representation of affricates, let us first dwell a bit on the alleged influence of feature economy and contrast dispersion in feature inventories, and more specifically in obstruent inventories.

[59] Phonetic data are required to verify whether it is *only* the fricative part that lengthens or whether the plosive part shows some degree of lengthening as well, albeit in a more restricted way than the lengthening of the fricative part.

3.10 Feature Economy and Maximal Dispersion

Recall from section 3.4 that two conflicting views exist as to which mechanisms underlie sound systems, i.e. maximal dispersion and economy of contrastive features. In several relatively recent studies, Clements (e.g. 2003a/b) has shown that abundant evidence can be found in favour of the principle of feature economy in consonant inventories. Ohala (1980) has also argued that maximal dispersion is unlikely to underlie consonant systems. He notes for instance that if such a maximal dispersion in the acoustic space were assumed for consonants, "we should undoubtedly reach the patently false prediction that a seven consonant system should include something like the following set: ɗ, k', ts, ɬ, m, r, |" (1980:185). As Ohala notes, such systems are not attested, but instead, the languages containing more "exotic" consonants have a large number of other consonants as well. Moreover, he argues that:

> "[r]ather than maximum differentiation of the entities in the consonant space, we seem to find something approximating the principle which would be characterized as 'maximum utilization of distinctive features'. Consequently, many of the consonants are, in fact, perceptually quite close – differing by a minimum, not a maximum number of distinctive features". (1980:185)

Let us now briefly consider how affricates, which are seen as relatively "exotic" segments, as can be deduced from Ohala's (1980) quotation above, relate to the principles of economy and dispersion. We will not provide a detailed examination of the two principles, as this would go beyond the scope of this chapter, but we will highlight several striking aspects. Moreover, we will not enter into a discussion on the adequacy of possible feature systems as such, as the aim of this section is only to illustrate the observable effects of the mechanisms of dispersion[60] and economy.

In the preceding sections, we alluded a number of times to several characteristics involving (near) symmetry between plosives, fricatives and affricates, or the apparent lack thereof. As Clements (2003b) notes, symmetry may correspond to feature economy, but symmetry of features does not necessarily imply economy of features. This is illustrated by means of three simple, hypothetical, examples in (65).

[60] With Clements (2003a/b) we assume that sounds that share one or more feature(s) are more similar to each other than sounds that do not.

(65)

a.				**b.**				**c.**			
p	t	k		p	t	k		p	t	k	
b	d	g		b	d			b	d	g	
f	s	x		f	s	x		f	s	x	
v	z	ɣ		v	z						

Clements provides a quantitative measure of feature economy, which gives the quotient of the number of sounds, divided by the number of features (cf. 2003b:289):

(66) $$\text{Economy Index (E)} = \frac{\text{Number of sounds}}{\text{Number of features}}$$

The higher the Economy Index, the more economical the inventory of the language. The value of E increases either by increasing the number of sounds and/or by reducing the number of features. In a maximally economical sound inventory, the number of sounds is equal to 2^n, where *n* represents the number of contrastive (binary) features in the language. Such systems, however, do not exist, as full economy is said to be bound by functional, phonetic constraints. The systems in (65) make use of five distinctive features: [continuant], [voice] and the three (monovalent) places of articulation [labial], [coronal] and [dorsal]. The system in (65a) is fully symmetrical, but also fully economical, as all possible feature combinations are fully exploited. Dividing the number of sounds (12) by the number of features yields an Economy Index (E) of 2.4. The inventory in (65b), which is not fully symmetrical, gives an Economy Index of 10/5=2.0. This does not mean, however, that symmetry always goes hand in hand with economy. Sound system (65c) is fully symmetrical, yet less economical than the systems in (65a) and (65b): 9 sounds divided by 5 features gives an E value of 1.8.

A first basic observation that needs to be made is that all languages have consonants and vowels, but not all languages have affricates. Besides, affricates are generally less common than non-affricated plosives and fricatives. The relatively low frequency of occurrence of affricates is generally seen as a consequence of their articulatory complexity (binarity). In a view assuming maximal dispersion of sounds, we would expect to find affricates only in sound systems with a small number of consonants. As we have seen in section 3.4, however, this prediction is not borne out, as the correlation between the number of affricates and the number of consonants turned out significant: the more

consonants a language has, the more likely it is to have affricates, and the more likely it is to have many of them.

A related aspect that merits attention is the fact that even though languages may contain up to 24 affricates, they typically do not exploit the full range of places of articulation where affricates are attested: languages that have a higher number of affricates have them at maximally four different places, and moreover, languages display a strong preference for coronal affricates. Besides, place features (e.g. [labial], [coronal], [dorsal]) used contrastively in the language tend to be used for affricates as well, which rather leads us into the direction of economy. This does not mean, however, that no perceptual aspects come into play, but they seem more subtle than maximal dispersion predicts. For instance, as we have seen, in the labial range, we find bilabial plosives but labiodental affricates

To put it in a very general way, the higher the number of consonants in a language, the more likely it is to have affricates that show voicing or length contrasts, secondary articulations or other modification types within a limited range of places of articulation, and moreover, these are typically features that are also found among other segments of the language. In line with economy, features thus tend to be reused to generate a larger number of sounds. A number of comments are in order, however. First of all, this economy is often far from fully exhaustive. Recall from the discussion of sibilant inventories in section 3.7 that the feature combinations that appear to be used, could in theory generate a larger number of sounds. Second, our examination of affricates clearly shows that Feature Economy is bound by phonetic constraints. Although languages may have a voicing contrast among plosives and/or fricatives for instance, affricates less frequently show a voiced set in such cases, which is, as we have seen, due to the conflicting aerodynamic requirements that a voiced affricate entails. Finally, there is a dispersion-related characteristic that may regulate the distribution of affricates that deserves to be mentioned, but which we have not yet considered elaborately. As we will see in the following chapter, affrication may be used as a phonetic strategy to enhance the distinctiveness of two plosives that resemble each other perceptually.

The distribution of affricates thus clearly shows the effects, but also the limitations of economy. Affricates do show economy effects, but these are bound by phonetic constraints that block or prevent unfortunate articulatory or perceptual feature combinations. Instead of maximal dispersion with a maximization of perceptual dissimilarity between sounds, the situation rather

seems to be one of economy of features, where at the same time a phonetic mechanism operates that comes into action when the articulation becomes (too) complex and that assures that there remains *sufficient* (rather than maximal) dissimilarity between sounds.

3.11 Conclusion

This chapter has presented a typological sketch of affricates on the basis of the inventories in the latest version of UPSID. As such, it adds to the relatively few number of existing typological studies and it updates the (conflicting) descriptions based on UPSID 1984. We have considered the behaviour of affricates with respect to place of articulation, voicing, segmental modification and the distribution of sibilant vs. non-sibilant affricates and of singleton vs. geminate affricates. For each of these aspects, a direct comparison has been made with the behaviour of plosives and fricatives respectively. Sometimes, we have found striking resemblances with plosives, sometimes with fricatives (or with both), but yet in other cases, the patterns of affricates were quite different from both plosives and fricatives.

In previous studies, several typological characteristics have been used as evidence for a specific representation of affricates. The next chapter will discuss the validity of these arguments in the light of our own findings, and consider the implications for the representation of affricates. Moreover, it will be examined to what extent a pure stop description (in the sense of LaCharité's 1993, Clements' 1999 and Kehrein's 2002 views) is able to account for the UPSID data, and several challenges for feature geometry will be discussed.

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4

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Theoretical Implications of Typological Patterns

4.1 Introduction

In this second typology-based chapter, the implications of the typological patterns for the formal phonological representation of affricates will be discussed. We will start out by considering the validity of the typology-based arguments in section 4.2. Afterwards, in section 4.3, we will examine to what extent a pure stop approach of affricates, a representation defended by LaCharité, Clements and Kehrein on the basis of UPSID 1984, can adequately account for the contrasts in UPSID 1992. Section 4.4 will discuss a number of typological issues in the light of feature geometry, and the chapter will be concluded in section 4.5.

4.2 Validity of existing arguments

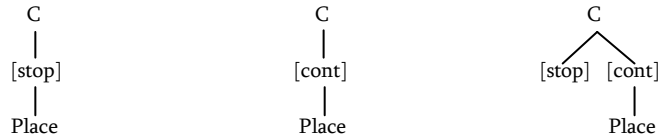
In the theoretical debate on the phonological representation of affricates, several typological characteristics have been used as arguments in favour of different representations. This section will zoom in on these arguments and consider to what extent they are supported by the UPSID data that have been presented in the previous chapter.

4.2.1 Place of articulation

As we have already briefly seen in the previous chapter, in several analyses (i.e. van de Weijer 1996, Hinskens & van de Weijer 2003a/b, van de Weijer & Hinskens 2004), the fact that affricates "typically occur at the same places of articulation as (coronal) fricatives" (2004:218) is put forward as a motivation for the [+continuant] part in their underlying representation. More precisely, the

alleged systematic identical place of articulation of affricates and fricatives is captured by a generalization based on [+continuant]: the two types of obstruents share their place of articulation because they are both [+continuant]. In the geometry proposed in van de Weijer (1996:139), the Place features are directly dependent on this [+continuant] part, as visualized for the different obstruents in (67).

(67)



a. *Plosives* **b.** *Fricatives* **c.** *Affricates*

If we consider the place of articulation data of the UPSID languages (cf. section 3.5), the validity of this argument in favour of a contour segment representation of affricates becomes highly questionable. As shown by the languages in UPSID, affricates indeed rarely have a corresponding plosive at the same place of articulation, while in the majority of cases there is a corresponding fricative. Full correspondence in place of articulation of affricates and fricatives, however, is only attested in fewer than two thirds of the languages with affricates. In the remaining languages, place of articulation does not, or only partially, correspond to place of articulation of fricatives. Besides, affricates may also share their place of articulation with plain plosives, and there is also a considerable group of languages where the affricates neither have a corresponding plosive, nor a corresponding fricative. Therefore, the claim that affricates and fricatives "typically" occur at the same places of articulation leaves numerous patterns unexplained and cannot be considered a solid typological argument in favour of the [+continuant] specification of affricates. Rather, in line with the objection raised by Kehrein (2002), if affricates and fricatives (and/or plosives) occur at the same place(s) of articulation, it is merely because they share their place feature(s), and not because this place feature is dependent on a specific value of the feature [continuant]. If the place of articulation of affricates differs from fricatives (and/or plosives), it is because their place features differ. The place of articulation characteristics can thus be accounted for in a more straightforward and more adequate way

4.2.2 Segmental modification

A second typology-based argument concerns the segmental modification patterns of affricates. The studies of Hinskens & van de Weijer (2003a/b) have shown that segmental modification of consonants typically occurs on natural classes of segments, rather than on a random selection of sounds. In the more elaborate study of the two (2003a), Hinskens & van de Weijer also address the behaviour of affricates with respect to segmental modification (MOD). Departing from the assumption that affricates are complex segments with a specification for both the features [-continuant] and [+continuant], they hypothesize that affricates may pattern with both plosives and fricatives.[61] On the basis of the data of the first version of UPSID, described in Maddieson (1984), they find that affricates and stops typically behave alike as far as segmental modification is concerned. Moreover, their data show that affricates strongly tend not to pattern with fricatives in this respect, which leads Hinskens & van de Weijer towards a stop account of affricates:

> "Our approach also made it possible to investigate the question what position affricates take in consonantal inventories: it turned out that these usually pattern with stops but *not* with fricatives with respect to their MOD pattern. This finding seems to imply that affricates might be looked upon as stops with special characteristics (as also in Jakobson, Fant and Halle's [1952] proposal to regard affricates as "strident stops"). It may also mean that diachronically affricates tend to develop out of stops rather than out of fricatives.
>
> Affricates pattern with fricatives with respect to their place of articulation (van de Weijer 1996). With respect to MOD, on the other hand, they pattern with stops. In this latter connection, we might conclude that our results accord well with recent insights of Steriade [...] and Clements [...], who propose that affricates are stops with certain special properties. Under such a conception, it comes as no surprise that affricates usually pattern with stops rather than fricatives with regard to their type of MOD". (2003a:1073)

Their claim is somewhat overshadowed, however, by a statement interfering in the first line of the concluding section of the above quotation, where they refer to the fact that affricates pattern with fricatives as far as their place of articulation is concerned. Strangely enough, Hinskens & van de Weijer do not discuss how this latter fact relates to the observations they make in their present study, or what it implies for the underlying representation of affricates. That is, the observation on the place of articulation of affricates contradicts their findings

[61] Recall from chapter 2 that in van de Weijer (1996), the place of articulation and secondary articulation patterns of affricates are used as arguments for a complex representation: the overlap in secondary articulations between plosives and affricates is ascribed to the [stop] part, the parallel patterning of affricates and fricatives as far as place of articulation is concerned, is considered the result of a shared [continuant] feature.

of the patterning of affricates with respect to modification.[62] Moreover, in the source to which they refer (van de Weijer 1996), the correspondence in place of articulation of fricatives and affricates is considered an argument in favour of a complex analysis of affricates. Therefore, one might wonder which argument should be seen as the most valuable one: the argument based on modification or the one based on place of articulation? Or do they rather consider both arguments equally important? In the latter case, does it imply that affricates are contours anyhow, as there would be evidence for both [-continuant] (on the basis of MOD) and [+continuant] (on the basis of place of articulation)? If not, and if affricates should indeed be described as stops, how would they account for the symmetry of place of articulation among fricatives and affricates, which they consider an important fact, and which is allegedly based on [+continuant]?

Even though the exact direction of the argument of Hinskens & van de Weijer (2003a/b) is not clear,[63] we have already argued earlier that place of articulation is not a solid argument in favour of either of these views on affricates: [place] and [continuant] are not directly related, it is just because obstruents share a given place feature that they behave alike. As for the segmental modification patterns, in line with the observations of Hinskens & van de Weijer (2003a/b), it indeed appeared that in the majority of UPSID 1992 cases, the modification pattern of affricates is mirrored by plosives. Still, there are numerous cases where the same pattern can also (partially) be found among fricatives, or where affricates (partially) behave differently from the other two groups of obstruents. Considering the modification pattern of affricates as support for a stop approach would then not do justice to the latter two cases. In turn, however, it should not be concluded either that the modification pattern strongly favours a contour description of affricates, since it would leave the asymmetry between affricates and plosives on the one hand and affricates and fricatives on the other unexplained. Moreover, why would affricates sometimes display the same modification as plosives, as fricatives, as both plosives and fricatives or why would they instead behave differently from both plosives and

[62] Furthermore, although they conclude that on the basis of the MOD patterns affricates are stops with some special features, they do not explicitly address the question what these special features look like. They touch upon the original strident stop analysis, but the matter is not explored any further. The remark that affricates tend to develop out of stops does not get any proper attention either.

[63] It is noteworthy that in a follow-up study (van de Weijer & Hinskens 2004), which mainly deals with the question whether there is a relationship between complexity in affricates and other types of segmental complexity like secondary articulations, their previous study is mentioned together with the stop analyses.

fricatives? Their patterning would then either be language-specific, or it would be entirely unpredictable.

This apparently arbitrary situation becomes more meaningful if we adopt a phonetic perspective. Modifiers may first emerge in a language because of specific phonetic conditions (for instance labialization of plosives before a following rounded vowel). As far as their phonetic characteristics are concerned, affricates partially equal plosives, partially fricatives, but at the same time, because of their articulatory duality, affricates also differ from both plosives and fricatives. From a phonetic point of view, it is therefore predicted that affricates sometimes behave plosive-like, sometimes fricative-like, and sometimes differently from both of them. Apparently, their plosive characteristics are more dominant, since, as we have seen, in the majority of cases plosives and affricates show a strong correspondence in their segmental modification patterns. At the same time, it also explains why plosives, fricatives and affricates may take the same modifiers: because of their obstruent-like nature with the corresponding phonetic characteristics. Once the modified segments become phonemes in the language, it is of course very likely that phonological factors come into play, like the symmetry among segment series for instance. However, this is only a secondary issue, and is not responsible for the emergence of a modification pattern as such. Moreover, as we will see below, for a number of cases where the affricate has a modifier which is not shared by the plosives or the fricatives in that particular language, several linguists have argued that the affricate as such is only a modified plosive, with affrication as a *secondary* effect: affrication of the modified plosive arises in order to enhance the perceptual difference with the corresponding plain plosive(s).

Therefore, the argument based on modification patterns as set out in Hinskens & van de Weijer (2003a/b) and van de Weijer & Hinskens (2004), seems not a valid one in favour of a stop account of affricates. It predicts that affricates pattern with plosives, and the cases where they pattern with fricatives or with neither of the other obstruents are left unaccounted for. Instead of making the modification pattern dependent on the phonological value of [±continuant] per se, an explanation that is primarily based on the phonetic characteristics of the obstruents seems to do more justice to reality: we can still understand why affricates mostly pattern with stops, but also with fricatives or independently.

To summarize the discussion up to now, we have seen that two existing typology-based generalizations turned out to be invalid on the basis of the

UPSID 1992 data. Moreover, these (conflicting) arguments did not turn out to be relevant for the simplex-complex discussion. In the case of place of articulation, the behaviour of affricates is not due to a generalization on the basis of [continuant], but on another, independent, place feature that affricates share with plosives/fricatives. In the case of segmental modification, the patterns are not primarily due to phonological considerations, but it is rather because of phonetic factors that affricates pattern with plosives and/or fricatives or not.

Although several arguments used in the past turn out to be invalid, we are still left with the question what affricates phonologically look like. Let us now, after having discussed the typological characteristics of affricates in the UPSID languages, adopt the most recent view on affricates, and examine to what extent a pure stop approach can be applied to this sample.

4.3 Applying a stop account to UPSID 1992

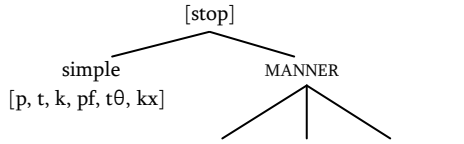
4.3.1 Stop accounts

In LaCharité's (1993), Clements' (1999) and Kehrein's (2002) analyses, the difference between non-affricated and affricated stops is phonologically described in terms of manner or place distinctions.[64] These stop approaches do not recognize a specific feature or structural configuration that serves to distinguish affricates from normal stops underlyingly. In this section, we will apply this pure stop approach to the UPSID 1992 sample, and examine whether its foundations do justice to the UPSID inventories.[65] For convenience's sake, the phonological taxonomy of affricates and stops proposed by Kehrein, which is the most elaborate stop account, is repeated in (68).

[64] Clements (1999) mainly stresses the fact that affricates are phonologically stops, and that the contrasts between plosives and affricates can be described in terms of independently motivated features. He only mentions in passing that characteristics like stridency or place of articulation may be used, but he does not develop this any further. Kehrein (2002), on the other hand, provides a comprehensive taxonomy which should be able to capture all plosive-affricate contrasts.

[65] Like Clements (1999) and Kehrein (2002), the examination is based on the inventories as such, and not on the processes active in the language.

(68)



(Kehrein 2002:8)

4.3.2 Strident and lateral affricates

Let us first of all look at the contrasts between strident and lateral[66] affricates on the one hand, and non-affricated stops on the other. (69) shows the inventory of Burushaski, a language with both non-affricated stops and strident affricates.

(69)

	p	t		ʈ	k	q
	b	d		ɖ	g	
	pʰ	tʰ		ʈʰ	kʰ	qʰ
		ts	tʃ	ʈʂ		
			dʒ	ɖʐ		
		tsʰ	tʃʰ	ʈʂʰ		
	f	s	ʃ	ʂ		χ
		z		ʐ		ʁ

Burushaski (Ungrouped)

The obstruent inventory of Burushaski consists of a set of non-affricated plosives with five different places of articulation, further distinguishing a voiceless, voiced and voiceless aspirated series. Affricates are produced at three places of articulation, and like the plain plosives, they also occur voiceless, voiced and aspirated (with a gap for voiced /dz/). Fricatives occur at five places of articulation, and consist of a plain voiceless series, with a voiced pendant for three of them.

In Kehrein's view on affricates (cf. (68)), and if we assume binary distinctive features, the oppositions between stops, affricate stops and fricatives could be described as in (70). /t/ and /ts/ are both [-continuant], but differ for Manner, the latter being [strident]. The strident stop /ts/ and the strident fricative /s/ share their Manner feature, but differ for [±continuant]. As for the difference between the plosive and the fricative, they first of all differ for continuancy, but obviously also for stridency.

[66] Lateral affricates are clearly distinct from *muta cum liquida* (i.e. consonant-liquid) clusters, which have been much discussed in the light of the sonority structure of the syllable (cf. for instance Vennemann 1988). Syllable patterns show that consonant-liquid combinations may be monosegmental (i.e. lateral affricates) or bisegmental (i.e. genuine *muta cum liquida* clusters).

(70)

/t/	/ts/	/s/
[-cont]		[+cont]
[-strident]	[+strident]	

In fact, the same story holds for the contrasts /ʈ – ʈʂ – ʂ/ and /t – tʃ – ʃ/. The opposition between plosive /t/ and the palatoalveolar /tʃ/ or the retroflex /ʈʂ/ is primarily described as a difference in stridency.[67] The contrasts between the three coronal affricate plosives, which are all strident in this language, involve differences in place of articulation. In the feature geometry presented by Clements & Hume (1995), the end-view of the three-way contrast of strident stops in Burushaski would look as follows (irrelevant features are omitted):[68]

(71)

/ts/	/tʃ/	/ʈʂ/
+strident	+strident	+strident
-continuant	-continuant	-continuant
coronal	coronal	coronal
+anterior	-anterior	-anterior
-distributed	+distributed	-distributed

In the above representation, apical /ts/ is described as [-distributed], a laminal /ts/ would be specified as in [+anterior, +distributed]. The representations in (71) predict that languages may have both apical and laminal anterior coronal sibilant affricates. A search in UPSID indeed confirms that such languages do exist, although they are very infrequent: the only instance of such a language is Tzeltal, a North American language.

Let us now have a look at a language that has, next to non-affricated stops, both strident and lateral affricates. An example of such an inventory is given in (72).

The obstruent inventory of Haida has voiceless plain, aspirated and ejective[69] plosive series (with a gap for labial ejectives). The velar and uvular

[67] Steriade (1994) points to the fact that analogously to the fricative contrast /s/ – /ʃ/, which involves a difference in place of articulation, a contrast between /t/ and /tʃ/ should also be described as a Place difference. As Kehrein notes, however, "[t]his cannot be the whole answer, of course, since other strident affricates clearly contrast with stops at the same place, and even palato-alveolar stop – affricate contrasts exist" (2002:14, footnote 13).

[68] Clements & Hume briefly discuss the position of [strident] in the feature hierarchy: directly under the root node as traditionally assumed or under the coronal place node. They leave the question open for future research, and provisionally adopt the classical assumption, as [strident] is usually not involved in processes of place assimilation (cf. Clements & Hume 1995:293-294).

[69] Ejective stops are realized with a glottalic egressive airstream (cf. Ladefoged 1975:114).

stops also show labialization, labialization and aspiration, and labialization and ejectivity. The affricate stops are all coronal, and all have an ejective counterpart. Only the lateral affricate occurs voiced as well as voiceless, and only the palatoalveolar affricate has an aspirated pendant. Fricatives occur at four places of articulation, and are all voiceless. The velar and uvular fricatives occur both plain as well as labialized.

(72)

p	t		c	k	q
p^h	t^h		c^h	k^h	q^h
	t’		c’	k’	q’
				k^w	q^w
				k^{wh}	q^{wh}
				$k^{w\prime}$	$q^{w\prime}$
	tɬ	tʃ			
	dɮ				
		$tʃ^h$			
	tɬ’	tʃ’			
	ɬ		ç	x	χ
				x^w	$χ^w$

Haida (Na-Dene)

Again, given a pure stop description, the difference between /t/ and the palatoalveolar /tʃ/ is primarily a difference of the Manner feature [strident] (even though both also differ for place of articulation). As far as the contrast between the plain plosive and the lateral obstruents is concerned, /t/ and /tɬ/ are both [-continuant] but can be distinguished by their specification for the Manner feature [lateral]. In turn, the laterals /tɬ/ and /ɬ/ entail a difference in continuancy.

(73)

/t/	/tɬ/	/ɬ/
[-cont]		[+cont]
[-lateral]	[+lateral]	

4.3.3 Non-strident and non-lateral affricates

Up to now, we have seen how the differences between the simple and Manner-specified stops[70] can be accounted for, but we have not yet seen cases where also non-strident and non-lateral affricates are involved. The inventory in (74)

[70] In this study, we will not consider the stops with a specification for the Manner feature [nasal] (cf. (68)), as this category includes the postnasalized stops, which are not part of the sounds that are traditionally labelled “affricates”.

represents a language with plain plosives and non-strident/non-lateral affricates, which in Kehrein's description would both belong to the category of simple stops.

(74)

p		t	k
b		d	g
	t̪θ̪	tʃ	
	d̪ð̪	dʒ	
f		s	ʃ

Luo (Nilo-Saharan)

Luo has bilabial, alveolar and velar plosives, with a voiced and voiceless series. The affricates show the same voicing distinction, and occur at two places of articulation where no plain plosives are attested, i.e. in the dental and palatoalveolar region. Fricatives are labiodental, alveolar and palatoalveolar, and only have a voiceless series. As we have already seen, the distinction /t/ – /tʃ/ involves, in the framework in (68), primarily a difference in stridency. As far as the non-strident affricates are concerned, Kehrein argues that they can result from three different sources:

(75) 1. As free or contextually determined allophones of stops;
2. As the phonetic realization of one laryngeal series (laryngeally driven);
3. In areas of small place contrasts (place driven). (2002:21)

With respect to a contrast /t – t̪θ̪/, as in Luo, Kehrein notes the following:

> "Simple stops do not have any feature combinations that would obligatorily require phonetic sequencing; and yet non-strident affricates do exist. They typically occur in areas of close contrasts […], and most frequently if a language has more than one contrastive place within a single articulator category (LABIAL, CORONAL, DORSAL) […]. Thus, simple stops are realized as non-strident affricates by a phonetic process of PLACE DRIVEN AFFRICATION (PDA). From the perspective of 'recoverability' PDA appears as a perfectly natural strategy because it prolongs and slows down the acoustically important phase of the stop and thus increases the perceptibility of phonological place distinctions. However, PDA is not obligatory even in languages with close place contrasts, and the reason is that there are other competing strategies as, e.g., maximizing place-of-articulation differences". (2002:9)

> "[…] non-strident affricates are not only much rarer than strident affricates in the languages of the world, but […] they never contrast with stops. Interestingly, they often 'nearly contrast', i.e. affricate and stop differ minimally with respect to PLACE". (2002:16)

Indeed, this observation seems to hold here. The plain stop and the non-strident affricate both occur in the (anterior) coronal range, and differ minimally for

place: the former is alveolar whereas the latter is dental. The contrast between /t/ and /t̪θ̪/ can be directly described as a place distinction, and there is no need for [+continuant]. In terms of Clements & Hume's (1995) inventory of distinctive features, the contrasts of Luo plosives and affricates can be captured as follows:

(76)

/t/	/t̪θ̪/	/tʃ/
-strident	-strident	+strident
-continuant	-continuant	-continuant
coronal	coronal	coronal
+anterior	+anterior	-anterior
-distributed	+distributed	+distributed

This representation predicts that languages do not contrast apical /t/, laminal /t̪/ and the non-strident affricate /tθ/, since the latter two sounds would have the same feature representation.[71] As far as the languages in UPSID are concerned, this indeed turns out to be the case. The languages with non-strident /tθ/ have at most one non-affricated plosive equivalent, and in all cases, the plosives and affricates have a different place of articulation, with an apical /t/ and a laminal /tθ/.

Let us next turn to the labial affricates. In Kehrein's analysis, contrasts between labial plosives and labial affricates, which occur in Beembe (77) for instance, are accounted for in a similar way as for the /t/ – /tθ/ contrasts.

(77)

p	t	
p^h	t^h	k^h
pf	ts	
pf^h	ts^h	
f		
v		

Beembe (Niger-Kordofanian)

Beembe has a labial and an alveolar plosive, which both also occur aspirated, and an additional velar aspirated plosive. The labial and alveolar stops are mirrored by the affricates /pf$^{(h)}$/ and /ts$^{(h)}$/, and only the labial affricates have fricative pendants /f/ and /v/. Again, both the labial plosive /p/ and the labial affricate /pf/ belong to the simple stops in Kehrein's description. Analogously to the preceding example where two [-continuant] sounds deprived from a Manner feature occurred in the Coronal region, two non-strident stops now occur in the Labial

[71] Affrication being a result of a non-obligatory process of Place Driven Affrication.

range. Likewise, Kehrein argues that the contrast involves a small place difference: the plain stop being bilabial, the affricate stop being labiodental. As for the contrast between the labiodental plosive (i.e. affricate stop) and the labiodental fricative, the two can be kept apart by [±continuant].

(78)

/p/	/pf/	/f/
[-cont]		[+cont]
bilabial	labiodental	

Others (e.g. Chomsky & Halle 1968, Rubach 1994, Gussenhoven & Jacobs 2005) have described the distinction /p/ – /pf/ in terms of stridency. Clements (1999:282) notes the following:

> "Crosslinguistically, labial plosives are bilabial and labial affricates are labiodental, at least at their release. Thus the same feature that distinguishes bilabial and labiodental fricatives – whether the traditional feature [+strident] or an alternative – can be used to distinguish plosives from affricates".

LaCharité (1993:99) and Kehrein (2002:15) reject a stridency description of the contrast between labial plosives and affricates, because it wrongly predicts a parallel patterning of [pf] and [f] with the sibilant affricates and fricatives, like [ts, tʃ, s, ʃ].[72]

In (78), the bilabial-labiodental opposition has not been expressed in terms of distinctive features, mainly because it is not directly obvious how this place contrast should be formalized, as in feature theory different views coexist as far as the specification of labials is concerned.

In linear SPE phonology (Chomsky & Halle 1968), labiodentals differ from their bilabial counterparts in that they are [+strident] and [-distributed]. Later on, in Clements' (1985) feature geometry, a feature [±labial] was added, and together with the SPE Place features, it was grouped under a single Place node. In Sagey (1986) and Clements & Hume (1995), this Place node was split into a Labial, a Coronal and a Dorsal node, the Labial node dominating [±round]. The feature [±round] distinguishes labial segments made with lip rounding (=[Labial, +round]) from labial segments without this characteristic (=[Labial, -round]). By means of these features, [pʷ] may be distinguished from [p], but it does not

[72] LaCharité and Kehrein strictly focus on the stridency aspect here. Still, it seems that his claim should be attenuated: if a distinction has to be made between the labial affricates and the sibilants, the two groups can of course always be kept apart by means of [coronal].

describe the difference between bilabial and labiodental sounds; a Manner feature like [strident] would then be required instead.

Even though the geometry of the Place node as proposed in Sagey (1986) and Clements & Hume (1995) is often taken as the standard, there are still some feature classifications that include a feature [±distributed], not only under the Coronal node as is common practice, but under the Labial node as well (cf. for instance, Gussenhoven & Jacobs 2005:160-162/2011:188-190). In such a geometry, it is again possible to describe the bilabial-labiodental place contrast by means of [±distributed]: bilabials are specified as [+distributed], labiodentals as [-distributed].

As a matter of fact, a framework of the latter kind seems required to model Kehrein's view. As we have seen, he rejects a stridency contrast for /p/ – /pf/ and defends a place contrast instead. His view can be formalized only in feature frameworks including not only [±round] under the Labial node, but also a feature distinguishing subtle place contrasts within the labial range.[73] (79) gives the specifications of the /p/ – /pf/ contrast, relying on a Labial node with [±round] and [±distributed]. For clarity's sake, the specifications of the /t/ – /ts/ contrast are given as well.

(79)

/p/	/pf/	/t/	/ts/
-strident	-strident	-strident	+strident
-continuant	-continuant	-continuant	-continuant
labial	labial	coronal	coronal
-round	-round	+anterior	+anterior
+distributed	-distributed	-distributed	-distributed

Besides the coronals and labials, UPSID also contains a considerable number of languages where palatal (non-sibilant), velar or uvular affricates contrast with a corresponding plosive. Consider for instance the inventories in (80)-(82), which illustrate these contrasts for each of the places of articulation.

[73] Another alternative might be to specify labiodentals as both Labial and Coronal, and bilabials only as Labial. This seems inappropriate, however, as it would yield a complex place segment, which goes against the assumption that affricates are homorganic entities, contrary to complex place segments like /ps/ or /ks/.

PALATAL

(80)

p		t		c	k
b		d		ɟ	g
			tʃ	cç	
			dʒ	ɟʝ	
		s	ʃ	ç	
	v	z	ʒ	ʝ	

Komi (Ural-Altaic)

VELAR

(81) **a.**

p		t		k
		t’		k’
				k^w
				$k^{w\text{’}}$
		$t^{ɣw}$		
	$t\underline{\underline{\theta}}$	ts	tʃ	
		tɬ		
	$t\underline{\underline{\theta}}^h$	ts^h	$tʃ^h$	kx^h
		$tɬ^h$		
				kx^{wh}
	$t\underline{\underline{\theta}}$’	ts’	tʃ’	
		tɬ’		
	θ	s	ʃ	x
	ð	z		ɣ
				x^w
				$ɣ^w$

Chipewyan (Na-Dene)

b.

p	t	c	k
b	d	ɟ	g
			kx
$\underline{\underline{ð}}$			

Nganasan (Ural-Altaic)

UVULAR

(82) **a.**

p	t̪	t	k		
p’	t̪’	t’	k’	q’	
				qχ	
		s	x		

Nez Perce (North American)

b.

b		d̪					
p^h		$t̪^h$					
p’		t̪’					q’
					g^j		
					$k^{j’}$		
					k^{jh}		
					g^w		
					k^{wh}		
					$k^{w’}$		$q^{w’}$
		ʦ̪					qχ
		ʣ̪					
							$qχ^w$
		ʦ̪’					
f		s̪	ʃ				χ
v		z̪	ʒ				ʁ
f’			ʃ’				
					x^w		$χ^w$
							$ʁ^w$
		ɬ̪^{j}			x^j		
		ɮ̪^{j}			$ɣ^j$		
		ɬ̪$^{j’}$					

Kabardian (Caucasian)

All the examples in (80)-(82) contrast at least a non-strident affricate with a non-affricated stop, and some of them also have corresponding fricatives. While the difference between /ts/, /tɬ/, /pf/ and /tθ/ on the one hand, and their non-affricated plosive pendants on the other, could in a pure stop approach be described as Manner or Place distinctions, the situation becomes more complicated here. That is, do the contrasts /c/ – /cç/, /k/ – /kx/ and /q/ – /qχ/ boil down to differences in Manner or Place of articulation?

(83)

/c/	/cç/	/ç/
[-cont]		[+cont]
?	?	

/k/	/kx/	/x/
[-cont]		[+cont]
?	?	

/q/	/qχ/	/χ/
[-cont]		[+cont]
?	?	

In traditional SPE phonology, [ç] and [x] are [-strident], whereas [χ] is [+strident], and therefore, the contrasts in (83) cannot all be accounted for in a similar way by means of this feature. Maddieson (1984) does not mention a difference of place of articulation in these cases, and neither does Kehrein (2002) assume that in these obstruent series a small place contrast is involved. Actually, Kehrein rejects the existence of the patterns in (83) altogether, and proposes a reanalysis of the languages for which such a contrast has been claimed.

In his view on non-strident affricates (cf. (75)), the velar contrast in Chipewyan (81a) reflects an instance of laryngeally-driven affrication. Chipewyan contrasts plain velar /k/ with ejective /k'/, labialized /k^w/, labialized and ejective /$k^{w'}$/ and the velar aspirated affricates /kx^h/ and /kx^{wh}/. These latter two sounds can be reduced to aspirated plosives, the affrication being a natural phonetic result of aspiration (cf. Kehrein 2002:22, 23).[74] In order to verify this view, we consulted the most recent Chipewyan grammar (Cook 2004) as additional, yet independent, evidence. Indeed, Cook (2004:7-9) distinguishes a plain voiceless, an aspirated and an ejective velar plosive in Chipewyan, and, as a matter of fact, there does not appear to be any objection against a view assuming affrication of the velar aspirated series as a phonetic process of enhancement.[75]

The uvular contrast /q'/ – /qχ/ in Nez Perce (82a) is also considered the result of laryngeally driven affrication, where it is the plain voiceless series that turns into an affricate in order to increase the distinction with the ejective uvular plosive. Similarly, the uvular contrasts in Kabardian (82b) are said to be brought about by the same mechanism. The laryngeal specifications present in the uvular series lead some of the same tokens to change into an affricate, enhancing the laryngeal distinctions. The affricate plosives in the languages in (80)-(82) thus do

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[74] Clements (1999) makes a similar observation on the basis of Nama (Khoisan), which has a contrast /k/ – /kx^h/ – /x/. His claim is mainly based on Trubetzkoy (1969:156-158), who notes the following: "Is it the opposition between plosives and affricates that is phonologically relevant for this pair of phonemes, or is it the opposition between unaspirated and aspirated occlusives? Aspiration cannot be explained as a phonetic consequence of affrication. Conversely, however, affrication may be interpreted as a phonetic consequence of strong aspiration. Consequently it would probably be advisable to consider Nama /kx/ (or more precisely /kx^h/) an aspirated fortis consonant, and the affrication an irrelevant phonetic phenomenon". Moreover, it is worth mentioning here that Ladefoged (1968) comes to the same conclusion on the basis of a typological study of West-African languages.

[75] As shown in (81a), Chipewyan lacks /t^h/, but does have aspirated affricates /ts^h, $tʃ^h$, $tɬ^h$/. It is actually not clear whether some enhancement process is involved here as well, as Kehrein clearly limits the discussion of the processes in (75) to the non-strident affricates. In any case, the coronal plosive-affricate contrasts in this language need to be captured in terms of [strident]/[lateral], because such an enhancement is excluded for the ejectives, as Chipewyan has both /t'/ and /ts', tʃ', tɬ'/.

not behave differently only because of affrication, and neither do they pattern with the strident sounds of the language.

However, the palatal obstruent contrast in Komi (80) and the velar plosive-fricative-affricate contrast in Nganasan (81b), do seem problematic for this approach. As for Komi, the contrast /c, ɟ/ – /cç, ɟʝ/ – /ç, ʝ/ is clearly not brought about by either (75.1) or (75.2), since it has plain plosive, fricative and affricate palatal series: there is no reason for a stop to turn into an affricate because of laryngeal specifications and affricate stops are phonemes and not allophones of an underlying stop. This contrast neither seems to be due to a process of Place driven affrication (75.3), since Komi has both plain palatal and velar plosives: the palatal affricate is thus not the result of a close plain plosive contrast in the Dorsal region that has to be perceptually optimized. The same can be said for the velar contrast in Nganasan: /kx/ is a phoneme, there are no laryngeal contrasts that are phonetically enhanced by means of affrication, nor is there a close place contrast that requires emphasis. A plain plosive and an affricate plosive thus occur at the same place of articulation, and the two sounds do not differ for stridency.

As Kehrein claims, however, these cases constitute only apparent counterevidence to a stop approach of affricates (2002:27), and he presents a reanalysis of the alleged affricates in both languages. As for Komi, he questions the palatal status of the affricates. Based on several phonetic descriptions where the palatal affricates are described as palatalized coronals instead, Kehrein concludes that these palatal affricates are in fact alveopalatals and therefore "Komi is no real counterexample, since contrasting stops and affricates are coronal, the affricates being [strident]" (2002:28).[76] Likewise, the status of the velar affricate in Nganasan is discussed by questioning the reliability of the single source on which Maddieson's (1984) assumption is based. As other descriptions report the sound to have both a labial and velar articulation, and to be a fricative rather than a plosive, Kehrein also does away with this apparent problematic contrast, which leaves him with no counterevidence to his Generalized Stop Approach. According to Kehrein, the attested contrasts among the non-strident affricates are the following (2002:25):

(84)

LABIAL		(anter)CORONAL		DORSAL		
lab	dent	apical	laminal	palatal	velar	uvular
p	p^f	t	$\underset{\sim}{t}\underset{\sim}{\theta}$	cç	k	
					k	qχ

[76] Clements (1999:281) also questions the non-strident release of the affricates in these cases.

Although slightly differing in detail, Clements' (1999) principle of Plosive-Affricate Complementarity stipulates the same as Kehrein's Generalized Stop Approach:

> "[…] given the simple-stop analysis of affricates, a small set of well-motivated features, not including [±continuant], is sufficient by itself to account for all known phonological contrasts between plosives and affricates, with no gaps and no residue". (1999:277)

As a matter of fact, we may thus conclude that the plosive-fricative-affricate contrasts of the UPSID 1992 languages can be adequately described under the assumption that affricates are only 'ordinary' plosives phonologically. Differences between affricates and fricatives indeed boil down to a difference in their specification for [±continuant], differences between affricates and plosives, however, do not need to be explained in terms of this feature. Rather, differences of Manner or Place features are involved, and in a number of cases, the affricate is only the surface result of phonetically-motivated processes.

The taxonomy provided by Kehrein (cf. (68)) thus captures the existing patterns, but at the same time it also entails some predictions that do not fit the frequencies of the typological patterns as such. That is, because both non-affricated plosives and non-strident/non-lateral affricates are described as simple stops, it is expected that both types of simple stops would occur more or less equally often (that is, they would be seen as equally (un)marked); but the affricated "simple" plosives are clearly less frequent than their non-affricated counterparts.[77]

4.4 Representational implications

4.4.1 Phonology vs. phonetics

Our typological search has provided a detailed sketch of the characteristics of affricates in the UPSID languages. Affricates often share characteristics with plosives and/or fricatives, but yet at the same time, they also often strikingly differ from both plosives and fricatives. Crucially, these patterns can only be fully understood by clearly separating phonetics from phonology.

That is, because affricates are combinations of plosives and fricatives phonetically speaking, it is expected that they will show patterns that (partially)

[77] Which, as indicated in section 3.10, is generally ascribed to the articulatory complexity of affricates compared to plain stops and fricatives.

resemble the patterns of normal plosives and (partially) those of fricatives, but precisely because of their binary structure – which clearly differentiates them from the other obstruents –, it is expected that the patterns of affricates may also substantially deviate from those of plain plosives and fricatives. As such, the patterns which relate to different parameters discussed above, i.e. voicing, place of articulation, segmental modification and length, come as natural results. Moreover, not only the differences between the different patterns among obstruents can be accounted for, the inherently variable nature of phonetics also straightforwardly explains the variation found across languages. For instance, some modifiers are more sensitive to plosives, whereas others more easily combine with fricatives. Affricates may attract modifiers that combine with plosives and fricatives, but at the same time, their composite nature may also prevent affricates from hosting modifiers. It depends on the language which segments ultimately become phonologized. Furthermore, as shown by Clements and Kehrein, and confirmed by the UPSID 1992 data, affricates can in specific cases be reduced to underlying stops, with affrication as a purely phonetic effect.

When affricates or affricate patterns become phonemic in the language, phonological aspects can come into play which may adapt the subset of affricates in specific ways (e.g. symmetry among series). A clear distinction therefore has to be made between what should be explained by phonetics and what by phonology. A phonological representation like a contour segment or a stop description simply cannot explain all the attested patterns in the UPSID inventories. And it does not need to. Using the typological patterns of affricate inventories as arguments for specific phonological representations, or departing from a specific representation (e.g. contour or stop) in order to explain the typological patterns, as several existing analyses have done, is not appropriate, and it leaves numerous patterns unexplained. Phonology comes into play when it comes to the question which phonological representation can account for the actual *contrasts* between plosives, fricatives and affricates as such: is a contour approach required to keep series apart and to account for their actual patterning, or can the natural classes be adequately captured by means of a stop account?

4.4.2 Complex vs. simplex descriptions

The typological investigation enabled us to falsify a number of typologically-based arguments, and we concluded that several existing arguments are not informative and even invalid. The correspondence in place of articulation between affricates and fricatives has been used in favour of a complex description of affricates, including two contradictory specifications for the feature

[±continuant]. Modification patterns, in turn, have been used as an argument in favour of a stop description of affricates. As we have argued above, these patterns are not as neat as assumed, and moreover, the generalizations appear ill-based. As such, one of the main arguments used in favour of a complex description of affricates could be eliminated. Crucially, in our subsequent application of a pure stop approach, the most recent but also the most controversial view, to the UPSID sample, we did not encounter major difficulties, and there seems to be no reason for preventing us from adopting such a radical representation of affricates. Affricates differ from fricatives in terms of [±continuant], but they may pattern together because they share Place or [strident] for instance. In order to capture the plosive – affricate contrasts, on the contrary, the feature [±continuant] is not necessary. Rather, the differences between the two boil down (i) to differences in the "Manner" of their release (i.e. [strident] or [lateral]), (ii) to small place distinctions (e.g. labial vs. labiodental, apical vs. laminal) or (iii) to surface results of phonetic processes (e.g. enhancement of a plosive contrast with an aspirated and a non-aspirated segment). Phonetically, affricates thus are plosive-fricative combinations, but phonologically speaking, affricates are stops. These affricate stops are not essentially different from non-affricated stops, and there is in principle no specific device in the universal phonological toolbox that serves to set all affricates apart from non-affricated plosives.[78] It depends on the language in question how the contrasts among the obstruents are exactly captured, according to the taxonomy in (68).

What has not been done in the existing stop accounts is providing an explicit formalization of affricates in terms of features or feature geometry. In the preceding section, we have already considered some feature-related issues, but we will discuss the affricate geometry in more detail in the following subsection.

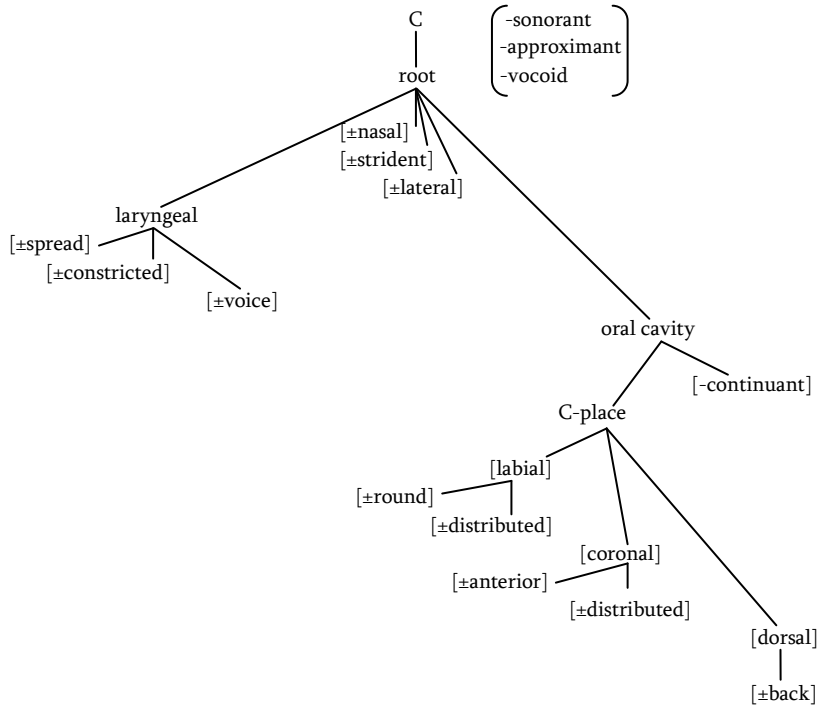
4.4.3 Affricate geometry

Several ingredients are required for our affricate geometry. Obviously, a first essential element is the feature [-continuant]. Second, we need the Manner of release features [strident] and [lateral] (either binary or monovalent) for the strident and lateral affricates respectively. Third, we need Place features that capture the different places of articulation where affricates are attested, ranging

[78] For some languages it may not be "visible" or noticeable that the concept "affricate" as such is not of phonological relevance. If a language has for instance only strident or lateral affricates, the affricated sounds may be referred to as "strident stops" or "lateral stops", and it thus seems as if there were a specific representation exclusively used for affricates. The languages which clearly show that such a concept does not exist are languages which contain several types of affricates: they should be separately referred to by means of different Manner or Place specifications.

from labial to uvular. (85) provides a cover-geometry for non-continuant obstruents, taking Clements & Hume's (1995) feature geometry as a starting point.

(85)

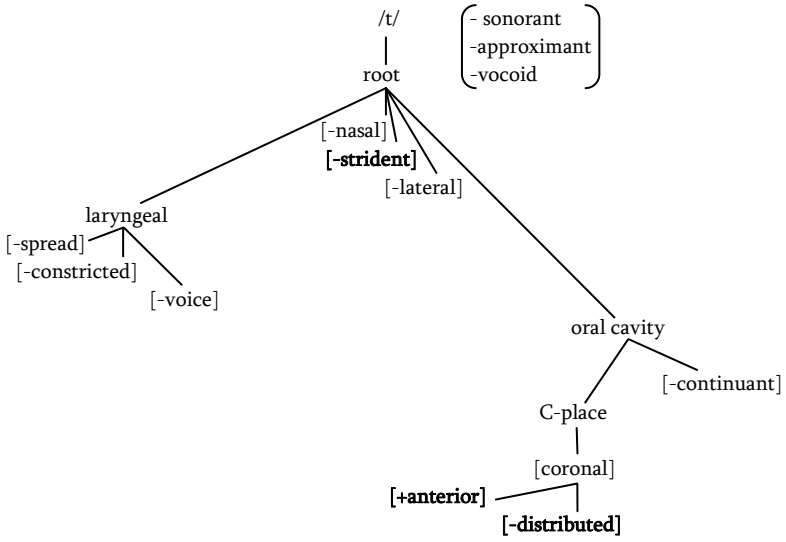


Depending on the feature specifications, the non-continuant segment in (85) may take different shapes. Starting with the direct dependents of the root node, the values of the features [±strident] and [±lateral] indicate whether the stop has a strident or lateral release or not (i.e. strident affricates, lateral affricates vs. non-strident affricates and plain stops). The laryngeal node further specifies the voicing and the glottal (i.e. aspirated vs. non-aspirated) and laryngeal settings (e.g. glottalized vs. non-glottalized) of the obstruent. Descending further in the tree, the oral cavity node only dominates a single value of the feature [continuant]. Finally, the C-place node dominates the monovalent place features [labial], [coronal] and [dorsal]. The representation in (85) basically keeps Clements & Hume's geometry intact, though some slight modifications are required in order to account for the attested patterns. A first adaptation concerns the [dorsal] place node. In order to capture the velar-uvular distinction, this feature should dominate [±back], specifying velars as [dorsal, -back], uvulars as

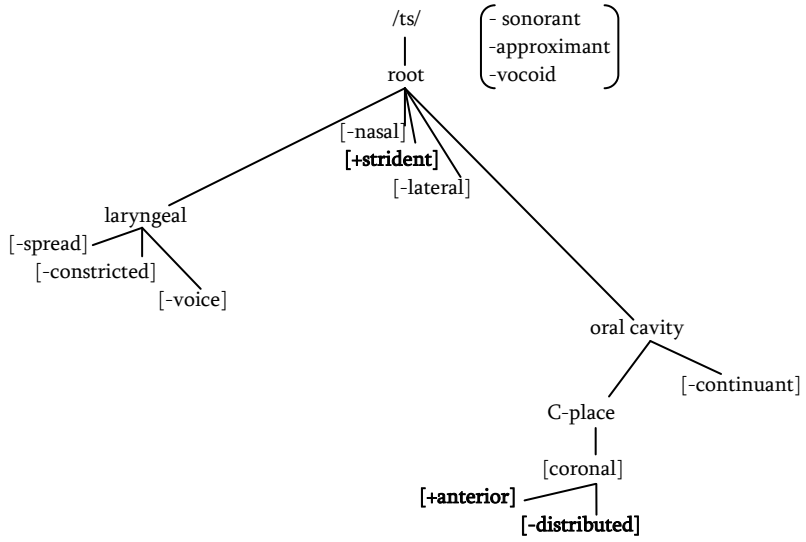
[dorsal, +back]. Other modifications may be required for the [labial] node. We added the feature [±round] in order to describe the contrast between labialized and non-labialized segments, but more importantly, we also added the feature [±distributed]. This latter modification is required if Kehrein is right in stating that the bilabial-labiodental distinction should be interpreted as Place and not as stridency (remember that Clements does not make a decision here).

In order to illustrate more clearly what this geometry looks like for non-affricated and affricated stops, (86) below gives the representations of plain plosive /t/, the strident affricate /ts/ and the non-strident affricate /tθ/.

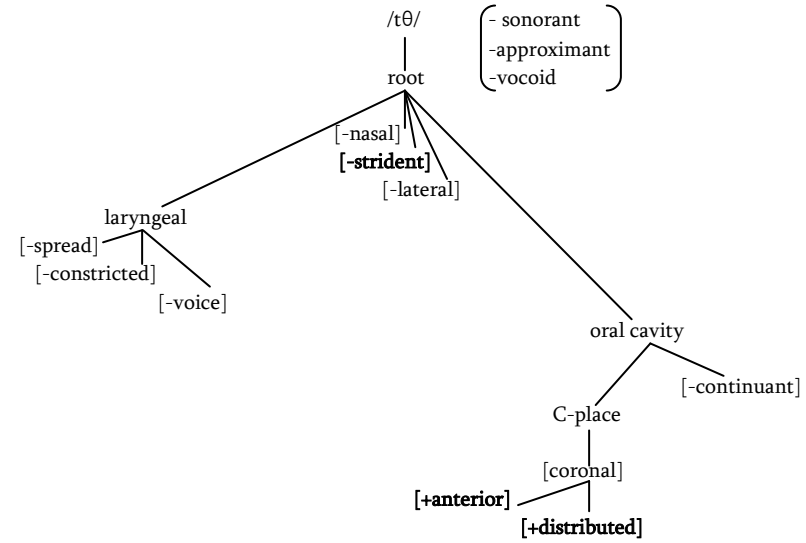
(86) a.



b.

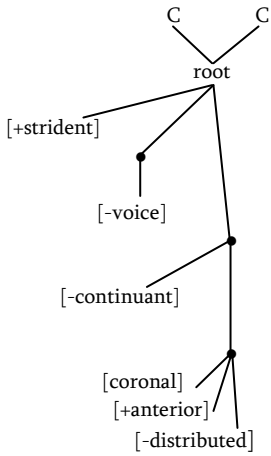


c.



The representations in (86) concern singleton affricates. As far as the geminate affricates are concerned, the representations as such remain the same, but instead of linking to a single timing slot, the root node now links to two slots in the time domain, as shown in (87) for strident /tts/.

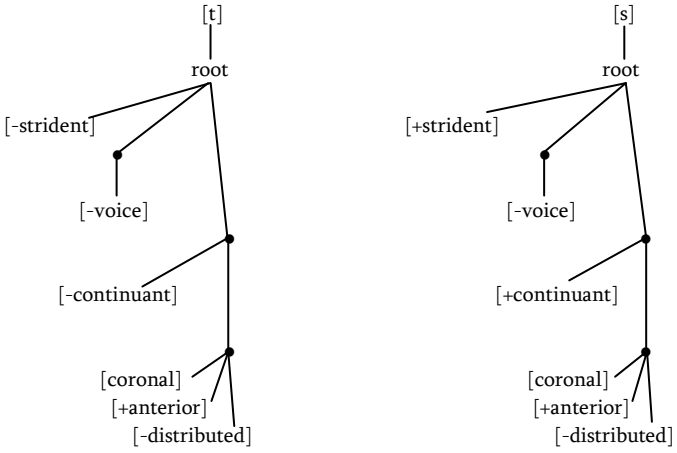
(87) *Geminate affricates*



Such a representation automatically expresses that gemination of affricates always involves some lengthening of the [-continuant] part, and that it is not a doubling of the entire affricate *[tsts] nor only a lengthening of the fricative portion (there is no independent [+continuant] part). In case the fricative part (also) lengthens (as in Avar, as we have seen in chapter 3), this is due to the phonetic implementation of the representation in (87), which may differ from one language to another.

Affricated stops, as phonetic sequences of plosives and fricative articulations, differ from plosive + fricative sequences in that the latter consist of two independent root nodes that each link to a separate timing slot, as shown in (88).

(88) *Plosive + Fricative clusters*



As such, the geometry in (85), describing affricates basically as stops, reflects the typological patterns we have seen and translates Kehrein's, LaCharité's and Clements' views into a more formal representation.

4.5 Discussion and conclusion

In this chapter, we have looked at the formal implications of the typological patterns presented in the previous chapter. We have shown that two typology-based arguments are invalid and ill-based, and we have argued that they should not be used in favour of a specific representation of affricates. Rather, independent features are involved. This does partially away with the existing controversies, because one of the main arguments in favour of a complex description of affricates can be eliminated. Moreover, it has turned out that the contrasts in UPSID 1992 perfectly fit a pure stop description of affricates, and, also taking into account the arguments provided in existing studies, this view seems the most plausible one to adopt at this stage.

Still, the problems concerning the phonological representation of affricates are not yet entirely solved. As followed from the previous section, it is not clear yet how the contrasts between plosives and non-strident affricates should be interpreted exactly: do they involve a difference in stridency and/or Place, and how are these contrasts formally modelled? This automatically leads

us to the question of the definition of the feature [strident]: is it a general manner feature or is it a dependent of the coronal node?

The final chapter of the typological part of this thesis will examine the behaviour of affricates in different phonological processes in the history of French, a language that is particularly interesting with respect to affricate reduction, and because it shows affrication in a typologically uncommon context, i.e. before the low vowel *a*.

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Affricates in the History of French

5.1 Introduction

The segment inventory of Classical Latin did not contain phonemic affricates, and neither does the native vocabulary of contemporary French. In the course of the evolution from Latin to French, several sound changes producing affricates took place. Ultimately, all these affricates were lost by a process of deaffrication.

This chapter focuses on the development and reduction of affricates in the history of French, and discusses the implications of these facts for the phonological representation of these sounds. We will proceed as follows. In section 5.2, we will describe the different processes that gave rise to affricates, and we will consider their general reduction in the thirteenth century. In section 5.3 we will turn to the formal description of the different phenomena in which affricates were involved, and discuss the implications for their phonological structure. We will conclude in section 5.4 by summarizing and evaluating the evidence provided by the French developments, and by proposing a refinement of the description adopted in the preceding chapter.

5.2 The rise and fall of affricates in French

5.2.1 Origins of affricates

The affricates that emerged during the development from Latin to French resulted from a considerable variety of sources, which will be treated separately in the following subsections.

5.2.1.1 Consonant coalescence

The deletion of unstressed vowels in Gallo-Romance created affricates if it took place between a coronal plosive and a sibilant fricative. As noted by Pope (1934:147), the two consonants that became juxtaposed after the erasure of the vowel merged into one single consonant: "[…] the resultant group **t** + **s** was replaced by the affricated denti-palatal **ʦ** […]". Examples are given in (89).

(89)	nāt(u)s	ne[t][s]	ne[ʦ]	*né*	'born'
	nūd(u)s	nu[t][s]	nu[ʦ]	*nu*	'nude'
	portat(i)s	porte[t][s]	porte[ʦ]	*porter,* PRÉS. 2PL.	'to carry, to bear, PRES 2PL.'
	grand(i)s	grãn[t][s]	grãn[ʦ]	*grand*	'big, large, NOM/GEN/VOC SG.'

The number of affricates that originated directly in this way is relatively limited. Indirectly, though, the loss of an unstressed vowel between a palatal consonant and word-final [s], yielded an affricate as well: "**s** *final*, when brought into contact with **j** and **ŋ** by the effacement of an unstressed final vowel in Gallo-Roman was shifted to **ʦ** […]" (Pope 1934:132).

(90)	filius	[filj(u)s]	[filʦ]	[fis] *fils*	'son'
	plaŋgis	[plaŋg(e)s]	[plãints]	[plɛ̃] *plaindre* PRÉS.2SG.	'to pity, PRES 2SG.'

Contrary to the affricates in (89), the ones in (90) did not directly result from the deletion of the vowel. The context that arose after the deletion of the vowel created the conditions for a concomitant change, i.e. the emergence of a plosive element, which is described in the following section.

5.2.1.2 Intrusive stops

Due to the deletion of pretonic and posttonic vowels, the consonantal sequences *-lr-*, *-nr-*, *-mr-*, *-ml-*, *-zr-* and *-sr-* were introduced in the language, later on followed by *-ns* and *-ls* by the end of the sixth century. These sequences were subject to epenthesis, the first instances of this process being attested at the beginning of the fourth century (cf. Matte 1982:90,186). Examples of epenthesis in these sequences (cf. Matte 1982:186) are given in (91), with the sequences resulting in affricates in bold.

(91)	a.	-lr-	molere	[molrɛ]	[mɔɬdrə]	[mudʁ(ə)]	*moudre* 'to grind'
		-nr-	ingenerare	[endʒɛnrarɛ]	[ẽndʒɛndrarə]	[ãʒãdʁe]	*engendrer* 'to engender'
		-mr-	cameram	[kæmbræ]	[tʃæ̃mbrə]	[ʃãbʁ(ə)]	*chambre* 'room'
		-ml-	assimulare	[as:emblarɛ]	[æsemblarə]	[asãble]	*assembler* 'to assemble'
		-zr-	consuere	[kozrɛ]	[kɔzdrə]	[kudʁ(ə)]	*coudre* 'to sew'
		-sr-	essere	[ɛstrə]	[ɛ:trə]	[ɛtʁ(ə)]	*être* 'to be'
	b.	**-ns**	annos	[æn:əs]	[æ̃nts]	[ã(s)]	*ans* 'years'
		-ls	filius	[fill'us]	[fiɬts]	[fis]	*fils* 'son'

5.2.1.3 Palatalization

"Palatalization" refers to the change where the place of articulation of a sound moves towards the hard palate. Generally, this change is induced by a following front vowel or palatal glide: dental or alveolar plosives are raised and retracted towards the palatal region, whereas the place of articulation of velars is moved forward (cf. Bhat 1978; Ladefoged & Maddieson 1996; Ladefoged 2005, among others). Depending on the strength of the influence exerted by the palatalizing sound,[79] a coronal or velar may either get a secondary palatal articulation, e.g. [tʲ]/[kʲ], or become a full palatal stop [c]/[ɟ]. Palatalized plosives are likely to undergo a subsequent process where they turn into an affricate.

In the course of the evolution from Latin to French, two important consonantal palatalization processes occurred. The first one took place during the third and fourth centuries, in the Late Latin period, and is therefore a widespread phenomenon in the Romance languages. It affected dental and velar obstruents, initially before yod, but also before the front vowels [i, e, ɛ] soon afterwards. Examples are given in (92) and (93), cf. Pope (1934:130-131).

[79] Bhat (1978:52) states that "a following front vowel is the strongest environment inducing the fronting (and hence the palatalization) of a velar consonant, whereas a following yod (palatal semivowel) is an even stronger environment for raising (and hence palatalization) an apical consonant".

(92) **Palatalization before yod**

	Classical Latin	*Late Latin*	*Gallo-Romance*	*Modern French*		
a. *Post-consonantal context*						
[kj]	arkionem	[ark'jonɛ]	[arts'jonɛ]	[aʁsõ]	*arçon*	'saddlebow'
[gj]	Georgium	[g'jɔrg'ju]	[dʒɔrdʒu]	[ʒɔʁʒ]	*Georges*	'George'
[tj]	fortiam	[fɔrt'ja]	[fɔrts'ja-fɔrts'jɛ]	[fɔʁs]	*force*	'force'
[dj]	hordeum	[ɔrd'ju]	[ɔrdʒu-ɔrdʒɛ]	[ɔʁʒ]	*orge*	'barley'
b. *Yod preceded by a geminate consonant*						
[k:j]	bisacciam	[bisakk'ja]	[bɛsatts'ja]	[bəzas]	*besace*	'beggar's pouch'
[t:j]	matteam	[matt'ja]	[matts'ja]	[mas]	*masse*	'mass'
c. *Intervocalic context*						
[kj]	*minacia	[minak'ja]	[menatts'jɛ]	[mənas]	*menace*	'threat'
[gj]	corrigiam	[kɔrriɣ'ja]	[kɔrrɛjja]	[kuʁwa]	*courroie*	'belt'
[tj]	rationem	[rat'jonɛ]	[rats'jonɛ-radz'jonɛ]	[ʁɛzõ]	*raison*	'reason'
[dj]	radium	[rað'ju]	[rajju]	[ʁɛ]	*rai*	'ray'

The subsequent evolution of the palatalized consonants depended on the context. In post-consonantal position, the voiceless stops [k^j] and [t^j] and their voiced counterparts [g^j] and [d^j] changed into the affricates [ts] and [dʒ] respectively. Similarly, if the plosive preceding yod was a geminate, it became palatalized and changed into the geminate affricate [tts].

In intervocalic context, however, palatalization was not always followed by affrication. That is, only the voiceless palatalized stops [k^j] and [t^j] were involved in this change. Besides, even though these two consonants were both subject to affrication, they did not develop in the same way: the voiceless velar became a geminate affricate [tts], whereas [t^j] gave a simplex [ts] (which was voiced afterwards to [dz]). Pope (1934:130), among others, attributes the difference between [t] and [k] in this context to the fact that the velar plosive changed into a geminate before affrication took place (and thus showed the same development as the original sequence [k:j] in (92b)). As far as the voiced plosives [d] and [g] in intervocalic context were concerned, affrication was blocked by lenition. Spirantization, which caused the weakening of the occlusion of voiced plosives, prevented the voiced obstruents [g] and [d] from affrication, and they changed into fricatives instead: [g] became [ɣ], and [d] became [ð]. These fricatives were subject to palatalization, but given that they no longer had a complete closure, they were assimilated entirely to the yod.

Contrary to palatalization before yod, the front vowels [i], [e] and [ɛ] only palatalized the velar plosives, but not the dental ones. Examples (cf. Pope 1934:125-129) are provided in (93).

(93) **Palatalization before *i, e***

Classical Latin			*Modern French*		
centum	[kʲentu]	[centu] - [tsentu]	[sɑ̃]	*cent*	'hundred'
mercedem	[merkʲede]	[mercede] - [mertsede]	[mɛʁsi]	*merci*	'thanks'
placere	[plakʲere]	[placere] - [platsire]	[pleziʁ]	*plaisir*	'pleasure'
picem	[pikʲe]	[pice] - [peits]	[pwa]	*poix*	'pitch'
gentem	[gʲente]	[ɟente] - [dʒente]	[ʒɑ̃]	*gens*	'people'
argentum	[argʲentu]	[arɟentu] - [ardʒentu]	[aʁʒɑ̃]	*argent*	'money', 'silver'
reginam	[reɟʲina]	[rejina]	[ʁɛn]	*reine*	'queen'

Again, the further development of the palatalized consonant depended on its context. The voiceless palatalized velar was subject to affrication in word-initial, post-consonantal and intervocalic context. The voiced palatalized velar also resulted in an affricate in word-initial position or when preceded by a consonant. In intervocalic context, on the other hand, the voiced velar was affected by lenition, and the resulting fricative afterwards changed into a palatal glide.

A second phase of velar palatalization became active in the fifth and sixth centuries. As this process only occurred when the Romance languages were evolving independently, it was limited to some of the Gallo-Romance dialects.[80] This time, velars palatalized before Latin *a*, as well as before the diphthong [au̯] (cf. (94a)).[81] The Latin instances of [k] and [g] followed by the front vowels [i, e, ɛ] had disappeared from the language after the first process of velar palatalization was completed, but a number of these sequences were reintroduced in Gallo-Romance by borrowings from other languages (and were mainly from Germanic or Arabic origin, cf. (94b)). These forms were also involved in the process of palatalization, and showed the same development as velars before Latin *a* (cf. Pope 1934:127-129).[82]

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[80] Picard constitutes an important exception as it was not affected by the Second Velar Palatalization: in this variety we find [k] where modern standard French has [ʃ] (cf. Walter 1988:160): *chanter<cantare* ('to sing'), [kɑ̃te] vs. [ʃɑ̃te]; *cheval<caballus* ('horse'), [kəval] vs. [ʃəval]; *vache<vacca* ('cow'), [vak] vs. [vaʃ]. The resistance of Picard against this second palatalization process has often been ascribed to the influence of Germanic languages, which are generally less inclined to palatalization, cf. Haudricourt & Juilland (1970), Spence (1965).

[81] Different explanations have been put forward for the activation of this second phase of velar palatalization. Some of these purely rely on the coarticulatory effects between the consonant and the vowel (e.g. Fouché 1958, Pope 1934), whereas others ascribe the phenomenon to the influence of the Celtic substratum (e.g. Matte 1982, Spence 1965), and yet others, who view the process from a structuralist perspective, invoke chain shift considerations (e.g. Haudricourt & Juilland 1970).

[82] As observed above, the voiceless and voiced velar stops [k] and [g] resulted in [ts] and [dʒ] during the First Velar Palatalization, but in [tʃ] and [dʒ] during the Second Velar Palatalization. The precise outcome of palatalization in the Romance languages is subject to a great deal of dialectal variation,

(94) a.	*Classical Latin*	*Late Latin*	*Gallo-Romance*	*Old French*	*Modern French*
	carrum	[karru]	[kʲarru] – [carru]	[tʃar]	[ʃaʁ] *char* 'cart'
	arcam	[arka]	[arkʲa] – [arca]	[artʃe]	[aʁʃ] *arche* 'arch'
	bacam	[baga]	[baɣʲa]	[baje]	[bɛ] *baie* 'bay'
	buccam	[bukːa]	[bukːʲa] – [bucːa]	[buttʃe]	[buʃ] *bouche* 'mouth'
	gardinum	[gardinu]	[gʲardinu] – [ɟardinu]	[dʒardin]	[ʒaʁdɛ̃] *jardin* 'garden'
	largam	[larga]	[largʲa] – [larɟa]	[lardʒe]	[laʁʒ] *large* 'large'
	ligare	[liɣare]	[liɣʲere]	[leiier]	[lje] *lier* 'to link'
	causam	[kau̯sa]	[kʲau̯sa] – [cau̯sa]	[tʃoz]	[ʃoz] *chose* 'thing'
	gaudium	[gau̯dʲu]	[gʲau̯ju] – [ɟau̯ju]	[dʒoie]	[ʒwa] *joie* 'joy'

b.	*Gallo-Romance*		*Old French*	*Modern French*
	(e)skina	[(e)skʲina] - [escine]	[estʃine]	[eʃin] *échine* 'spine'
	meskinu	[meskʲina] - [mescin]	[mestʃin]	*[meʃin] *meschin* 'young man, servant'

The palatalization of plosives created an important number of affricates in Gallo-Romance and Old French. Let us now turn to the final process creating affricates: the strengthening of the palatal glide [j] in specific contexts.

5.2.1.4 Glide strengthening

The palatal glide [j], which resulted from Latin *i* and from the consonantalization of unstressed high and mid front vowels in hiatus in Late Latin, palatalized a preceding consonant, as described in the preceding section, except when preceded by a labial[83] or in word-initial position. In these latter contexts, the glide was strengthened and turned into [dʒ] in the early years of the Gallo-Romance period, as illustrated in (95) below (cf. Pope 1934:96-97, Niedermann 1953:104-106, Väänänen 1981:50-55).

(95)	*Classical Latin*	*Late Latin*	*Gallo-Romance*	*Modern French*
	caveam	[kaβja]	[kadʒe]	[kaʒ] *cage* 'cage'
	iam	[jam]	[dʒam]	[deʒa] *déjà* 'already'
	rubeum	[robju]	[robdʒe]	[ruʒ] *rouge* 'red'
	sapiam	[sapja]	[saptʃe]	[saʃ] *sache* 'know, 1sg./3sg. subj'

The strengthening of the palatal glide is the fourth and final source of affricates in the historical phonology of French. In the following section, we will turn to the reduction of affricates.

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which we will not consider here as such. For more discussion we refer to, among others, Meyer-Lübke (1890), Fouché (1958), and Calabrese (1993).

[83] Traditionally, it is assumed that labial obstruents cannot be palatalized (cf., among others, Bhat 1978, Pope 1934:120).

5.2.2 Deaffrication

The native vocabulary of Modern French no longer contains phonemic affricates. The reduction of affricates started by the end of the twelfth century in the north of France and spread throughout the other regions of the territory during the thirteenth century (cf. Pope 1934:93, 430; Fouché 1958:625, 780). Deaffrication (cf. (96)) was a general process whereby affricates lost their plosive closure and turned into fricatives.

(96) a.	[ts]	[nets] – [nes]		[ne]	*né*	'born'
	[tʃ]	[tʃar]		[ʃaʁ]	*char*	'chariot, wagon'
	[dʒ]	[dʒẽnt] – [ʒãnt]		[ʒã]	*gens*	'people'
b.	[tj] > [ts] > [dz]		[radz'jonɛ]	[ʁɛzõ]	*raison*	'reason'
	[ke] > [ts] > [dz]		[pladzire]	[pleziʁ]	*plaisir*	'pleasure'
	[ke] > [ts] > [dz]		[peits][84]	[pwa]	*poix*	'pitch'

This general affricate reduction affected all plosives which were by that time part of the language. It is certain that affricates could by then be found in initial and postconsonantal position, but it is actually uncertain what their evolution in intervocalic position has been.

That is, in this context plosive lenition took place (cf. section 5.2.1.3). Between the second and third century, voiced plosives changed into fricatives and ultimately disappeared; between the fourth and sixth century, the voiceless plosives became voiced and afterwards spirantized as well. The voiceless affricate [ts] underwent voicing and changed into [dz] at the same time the non-affricated plosives did; but it is actually not clear whether they took part in the subsequent spirantization and turned into fricatives. The French developments are summarized in (97):

[84] From Latin *picem*: the affricate became final after apocope, and then became voiceless.

(97)	**Spirantization (stage I)**			
[b]>[β]	ha[b]ere - ha[β]ere	'to have'		
[d]>[ð]	au[d]ire - au[ð]ire	'to hear'		
[g]>[ɣ]	ne[g]are - ne[ɣ]are	'to deny'		
	Voicing			
[p]>[b]	sa[p]onem - sa[b]one	'soap'	[ts]>[dz]	[platsire] - [pladzire] 'pleasure'
[t]>[d]	vi[t]am - vi[d]a	'life'		
[k]>[g]	lo[k]are - lo[g]are	'to place, to rent'		
	Spirantization (stage II)			
[b]>[β]	sa[b]onem - sa[β]one	'soap'	[dz]>[z]?	
[d]>[ð]	vi[d]am - vi[ð]a	'life'		
[g]>[ɣ]	lo[g]are - lo[ɣ]are	'to place, to rent'		

Pope is not very explicit about the fate of [dz] in intervocalic position (cf. 1934:93, 125, 263, 268). She seems to date spirantization in instances of the *rationem>raison*-type (i.e. [t]+yod sequences) already in Gallo-Romance (simultaneously with [d] originating from intervocalic [t]), whereas reduction of [dz] originating from [k+i/e] (e.g. *placere>plaisir*), is dated in the Old French period. Moreover, her description of the developments in instances of the *picem>poix*-type shows that the affricate had not yet disappeared when apocope took place. That is, because of the vowel deletion, [dz] moved to word-final position and devoiced to [ts] in Old French, which was afterwards reduced to [s].

Fouché (1958:625), on the other hand, is more explicit about intervocalic [dz] and notes the following:

> "Soit maintenant l'affriquée *dz*. Son evolution a pris deux directions différentes, suivant qu'elle a continué ou non à rester intervocalique, au moment de la chute des voyelles finales.
>
> Lorsqu'elle est restée intervocalique, elle s'est tout d'abord conservée, pour se réduire ensuite à *z* vers la fin du XII^{e} siècle. […]
>
> Mais après la chute de *e* final, l'affriquée *dz* a pu se trouver soit à la finale absolue du mot, soit devant une consonne finale, en l'espèce *t* ou *s*. […] Dans le premier cas, elle a d'abord conservé ses deux éléments mais en les assourdissant; d'où *ts* (écrit *z* en v. fr), lequel s'est réduit à *s* […] vers la fin du XII^{e} siècle. Dans le second cas, l'affriquée *dz* s'est d'abord assourdie au contact de *t* et *s* finals. […] [*ts*] s'est maintenu devant un *s* final, qui s'est fondu avec son second élément, jusque vers la fin du XII^{e}".[85]

[85] Let us consider now the affricate *dz*. Its evolution has taken two different directions depending on whether it continued to be in intervocalic position after the deletion of final vowels, or not.

If it did remain in intervocalic position, it was first preserved to become reduced to *z* by the end of the twelfth century.

Fouché thus adopts a view where all affricates reduced simultaneously, independently from the way they originated or their position in the word or syllable: spirantization (or frication) for plosives would then be different from spirantization for affricates.

Up to now, the overview of affrication and deaffrication processes in the history of French has been purely descriptive. The following section will focus on the formal modelling of these different phenomena, and more importantly on the implications of the French facts for the phonological representation of affricates as such.

5.3 Affrication and deaffrication: formal modelling

5.3.1 Preliminaries

In the preceding chapter, we provisionally adopted a stop account of affricates, in line with most recent proposals, as the typological sketch did not provide evidence for a contour analysis, nor counter-evidence to a stop description. However, as we have already seen in chapter 2, and as we will see in even more detail in the present chapter, the historical developments of French have been used in favour of a contour description of affricates in a number of existing analyses (Wetzels 1985, Jacobs 1989/1993, Jacobs & van Gerwen 2006).

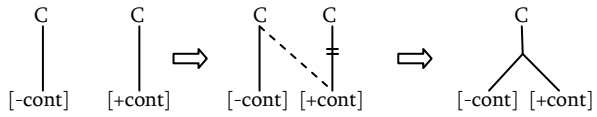
Do the different affrication or deaffrication processes described in the preceding sections indeed force us to adopt a contour (or complex) description of affricates, or can the existing analyses be reformulated in such a way that a stop description can do the job as well? For each of the phenomena described above, we will consider both the existing accounts and possible alternatives, and we will discuss the implications for the representation of affricates in general. Like in the preceding section, let us start by considering consonant coalescence.

But after the deletion of final *e*, the affricate *dz* could become word-final or preconsonantal, in this case preceding *t* or *s*. In the first case, it initially retained its two elements, which became voiceless: *ts* (written *z* in Old French), which was reduced to *s* by the end of the twelfth century. In the second case, the affricate *dz* first became voiceless by the contact with a final *t* or *s*. […] [*ts*] was retained before final *s*, which merged with its following element, until the end of the twelfth century.

5.3.2 Consonant coalescence

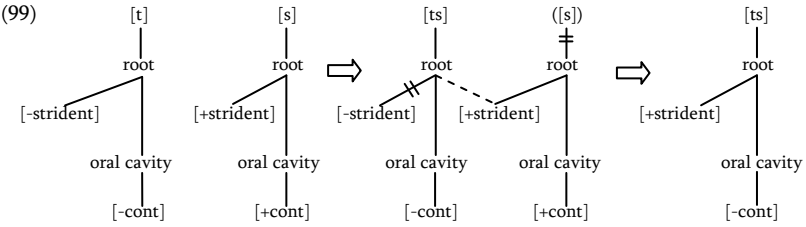
The erasure of an unstressed vowel between a plosive and a fricative caused the two consonants to merge into an affricate. If affricates are considered complex or contour segments, this fusion can be straightforwardly modelled in a non-linear framework. The two [continuant] features of the two consecutive segments become associated with a single C-slot, whereas the other C-position is erased after spreading, as shown in a simplified way in (98).

(98)



In turn, when adopting a (strident) stop approach, the process could be seen as the spreading of the (distinctive) feature [+strident] from the fricative to the preceding plosive (triggering the deletion of its [-strident] value, under a binary view of distinctive features). The creation of this single segment [-continuant, +strident] is accompanied by the erasure of the second C-slot, occupied by the fricative. This operation is visualized in (99), arbitrarily adopting Clements & Hume's (1995) geometry.[86]

(99)



The description in (99), although simplified, leaves one aspect untouched: the position of the feature [strident] in the feature tree, which is crucial for a strict strident stop representation of affricates. Recall from the discussion in the preceding chapter that under a stop representation of affricates, different options are available. The first possibility is to use [strident] as a feature capturing the fricative release of an affricate in general: [p], [t], [k] are [-continuant, -strident], whereas [pf], [ts], [qχ] are [-continuant, +strident]. The second, alternative, stop

[86] Recall from chapter 4 (cf. footnote 62) that Clements & Hume (1995:293-294) leave the question of the exact position of the feature [strident], i.e. directly under the root node or under the coronal place node, open for future research, and provisionally adopt the traditional view of [strident] as a direct dependent of the root node.

approach does not define [strident] as a feature reflecting "affricateness". Rather, the sibilant affricates are characterized as strident stops, but the non-sibilants are distinguishable from plain stops by other independent features, like Place features for instance. In the literature on feature geometry, several proposals have been put forward as far as the exact location of the feature [strident] is concerned. Originally, in Clements (1985), this feature was seen as a direct dependent of the Manner tier, together with the features [nasal] and [continuant]. Depending on the exact flavour of feature geometry adopted, the feature may also find itself as a direct dependent of the Supralaryngeal node (cf. Gussenhoven & Jacobs 2005) or the Root node (cf. Clements & Hume 1995). Yet others do not put [strident] in the upper regions of the feature geometry. Instead, they consider it a feature dependent on the Place feature Coronal (cf. Gussenhoven & Jacobs 1998). For the moment, French does not provide any evidence which would favour the view of [strident] as a place-dependent feature or as a general feature, and as we are only dealing with strident affricates, no choice can be made either between a strident stop description or a pure stop account of affricates. What the process of consonant coalescence does show, however, is that for a stop account of affricates in terms of autosegmental spreading to be possible, the feature [strident] should be able to spread independently of [continuant]: spreading of both features at the same time[87] would still yield a contour segment, explicitly rejected by the adherents of a stop account.

The process of consonant coalescence as such can thus be modelled by means of both a contour segment and a stop description of affricates. However, even though both (98) and (99) express the fusion of two independent segments into a single one, nothing explains what brings about the process of consonant coalescence in the first place. Why would two consecutive obstruent segments turn into a single plosive with a fricative release; why would a [+continuant] or [+strident] part spread and entail the erasure of a segmental timing unit? It is in fact here that we touch upon one of the principal criticisms directed at generative phonology during the past three decades (cf. among others, Ohala 1981, 1983, 1989, 1990, 1995, 1997a/b; Blevins 2004, 2008). Roughly speaking, generative phonology is accused of neglecting the essence of sound change by drifting away from the basic mechanisms involved, and by relying on ill-founded, abstract formal machinery like distinctive features, rules or constraints,

[87] Which would happen in Clements' (1985) geometry by spreading of the Manner tier, subsuming [nasal], **[continuant]** and **[strident]**.

and principles such as markedness or underspecification. Instead, it is argued that any account of sound change should depart primarily from the basic phonetic mechanisms involved. Sound change is seen as non-teleological and may be ascribed essentially to the speaker and/or the listener. Ohala (e.g. 1989) considers all variation found in the speech of the speaker the result of physical constraints (i.e. aerodynamics, muscular control etc.). The listener then has to retrieve the corresponding exemplars in this noisy signal. If listeners misperceive certain elements on a large scale, sound change may eventually be the result. In this respect, Ohala (1989) distinguishes three sources of listener-related sound change: (i) confusion of similar sounds, (ii) hypo-correction (i.e. noise is incorrectly not filtered out, and the perceived form comes to be used as the new pronunciation norm) and (iii) hyper-correction (i.e. corrections are applied where they are not required). A slightly different, yet essentially identical typology of sound change is proposed in Blevins (2004). She distinguishes three possible sources of sound change, which are listed and summarized in (100), cf. Blevins (2004:32-33).

(100)

Change:	Because of **perceptual similarities**, a phonetic signal uttered by the speaker may be **misheard** by the listener. For instance, [anpa] may be perceived as [ampa].
Chance:	The listener **correctly perceives** the acoustic form, but because of **coarticulation effects**, the process of segmentation may become ambiguous. Sound change arises if the listener associates the phonetic form with a phonological representation that differs from the phonological representation of the speaker. For instance, the speaker pronounces [ʔa̲ʔ] which is in his grammar associated with underlying /aʔ/. The listener indeed perceives [ʔa̲ʔ], but, contrary to the speaker, he links it to the phonological form /ʔa/
Choice:	A single phonological form corresponds phonetically to **multiple variants** in the realizations of the different speakers of the speech community because of different degrees of **hyper- or hypoarticulation**. These variants are correctly perceived by the listener, but due to this variation, it may be the case that the listener associates an underlying form to these allophones which deviates from the phonological form in the grammar of the speaker. For example, for the speaker's underlying /kakata/, he or she produces [kakáta], [kăkáta] or [kkáta]. The listener perceives all these forms correctly, but he chooses an underlying form which is different from the underlying form in the speaker's grammar, for instance /kkata/.

If this essentially phonetically-based view on sound change is applied to consonant coalescence, the following scenario could be considered. Phonetically, bisegmental [t][s] and monosegmental [ts] are very close. Perceptual confusion is likely to arise, especially when the length of the cluster is somewhat shortened, which may cause [t][s] to be heard as monosegmental [ts]. If speakers misproduce and/or listeners misperceive the bisegmental sequence on a large scale, sound change may eventually be the result, and speakers and listeners will change their mental representations: /ts/ instead of /t//s/. Note that as such no predictions are made as to what the changed representation looks like. That is, the way an affricate is represented phonologically is an aspect of minor relevance: an underlying /plosive+fricative/ sequence either gets replaced by a strident stop or by a [-continuant, +continuant] segment, but the change is primarily brought about by phonetic factors.

Adding a phonetic motivation to the representations in (98) and (99) indeed provides the missing ground for the operations that are visualized. These formalizations then capture in a more abstract way what happens because of phonetic factors, but still, it is not yet possible to choose between a contour or (strident) stop description of affricates.

5.3.3 Intrusive stops

In his analysis of consonant epenthesis in the history of French, Wetzels (1985) makes a distinction between two types of sequences: the ones where the rightmost consonant is a liquid (as in (91a), labelled "type-1"), and the ones where the rightmost member is a non-liquid (as in (91b), labelled "type-2"). The intrusive stop in each of these sequences receives a different formalization, modelled in the framework of non-linear phonology. In the case of the liquid-final sequence, the epenthetic consonant acquires segmental status, in the sense that it occupies a C-slot on its own. The non-liquid-final sequences, on the other hand, are represented as contours on a single C-slot. This dichotomy is motivated, among others, by the fact that the liquid-final type is sensitive to language-specific cluster restrictions, and by the fact that the inserted consonant is not completely predictable from the material from which the surrounding segments are made. For the type-2 sequences, Wetzels adopts the common account that considers the intrusive stop the result of an inappropriate alignment of articulatory gestures. Before considering the details of Wetzels' formalization, let us, for clarity's sake, first briefly present the main aspects of this classical view on epenthesis.

As far as epenthesis in the nasal+obstruent context is concerned, as for instance in English *warmth* which may be realized as *warm[p]th*, Anderson (1976) argues that the stop arises because of an anticipation on the non-nasality of the final obstruent. For the nasal consonant [m], the velum needs to be lowered, whereas for the following oral fricative [θ] the velum has to be raised. If the raising of the velum takes place too early, a stop will be produced:

> "It is thus plausible to imagine that the velum is often raised earlier than necessary – in fact during the portion of the utterance which is otherwise associated with [m]. This corresponds to an anticipatory extension of the domain of the following [-nasal] specification […]. This shift in the domain of nasality has the consequence not of creating a new segment, but of creating a period of the utterance which belongs partly to one segment, partly to another". (1976:339)

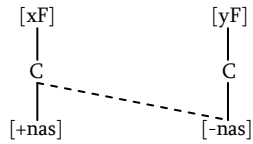
Anderson (1976:340) schematizes this explanation as in (101), again illustrating the sequence /mθ/.

(101)	[…]	m	θ	…]	→	[…]	m	θ	…]	→	[…]	m(p)	θ	…]
Syll.		-	-				-	-				-	-	
Sonorant		+	-				+	-				+	-	
Nasal		+	-				+	-				+	-	
Cont.		-	+		>		-	+		>		-	+	
Labial		+	-				+	-				+	-	
Coronal		-	+				-	+				-	+	
'Voice'		+	-				+	-				+	-	

As noted above, in line with Anderson's reasoning, Wetzels considers the epenthetic stop in a non-liquid-final cluster the result of a retiming of features, because it also explains why the shape of an epenthetic consonant in such a cluster can be fully derived from the neighbouring segments. Moreover, Wetzels notes that this kind of epenthesis is a "low-level phonetic phenomenon" (1985:315), which causes the stop arising in the type-2 context to be less stable and generally shorter in duration than an epenthetic stop arising in the other context. Formally, the retiming of features is seen as the spreading of the feature [-nasal][88] of the rightmost element of the cluster onto the preceding segment, creating a [+nasal, -nasal] contour segment on the first C-slot, as shown in (102).

[88] In this respect, it is interesting to mention Pope (1934:148), who makes the following observation for the epenthesis contexts: "When m and n were brought into contact with l and r in Gallo-Roman by the effacement of an unstressed vowel, pronunciation was facilitated by their partial denasalization and thus m'l>mbl, m'r>mbr, n'r>ndr", and "s *final* juxtaposed to ʎ and ŋ, palatalised to ts" (1934:125). Bourciez & Bourciez (1967:179), on the contrary, do not analyze the intrusive element

(102)



(cf. Wetzels 1985:303)

Clements (1987) adopts the dichotomy between the two types of intrusive stop formation proposed by Wetzels. For both types of epenthesis, however, Clements presents a slightly revised version of Wetzels' analysis, on the basis of data from English. Type-1 intrusive stop formation is essentially seen as a process that improves syllable structure. As far as Wetzels' type-2 intrusive stops are concerned, the context where affricates may arise, Clements recognizes that Wetzels' proposal nicely translates Anderson's description of the anticipation of features into a non-linear framework, and that it expresses at the same time why a type-2 intrusive stop is shorter in duration than a type-1 epenthetic consonant or an underlying stop. Clements argues, though, that the view adopted by both Anderson and Wetzels can only deal with nasal-initial clusters, but not with liquid-initial ones.[89] As he claims (1987:38), in English (e.g. *dense, else*) this seems to be a single phenomenon. Therefore, an alternative view is presented. While adhering to the idea of a mistiming of articulatory gestures, he claims that the intrusive stop is not due to an anticipation on orality, but rather to a *delay* in the release of the *oral occlusion* of the nasal or liquid.[90] This involves the feature [-continuant] and is formalized as the spreading of the oral cavity node of the nasal or liquid onto the following obstruent (cf. (103) below). By this operation, the rightmost member of the original cluster turns into a contour segment. Except for the oral cavity features,[91] all other features of the intrusive stop come from the right-hand member of the cluster.

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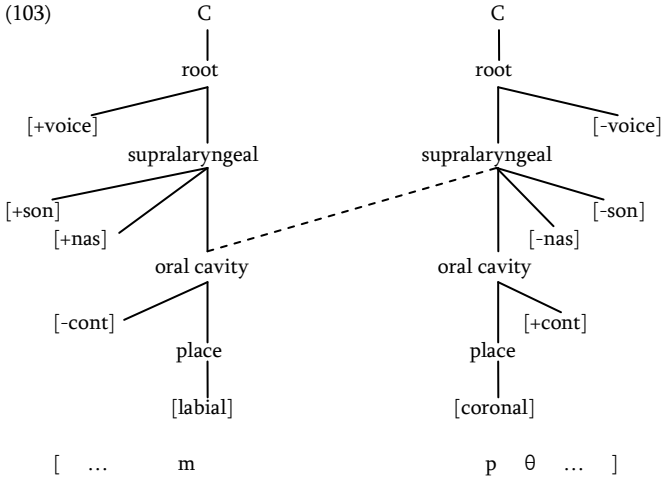
as the result of denasalization, but rather as a transitional sound: "Lorsque l, n, m se sont trouvés devant un r (par effacement d'une voyelle atone), il s'est développé en français un son transitoire, qui a été la dentale d pour les groupes l'r, n'r et la labiale b pour le groupe m'r (ainsi que pour m'l)" [When l, n, m were followed by a r, due to the deletion of an unstressed vowel, a transitional sound developed in French, which was the dental d for the groups l'r, n'r and the labial b for the groups m'r and m'l].

[89] Clements also points to a number of minor difficulties related to the sonorant-spreading and devoicing rules adopted (1987:37-38), but these are of no direct relevance here.

[90] In this respect, Clements (1987:39) refers to Ohala (1975), who has shown that the velum moves more quickly than the tongue body.

[91] As Clements (1987:35-39) notes, this treatment of intrusive stop formation also eliminates the need for a separate rule of place assimilation.

(103)



(Clements 1987:40)

As such, the resulting segment is a [-continuant, +continuant] contour segment. Note that this configuration thus holds for the resulting affricates as well, a conception which Clements would abandon some ten years later, as we saw in chapter 2.

Crucially, as Clements argues, this newly created contour segment plays a role in phonology. Even though the type-2 intrusive stop in a sequence CC does not neutralize the contrast with an underlying CCC cluster,[92] and even though it is an optional rule in English that is only active in certain varieties, Clements argues that if it is active, the intrusive stop is of phonological relevance, because it feeds a later rule of (pre)glottalization. This rule (pre)glottalizes voiceless stops preceded by a tautosyllabic sonorant (1987:34). Consider for instance *camp*, where the final consonant is preglottalized or even fully glottalized, and may be realized as [kæ̃mˀp] or [kæ̃mˀ]. The realization of a word like *warmth* is dependent on the fact whether there is an intrusive element or not. If epenthesis takes place, [wɔrmpθ], the inserted element may trigger (pre)glottalization, yielding [wɔrmˀpθ] or [wɔrmˀθ]. The intrusive stop thus behaves like an underlying stop, as both are subject to (pre)glottalization; if no epenthesis takes place, there is no context for (pre)glottalization to apply.

The dichotomy between two types of intrusive stop formation has been challenged in the years following the publication of Wetzels' and Clements'

[92] It turns out that speakers are able to discriminate between them on the basis of durational differences, which provides additional evidence for a contour analysis.

accounts. Murray (1989) denies the existence of a syllable-based rationale for type-1 intrusive stops, and argues instead that all cases of epenthesis find their origin uniquely in segmental transitions: "The crucial pre-condition for epenthesis is the sequential contact of certain segments regardless of syllable structure. Accordingly, epenthesis represents a similarity adjustment between segments […] and should be placed in this class along with e.g. assimilation, syntagmatic dissimilation, etc." (1989:311-312). A similar position is taken by Ohala (e.g. 1983, 1995, 1997a). Refusing to rely on features as primitives,[93] he accounts for epenthesis in purely phonetic terms. As he argues, the stop that arises consists of phonetic material provided by the surrounding sounds, and given this, he favours the term "emergent" stops over "intrusive" or "epenthetic" stops (1997a:84). This stop emerges because of a hitch in the coordination of opening or closing of two possible exit valves of air, as is the case with nasals and laterals. Nasals require a lowering of the velum, in order to enable the nasal passage of air, whereas the following oral segment requires a raising of the velum to close the nasal passage. If the closure of the velum is somehow mistimed with respect to the opening of the oral passage, i.e. when both exit valves are closed, a stop emerges between the two sounds, which, as the oral occlusion of the nasal is not yet released, has the place of articulation of the first segment in the cluster. An example of epenthesis in the sequence /mθ/ is given in (104).

(104) For CC where C1 is nasal: (Ohala 1997a:86)

Consonants		**Valve A** nasal cavity	**Valve B** oral cavity
C1	[m]	open	closed
Emergent stop	[p]	closed	closed
C2	[θ]	closed	open

A similar scenario holds for the laterals. There are two exit valves that come into play in clusters of a lateral followed by a fricative; the tongue side(s) in the case of the former, and the tongue midline in the case of the latter. If both valves find themselves closed at the same time, again, a stop is created before the closure of the tongue midline is released for the following segment, as illustrated for the sequence /ls/ in (105).

[93] "In fact, one lesson we can derive is that features like [sonorant] and [continuant] are of little use in helping us to understand these cases. […] These features obscure the true nature of the mechanism involved. The problem is that features like [sonorant] and [continuant] are not primitive features for this purpose. They are, in fact, derived from more primitive features which include a specification of the valves and their states in the vocal tract" (Ohala 1997a:90).

(105) For CC where C1 is lateral: (Ohala 1997a:88)

Consonants		**Valve A** tongue side(s)	**Valve B** tongue midline
C1	[l]	open	closed
Emergent stop	[t]	closed	closed
C2	[s]	closed	open

In Warner & Weber (2001) a study is presented demonstrating the variability in the production of epenthetic stops. Moreover, the experiments they conducted show that the likelihood of an epenthetic stop being interpreted as a genuine stop depends on the strength of the acoustic cues present in the signal, and that it is further influenced by language-specific syllable structure constraints.

As a matter of fact, we are facing the same issue here as in the preceding section: an autosegmental representation like the one in (103) gives an abstract visualization of the process involved, but again, the direct motivation is absent. Indeed, a stop arises in a specific context, but there is nothing that directly explains why the process only operates in this environment. In order to fully describe the process, the phonetic basis needs to be taken into consideration, and then, the representation in (103) indeed straightforwardly captures the change in terms of phonological features.

(103) describes the epenthetic plosive element together with the following fricative as a contour segment: [-continuant, +continuant]. Is the contour representation the only adequate analysis, or would it be possible as well to capture the resulting affricate as a (strident) stop?

The elegant aspect of Clements' (1987) formalization is that it nicely expresses that a [-continuant] element is added to an already existing [+continuant] segment, and that the two together form a combination of these two features within a single segment. Modelling the relevant type of epenthesis as strident stop formation in an autosegmental framework would involve the insertion of a [-continuant] element, which comes to be combined with the following [+continuant, +strident] segment. Afterwards, delinking of [+continuant] has to take place (as otherwise a contour segment would result), while [+strident] and all other features are maintained.

But then again, also in the case of this process, one might think of an explanation following Ohala's and Blevins' lines of reasoning, which preserves the underlying idea of a false coordination of articulatory gestures, but which does away with the representational difficulties of an autosegmental analysis. Under such a scenario, a fricative comes to be (systematically) perceived as an

affricate in a specific context, i.e. when preceded by a nasal or lateral. This misperception is likely to arise exactly because a mistiming of articulatory gestures provides a challenge to the listener. If this comes to be the case, it is the representation of a fricative that ultimately gets replaced by the representation of an affricate, which may then either be a contour segment or a strident stop, depending on the way affricates are represented in the language.[94]

5.3.4 Palatalization before front vowels or the palatal glide[95]

Palatalized plosives are likely to undergo a subsequent change where they turn into affricates. A number of linguists have described this latter transition in articulatory terms, as Keating (1993:7) for instance, who ascribes it to the fact that the segments have become more laminal, thus creating the conditions for affrication. Others (e.g. Ohala 1992, Plauché et al. 1997, Guion 1998, Chang et al. 2001, Blevins 2004, Wilson 2006) consider the change of a (fully) palatalized consonant into an affricate the result of perceptual similarity of the two sounds. Both approaches will be discussed in this section.

Formalizations of the first type are articulatory-based and assume that due to coarticulation of the velar consonant with the following vowel or glide, the velar acquires a palatal off-glide. Subsequently, the velar moves further forward, and its primary place of articulation shifts to the coronal region (cf. Pope 1934; Fouché 1958; Bourciez & Bourciez 1967, and for a feature geometry-based approach, Lahiri & Evers 1991; Calabrese 1993; Jacobs 1993; Clements & Hume 1995). The different proposals accounting for palatalization in articulatory terms share the fact that the phenomenon is essentially considered the result of assimilation.[96] As it is not our aim to provide an exhaustive overview of the articulatory-based analyses that have been put forward, this section will only randomly describe a number of them in order to illustrate the basic mechanism these analyses adopt.

Clements & Hume (1995:294-296) describe the palatalization process in two stages. In the version of feature geometry they present, front vowels are specified for the feature [coronal]. In the first stage, the coronal V-place node of the front vowel spreads to the preceding velar, where it is attached as a

[94] Evidence for the choice between these two representations then has to be provided by the patterning of these affricate sounds in phonological processes.

[95] Parts of sections 5.3.4 and 5.3.5 are published in Jacobs & Berns (2013).

[96] The different proposals differ in detail though, as they do not all adopt the same version of feature geometry.

secondary articulator node, resulting in a velar with a secondary palatal articulation [kʲ]. Tier Promotion then subsequently causes the deletion of the Dorsal C-place node of the velar and promotes the secondary Coronal V-place node to primary articulator, resulting in [c]/[tʃ].

In Jacobs (1989), Jacobs & van de Weijer (1992) and Jacobs (1993), front vowels and the palatal glide [j] are specified for a Coronal as well as a Dorsal place feature, instead of for Dorsal only (as in Sagey 1986) or for Coronal only (as in Clements & Hume 1995). Furthermore, it is assumed that all vowels are specified for Dorsal and for the tongue body features [±high, ±low, ±back]. This yields the following representation of the vowels at the time when palatalization took place in Latin:

(106)

/i/	/e/	/ɛ/	/a/	/ɔ/	/o/	/u/
[COR]	[COR]	[COR]		[LAB]	[LAB]	[LAB]
[-ant][97]	[-ant]	[-ant]				
[DOR]	[DOR]	[DOR]	[DOR]	[DOR]	[DOR]	[DOR]
[+high]	[-high]	[-high]	[-high]	[-high]	[-high]	[+high]
[-low]	[-low]	[+low]	[+low]	[+low]	[-low]	[-low]
[-back]	[-back]	[-back]		[+back]	[+back]	[+back]

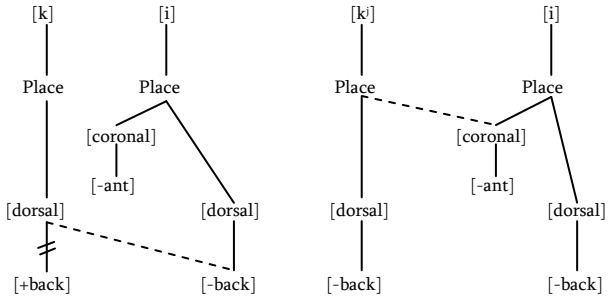
The fronting of [k] to [kʲ] before a front vowel is described as the spreading of the [-back] specification from the front vowel to the preceding velar, as in (107a).[98] The subsequent development of [kʲ] to [c], where the velar with a secondary articulation becomes a true palatal stop, is captured by the spreading of the coronal node to the preceding palatalized velar (107b), resulting in a complex Coronal-Dorsal segment.[99]

[97] The specification follows Clements & Hume (1995).

[98] The velar remains purely [-continuant]: there is no contour creation, the stop only gets a secondary place of articulation.

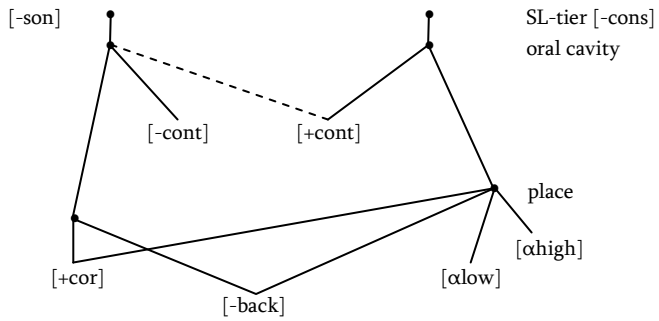
[99] As Jacobs & van de Weijer (1992:129) and Jacobs (1993:165) note, this representation is supported by phonetic evidence presented by Keating (1988).

(107) a. [ki] → [kʲi] b. [kʲi] → [ci]

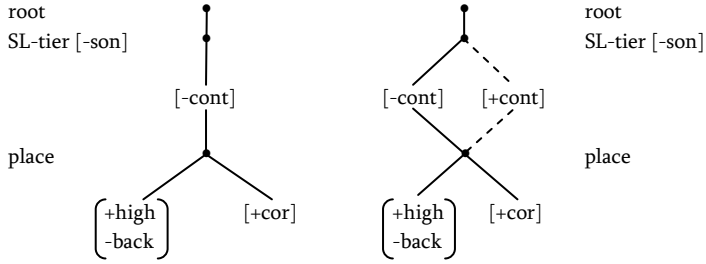


The final stage in the velar palatalization process in French is not directly addressed in Jacobs & van de Weijer (1992), but is described as contour-creation in Jacobs (1989/1993). Depending on the precise hierarchy of features adopted, this contour segment results either from (i) spreading of [+continuant] from the following vocalic segment, (ii) from insertion or (iii) from the split of the feature [continuant] into two contradictory values (an operation proposed by Clements 1989). Figure (108a) illustrates the contour-creating process by spreading of [+continuant] from a front vowel onto the preceding palatalized velar; (108b) visualizes the creation of an affricate by insertion of the feature [+continuant].

(108) **a. Spreading of [+continuant]** (Jacobs 1989:141)



b. Insertion of [+continuant] (Jacobs 1989:156)



According to Jacobs (1989/1993), a non-linear contour analysis of affricates adequately describes the French facts, and furthermore, contrary to linear rule-based approaches, it directly accounts for the interaction between lenition and affrication: velar stops affected by spirantization cannot be affricated any more, as there is no possibility left to create a contour of the features [-continuant, +continuant] on the velar slot. Moreover, it is argued that such a contour analysis, just like a traditional rule-based SPE account, properly describes affrication of palatalized velars as a process of demarking (=markedness reduction).[100]

In the preceding chapter, we have seen that on the basis of the inventories of the languages in UPSID 1992, there is no direct evidence for a contour analysis of affricates, and we therefore provisionally adopted a stop account, in line with most of the recent descriptions of affricates. Yet, must velar palatalization in French then be seen as evidence in favour of a description of affricates as contour or complex segments, or are other factors involved? We will return to this question below, after having presented the main elements of the perception-based approaches.

The traditional view of velar palatalization as a purely articulatory-based phenomenon has been challenged during the past 25 years by, among others, Ohala (1992, 1999), Guion (1998) and Chang et al. (2001). As argued by Ohala (1992:320), an articulatory account fails in two important respects. First of all, it is not clear why a velar in a palatalizing environment would result in a coronal stop or affricate, as it often involves a more radical movement forward than

[100] Jacobs (1989:156, footnote 31) refers to Schane (1973:115), who claimed that creating a complete closure in the palatoalveolar region is marked in the sense that it requires a great deal of muscular control. As we will see below, the fact whether we are really dealing with an instance of demarking has been challenged by the adherents of a perceptual-based view of palatalization.

induced by the palatalizing front vowels or palatal glide. Second, from an articulatory point of view, the change from a velar plosive to a coronal affricate involves a change from the tongue body to the tongue blade or the tongue tip. The shift between these two articulators is considered so substantial that it cannot be the result of assimilation. Instead, it is argued that velars followed by a high front vowel or palatal glide are perceptually close to the palatoalveolar affricate [tʃ].

Indeed, the experiments conducted by Guion (1998) show that velars before front vowels are both acoustically and perceptually similar to palatoalveolar affricates. Guion does not deny that some articulatory factors play a role (velar fronting) but she rejects the assumption that "palatalization is *purely* an articulatory motivated change" (1998:19). A velar plosive and palatoalveolar affricate are most often confused before high front vowels, and additionally, [k] is perceived as [tʃ] more often than [g] as [dʒ]. The reverse confusion, [tʃ] heard as [k], is exceptional, and is attributed to chance. As noted by Guion, these observations correspond to the typology of velar palatalization: velars mostly palatalize before high (front) vowels, and the process of [k] becoming [tʃ] is quite common whereas [tʃ] turning into a [k] is exceptional, if existent at all.

Similar findings have been reported by Chang et al. (2001), who based their experiments on the asymmetry in the [ki]/[ti] confusion demonstrated in Plauché et al. (1997). In this follow-up study, they show that the confusion is primarily due to acoustic-auditory similarity, and not to markedness: "There is no reason according to the markedness hypothesis why one should find the [k]>[t] confusion only in the environment of a high, front vowel since velar stops are presumably more marked than alveolar stops in all vocalic environments" (2001:94). Filtering out the high frequency spectral peak characteristic for velars, leads to confusion of [k] and [t] in a front vocalic environment. Moreover, adding this velar peak to the coronal stop causes identification difficulties for subjects as well. Previous studies focused on the confusion [ki]>[ti], but never on the actual pair [ki]>[tʃi], as is the case in velar palatalization. The confusion between velars and coronal affricates is addressed in the final experiment of their study. Participants had to grade the similarity of a series of tokens (ranging from canonical [kʰi], to manipulated [kʰi], to canonical [tʃʰi] tokens) on a seven-point scale. Indeed, the manipulated [kʰi] tokens were confused more often with a palatoalveolar affricate than the non-filtered instances of [kʰi]. It was hypothesized that the [kʰi]>[tʃʰi] perception was brought about by a combination of the aspiration of [kʰi]/[tʃʰi] and the absence of the spectral velar peak in the case of the filtered tokens of [kʰi]. This hypothesis was confirmed by

the fact that the voiced velar [g], typically lacking aspiration, was less often identified as a voiced affricate [dʒi].

Yet, if the shift from a palatalized velar to a palatoalveolar affricate were perceptually conditioned, coronals would be expected to be erroneously identified as velars in the same context. However, it has been shown that this confusion only exceptionally occurs in perception experiments, and moreover, it is an uncommon change from a typological point of view. How can this one-way pattern be explained? A phonetic explanation is provided by Chang et al. (2001), who make a distinction between "robust" and "non-robust" acoustic cues. Robust cues are likely to preserve their distinctiveness throughout the realization, whereas non-robust cues can be weakened to such an extent that the sound may become perceptually identical to another one. Chang et al. note that the release of the plosive into a high front vowel is acoustically similar for velar and coronal plosives, albeit that the release in the velar context [ki] is accompanied by an additional cue, i.e. front cavity resonance. This cue, however, is considered a non-robust perceptual feature, and therefore: "If this 'extra', non-robust feature is degraded to the point of losing its contrastiveness, listeners are likely to confuse the [ki] as [ti]" (2001:81), as indeed followed from their perception experiments. It also followed from their data that the reverse confusion (the perception of [ti] as [ki]) only incidentally occurred. This is accounted for by the fact that for [ti] to be heard as [ki], the additional non-robust perceptual cue of front cavity resonance needs to be present: "[ti] will very rarely, however, be confused as [ki], since listeners are unlikely to erroneously insert a nonexistent cue into the speech signal of [ti]" (2001:81).

The French facts are problematic for both the production-based and perception-based approaches. From a production point of view, it is not clear why a palatalized velar results in an alveolar or a palatoalveolar affricate (as noted by Ohala 1992: the resulting place of articulation is not clearly articulatorily motivated) or why palatalization would occur before the low vowel /a/. For a perceptual account, the latter fact is problematic as well, since it turned out that speakers do not confuse [ka] with [ta] or [tʃa]. Moreover, to the best of our knowledge, the velar plosives of Latin were unaspirated, most probably also when velar palatalization took place. If the affrication of the fronted velar is the result of a reanalysis of the aspiration and the degradation of the spectral peak of the velar, an account relying on perception alone seems unlikely in the case of French, also taking into account that the voiced velar – a stop typically lacking aspiration – palatalized as well.

An alternative account which we would like to propose here contains ingredients from both perception and production. In this view, the change from [k] to [k^{j}] and then further to [c] can be seen as assimilation, and can straightforwardly be described as articulatory-based. As we have seen, however, an explanation relying on assimilation alone fails to account for the subsequent change from palatal stop to affricate. Instead, along the lines of Clements (1999) and Kim (2001), we assume that the release of a palatal plosive, just like a coronal one, into a narrow constriction (i.e. before a palatal glide or high vowel) creates turbulent airflow which may be (mis)perceived as stridency. In this respect, Blevins' (2004:139) remark that "resulting palatalized velars may give rise to coronal percepts" could be reformulated in a more specific way: plosives before a palatal off-glide may give rise to *affricate* percepts. Again, the answer to the question whether these affricate percepts are represented phonologically as combinations of [-continuant] and [+continuant] or as strident stops, is left in suspense.

Even though we have argued that both production and perception are involved in palatalization, we still need to account for the fact why the low vowel /a/ acted as a trigger for this process in the Second Velar Palatalization. This problematic fact will be discussed in the following section.

5.3.5 Velar palatalization before a*: phonetics, phonology or both?*

In the existing literature, different views on velar palatalization before /a/ have been put forward, which can roughly be classified into three categories. The first one assumes a general fronting of Latin *a*. In Pope (1934) for instance, the front vowels are considered the triggers for velar palatalization. Pope assumes that in early Gallo-Romance, the Latin vowel *a* moved forward, causing it to participate in the Gallo-Romance palatalization process, next to [i] and [e].

Analyses belonging to the second group do not depart from a specific change in the quality of *a* that would have made it a trigger for velar palatalization, and the quality of the vowel in Gallo-Romance is not crucially different from the quality of the vowel in the Latin period. Fouché (1958:223-227), for instance, notes that Latin *a*[101] diphthongized in stressed open syllables, and remained unchanged in other contexts. The second series of velar palatalization then just took place in a context where it failed to apply in Latin,

[101] Fouché does not specify whether this is a front or back vowel.

and must be considered a specific characteristic of the Gallo-Romance languages (cf. footnote 81).[102]

The third view on Gallo-Romance palatalization lies somewhere in between the two extremes. Buckley (2003) claims that both phonetic and phonological factors are involved. He assumes that palatalization is primarily phonetically conditioned, by the coarticulation of a velar plosive and the following front vowel: "[…] the second palatalization was in fact triggered by *all* front vowels, and the rule must be understood from that perspective" (2003:7). However, he rejects a general fronting of all allophones of Latin *a*. He argues that in stressed open syllables, /a/ took a fronted realization [æ], creating the phonetic context for velar palatalization to occur. Palatalization then gradually extended to all contexts where a velar consonant was followed by any token (both fronted and unfronted) of the phoneme /a/, causing the process to take place also in contexts lacking a direct phonetic motivation.

Buckley's account sounds interesting, but it is questionable whether (allophonic) fronting of the vowel is really the crucial factor in velar palatalization before /a/; it appears to be neither sufficient nor necessary. Not sufficient, because in Artois, Normand and Picard, velars did *not* end up as affricates before low *a*, although in those varieties the vowel also had a fronted allophone in stressed open syllables. Thus, *a*-fronting in stressed open syllables and velar palatalization and affrication before /a/ seem to have been two independent phenomena. Allophonic fronting also does not appear to be a necessary conditioning factor. In an earlier paper, Buckley (2000:4-5) refers to Zuni, where velars were fronted before the front vowels /i/ and /e/. The process was extended to the non-front vowel /a/, and, interestingly enough, after the velar was palatalized, the non-front vowel itself was fronted to [æ] by the influence of the preceding segment. Furthermore, Buckley (2003:11), referring to personal communication with Paul Boersma and Yves Charles Morin, notes that in some contemporary varieties of French, [k] also takes a fronted realization before /a/, as in *quatre* ('four') for instance, which may be realized as [kʲatʁ], even though the vowel is still "relatively central".

Buckley (2000) proposes a phonological explanation for the Zuni facts, and stipulates that /a/ joins one of the existing patterns of Velar + Vowel interactions (fronting before front vowels and rounding before round vowels). As a matter of fact, such an account would be applicable to French as well: it is the *phonological* categorization of /a/ that crucially conditions its behaviour with respect to

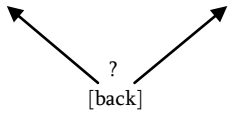
[102] Canavati (1970:15) considers velar palatalization in Gallo-Romance the result of rule simplification: the vocalic feature [-low] was deleted from the previous rule of palatalization.

palatalization. Contrary to Buckley (2003), however, we argue that this categorization is in principle independent of its evolution in stressed open syllables.

Phonetically speaking, it cannot be accounted for why the low central vowel /a/ would pattern with either the front or the back vowels as it is neither front nor back, but central. Therefore, as far as its feature specification is concerned, the vowel has an ambiguous status with respect to the feature Dorsal [±back], as shown in (109).

(109)

/i/	/e/	/ɛ/	/a/	/ɔ/	/o/	/u/
[COR]	[COR]	[COR]		[LAB]	[LAB]	[LAB]
[-ant]	[-ant]	[-ant]				
[DOR]	[DOR]	[DOR]	[DOR]	[DOR]	[DOR]	[DOR]
[+high]	[-high]	[-high]	[-high]	[-high]	[-high]	[+high]
[-low]	[-low]	[+low]	[+low]	[+low]	[-low]	[-low]
[-back]	[-back]	[-back]		[+back]	[+back]	[+back]



Even though in Gallo-Romance, Latin *a* might have been raised or fronted in some specific context, there was only one phoneme /a/. In this vocalic system, the vowel /a/ has a rather isolated status, given that it is the only vowel that is neither front nor back (and therefore unspecified). It could be stipulated then that since the vowel finds itself in this isolated position, it starts to pattern with either the front or back vowels of the language. In the case of the Second Velar Palatalization, it behaves as a front vowel, triggering fronting of the velar, just like the vowels that are both phonetically and phonemically front.[103]

Interestingly, the Second Velar Palatalization is not the only phenomenon where /a/ patterns with the front vowels. In Klausenburger (1974), two cases are presented: one where /a/ patterns with the front vowels and one where it behaves like a back vowel. In the case of diphthongization, the back rounded vowels [ɔ] and [o] develop a labiodorsal glide [w] respectively before and after

[103] The assumption entailed by this scenario is that /a/ was categorized as a back vowel in Artois, Normand and Picard where velar palatalization did not apply in this context. Moreover, if this scenario indeed applies, the choice made by the Gallo-Romance dialects is not a frequent one, otherwise palatalization before /a/ would be crosslinguistically more common.

the vowel, as in [flore] > [flowre] 'flower', whereas the front unrounded vowels [ɛ] and [e] develop a palatal glide [j] respectively before and after the vowel, as in [debɛt] > [debjɛt] 'must PRES 3sg.'. The vowel /a/ behaves as a front vowel in developing a palatal glide as in [mare] > [majre] 'sea' (cf. Klausenburger 1974:20). On the contrary, /a/ patterns with the back vowels in the processes of "[l]-Vocalisation" and "[l]-Loss". [l] changes into [w] if preceded by a back vowel in singular-plural alternations in the oblique case: [kɔl]-[kɔws] 'neck, sg./pl.' and also [bal]-[baws] 'dance sg./pl.', but is deleted after front vowels, as in [nyl]-[nys] 'nobody sg./pl.' and [fil]-[fis] 'son sg./pl.' (cf. Klausenburger 1974:42-43).

It goes without saying that because of the absence of spoken material, we will never be entirely certain about the exact quality of *a* when Gallo-Romance palatalization took place, nor about the extent to which it differed from the Late Latin period.[104] The point to retain at this stage, however, is that both phonetics and phonology are likely to play a role. Let us move on now to the final source of affricates in French: the strengthened palatal glides.

5.3.6 Glide strengthening

As we have seen in section 5.2.4.1, strengthening of the palatal glides resulted in palatoalveolar affricates. In Jacobs & van Gerwen (2006), an analysis is presented which not only accounts for the development of the palatal glide, but also of its labial counterpart, which was subject to strengthening in the same period. In initial or post-labial position, the labial glide [w] in Germanic loanwords was strengthened and turned into [gw]; the labial glide resulting from Latin *v*, was deleted when preceded or followed by a back vowel, elsewhere it survived as [v]. The strengthening trajectories of both glides are illustrated in (110), cf. Jacobs & van Gerwen (2006:79-80).

[104] An important complicating factor of course resides in the absence of uniformity in the way the low vowel has been transcribed in the different descriptions and analyses. Often an orthographic *a* is accompanied by a short phonetic description, yet other times we find a phonetic transcription, but these are symbols from different phonetic alphabets, which makes comparison of analyses and interpretation of Gallo-Romance *a* a hazardous task.

(110) a. Germanic [w]

Germanic	*Gallo-Romance*	*Modern French*		
want	[gwant]	[gã]	*gant*	'glove'
wardar	[gwardar]	[garder]	*garder*	'to keep, to guard'
werra	[gwɛr:a]	[gɛr]	*guerre*	'war'
wespa	[gwɛspa]	[gɛp]	*guêpe*	'wasp'
wisa	[gwisa]	[giz]	*guise*	'manner, way'

b. Latin *v*

Latin		*Gallo-Romance*	*Modern French*		
oviculam	[owikulam]	[oβikula]	[waj]	*ouaille*	'sheep, flock'
vivere	[wiwere]	[βiβere]	[vivr]	*vivre*	'to live'
viburnam	[wiburnam]	[βiβurna]	[vjɔrn]	*viorne*	'guelder rose'
servire	[serwir]	[serβir]	[sɛrvir]	*servir*	'to serve'

According to Jacobs & van Gerwen (2006), the strengthening of the labial and palatal glides should be described in a uniform way. They claim that the different strengthening trajectories serve a single purpose: strengthening the onset, thus increasing the sonority difference between the onset and the preceding coda, if present. As far as the strengthening of [j] to [dʒ] and of [w] to [gw] is concerned, it is argued, as we have already briefly seen in chapter 2, that it results from the insertion of [-continuant] onto the glide, creating a [-continuant, +continuant] contour segment.

The main reason for Jacobs & van Gerwen (2006) to describe the development of the two glides in a uniform way (i.e. the creation of a contour segment) is because their strengthening and reduction ([tʃ] > [ʃ] and [gw] > [w]) took place at the same time. However, this latter aspect is not confirmed by, among others, Pope (1934:93), who situates the reduction of [gw] prior to the general affricate reduction, which also concerns [tʃ] created by strengthening of [j]. The completion of the simplification of [gw] is dated before the end of the twelfth century, whereas general deaffrication mainly takes place during the thirteenth century and only starts by the end of the twelfth. It might of course be the case that the treatment of [gw] has influenced the development of affricates, but still, the difference in time shows that both types of sounds are not considered phonologically similar. That is, if both strengthened [w] and strengthened [j] resulted in a contour segment, it is not clear why one contour would behave differently from another, structurally identical contour segment. Moreover, a second problematic issue is that the reduction of the strengthened palatal and labial glides respectively, yields a different outcome: [tʃ] loses its

plosive closure, [gw] on the other hand preserves its plosive part but is delabialized and loses its more sonorous element.

An alternative view on the development of the palatal glide is presented in Scheer & Ségéral (2001). They argue against the traditional view on palatalizing and strengthening contexts by claiming that strengthening took place in *all* Consonant+Yod sequences, not only in word-initial and post-labial position, and that it is the result of a general process targeting glides in strong position.

As for word-initial or post-labial position, Scheer & Ségéral agree with mainstream accounts that the change affecting yod in these contexts is indeed a strengthening process, which implies, as they argue, that the Labial+Yod sequences had to be heterosyllabic, since otherwise yod would not be in strong position. In standard syllable theory, however, this does not follow automatically, as it is based on the "Maximum Onset Principle" (cf. Kahn 1976). In order to account for fortition in this context, traditional accounts therefore generally stipulated that the syllable-boundary between the labial and the following glide was the consequence of the fact that the labial could not be palatalized. This is a position explicitly rejected by Scheer & Ségéral (2001:92-93), who approach the change primarily from a strictly syllabic point of view; sound changes actually taking place crucially depend on the position a segment occupies within the syllable. With respect to the syllabic position of [j] in Consonant+Yod-sequences they note the following:

> "Nous pensons qu'en fait la réalité est beaucoup plus simple et que les séquences [labiale + yod] nous donnent l'image nue de ce qui se produit pour toute séquence Cj, l'absence d'interaction phonétique dans ce cas précis n'ayant pour effet que d'exempter le processus central, *i.e.* le renforcement en position forte, de l'opacité apportée dans les autres cas (vélaires et coronales) par les interactions de niveau phonétique qui se superposent à ce processus central.
>
> En d'autres termes, nous pensons que dans toute séquence Cj créée par la consonification des brèves en hiatus, le yod est placé en position postconsonantique hétérosyllabique, et que ceci résulte mécaniquement du processus même de consonification des brèves en hiatus".[105] (2001:96-97)

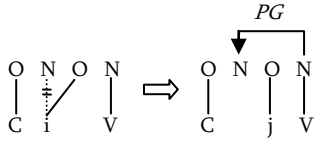
[105] We think that reality is much simpler and that the [labial + yod] sequences show what is really going on in every Cj sequence; the absence of a phonetic interaction in this context just prevents the central process (i.e. strengthening in strong position) from the opacity that arises in the other cases (velars and coronals) by the interactions at the phonetic level which are superimposed on this central process.

In other words, we think that in every Cj sequence created by the consonantalisation of short vowels in hiatus, the yod is placed in postconsonantal, heterosyllabic position, and that this results automatically from the processes of consonantalisation of short vowels in hiatus as such.

An important deviation with the classical conception comes into play here, as not only the word-initial and post-labial contexts of yod are seen as the contexts where strengthening takes place: in *all* post-consonantal contexts, the yod is the onset of a heterosyllabic cluster and therefore subject to strengthening. This thus also involves the contexts Coronal+Yod and Velar+Yod, which have both been purely described as palatalization contexts for many years (cf. (92) above), but where according to Scheer & Ségéral the strengthening is obscured because of a phonetic process (= palatalization).

Their approach to C+Yod clusters is formally modelled within the framework of "CVCV" (or "strict CV") phonology, which is said to account automatically for the behaviour of yod. CVCV phonology (cf. Scheer 1998; 2004, among others) has been developed in close connection with the theory of Government Phonology (whose principal initiators were Kaye, Lowenstamm & Vergnaud, and which was presented in a paper published in 1985). In the CVCV conception of the syllable, only two constituents exist: the Onset (O) and the Nucleus (N), which may also be referred to as C and V respectively. Both constituents are not allowed to branch, and can therefore maximally contain a single segment, thus yielding a syllable structure CV. This means that a tautosyllabic surface cluster CC is represented underlyingly as a sequence CV.CV, where the first V is empty; surface coda consonants are underlying onsets of a syllable. Crucially, a Nucleus can only be left unfilled if it is "properly governed" (Proper Government, PG) by a following, filled, Nucleus. More specifically, in the case of consonantalization of high and mid front vowels in hiatus, the following operation takes place:

(111)



(cf. Scheer & Ségéral 2001:98)

In the initial situation, the unstressed vowel [i] is linked to a N-slot. When the vowel turns into a palatal glide, it delinks from this position, and reattaches to the O-slot at its right. The first N-slot can be left unfilled because it is properly governed by the second, filled, Nucleus. In this framework, the supposition that C+*j* is a heterosyllabic cluster is directly captured. After the restructuring of ON (or CV) slots and the underlying material has taken place, it is expected that yod is strengthened, because it now appears in Onset – and hence strong – position. Contrary to mainstream syllable theory, there is thus no need to postulate

separately that a homosyllabic cluster [bj] resyllabified to a heterosyllabic cluster [b.j].

In the ensuing discussion, it is claimed that if Labial+Yod clusters were heterosyllabic, in fact *all* Consonant+Yod clusters must have had the same syllable structure. Therefore, Scheer & Ségéral argue that not only initial yod and Labial+Yod clusters were involved in a strengthening process, but instead, that it is an instance of a *general* change affecting Consonant+Yod clusters.

> "En fait, le renforcement de j est susceptible de survenir dans la presque totalité des groupes Cj. Il apparaît ainsi indépendant de la nature de la consonne antécédente: il peut concerner des consonnes éminemment « palatalisables » telles que n, aussi bien qu'une consonne « impalatalisable », pour laquelle la métathèse est massivement attestée, comme r".[106] (2001:103)

As the above quotation shows, Scheer & Ségéral thus draw a parallel between the uncontroversial contexts of glide strengthening (word-initial and post-labial glides) and the contexts where traditionally palatalization is assumed (Coronal/Velar+Yod).

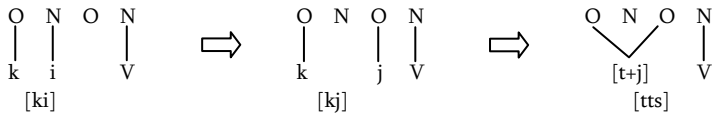
A reanalysis is presented, supported by a CVCV conception of the syllable, which boils down to the proposal that two different phases must have existed in the evolution of French. In the first one, Phase A, the unstressed vowels in hiatus become illegitimate, but do not yet shift towards the O-slot of the following syllable. Metathesis of yod and the preceding segment may apply, but yod is never in strong position, and there is thus no reason for strengthening to take place. During this phase, no syllable-based processes apply, only phonetic changes, where [t] is palatalized by yod and ultimately turns into an affricate. In Phase B, every [j] resulting from the consonantalization of the unstressed vowel is reattached to the empty O-slot. Because yod now is in strong position, it is affected by strengthening, which may take two different shapes: gemination of yod or affrication (fortition). The changes occurring in phase A and B, respectively, are schematically represented as follows: [107]

[106] In fact, the strengthening of j is likely to occur in almost all Cj sequences. It occurs then independently of the nature of the preceding consonant: it may concern consonants which are eminently "palatalizable", such as n, as well as a non-palatalizable consonant for which metathesis is frequently attested, such as r.

[107] Except for the gemination, (112b) also holds for the other Cj sequences.

(112) **a. t+i/e in hiatus**

b. k+i/e in hiatus



(Scheer & Ségéral 2001:111)

Although this account takes care of the Consonant+Yod sequences in a uniform way, it leaves us with several issues for debate. First of all, it is not immediately obvious why only primary [t]+[i] sequences would be subject to palatalization in Phase A. All C+hiatus sequences went through Phase A, that is, the phase where hiatus was banned by the language but where yod did not yet shift towards the strong O-position. Phonetic processes – in this case palatalization – may apply, but strangely enough, these only apply to [t]+hiatus. Neither from a phonetic nor from a phonological point of view is it clear why [k]+*j* was not involved, a crosslinguistically common context for palatalization. Second, it is generally assumed that palatalization before yod took place prior to glide strengthening (Pope 1934, Fouché 1958). Now, even if we let go of the traditional view and adopted Scheer & Ségéral's view instead, it is not clear why yod strengthened earlier when preceded by [k] than in word-initial or post-labial context.

Summarizing so far, it appears that both views on glide strengthening described above entail a number of problematic issues. In Jacobs & van Gerwen's view, it is not clear why reduction of an identical contour structure takes place at two different moments: reduction of contour [gw] taking place before the reduction of contour [tʃ]/[dʒ]. Moreover, it is not clear why the reduction of a similar contour configuration targets the [+continuant] branch of the strengthened labial glide, but the [-continuant] branch of the strengthened palatal glide.

In Scheer & Ségéral's view, on the other hand, an arbitrary distinction is introduced between different types of Consonant+Yod sequences, as a result of which it is not clear why strengthening did not take place at the same time in the different Consonant+Yod sequences (velars vs. labials).

Let us therefore consider an alternative view that adequately accounts for the facts, and that does away with the problems of existing analyses. There does not seem to be any need to draw a parallel between the Consonant+Yod sequences where palatalization applies and the Consonant+Yod sequences where glide strengthening takes place. As a matter of fact, as described in the previous section, palatalization of coronals and velars can be described in a straightforward way as an articulatory-induced change in place of articulation of the consonant towards the palatal region. The labial plosives do not take part in this process because there is no tongue movement involved. In line with Jacobs & van Gerwen (2006), we assume that strengthening serves to increase the sonority pattern of consecutive syllables. Moreover, as described in Ohala & Solé (2008:318), fricativization and affrication of syllable-initial glides[108] is a phonetically expected process, given that in this position the oral constriction of these sounds tends to narrow. With respect to the French developments then, if the passage of the palatal glide is narrowed to such an extent that a narrow constriction arises and turbulent airflow is generated, the glide is strengthened to a fricative. If the articulatory effects are even stronger and if the passage is narrowed even further, a stop-like element emerges, which, in combination with a noisy release, makes that the segment becomes articulatorily, acoustically and perceptually similar to an affricate.[109] The phonological representation of the strengthened palatal glide becomes identical to the one of the other affricates already created in the language and they therefore behave alike afterwards, whereas the strengthened labial glide also becomes phonologized at a given moment, but receives a representation that differs from the one of the palatal glide.

Up to now, we have discussed the formal description of the processes which led to the creation of affricates. Let us turn now to the formalization of their general loss.

5.3.7 Deaffrication

Fricativization (or spirantization) of affricates has been used as an argument in favour of a contour or complex description: the deletion of the [-continuant] or

[108] Ohala & Solé (2008:318) note that this holds in particular for the palatal glide and to a lesser extent for the labial glide, for which fortition in general is less common.

[109] This would account for the strengthening trajectory of [j]. Strengthening of the labial glide could then also be seen as purely phonetically motivated (possible according to Ohala & Solé 2008, although this change is less frequent, precisely because of its phonetic characteristics).

[stop] branch of the affricate would leave its [+continuant] or [continuant] branch unaffected, thus directly capturing the shift from affricate to fricative (e.g. Jacobs 1989). In Kehrein's framework, where affricates are basically assigned the same status as normal plosives, it is argued that no such label as "deaffrication" has to be invoked. Rather, when it comes to the reduction of an affricate to a fricative, it is just an instance of general spirantization, which targets both normal stops and affricates, or a well-defined subset of the phonological category of stops (cf. (32)):

> "[…] suffice it to say that the Generalized Stop Approach predicts rather than stipulates that strengthening/weakening phenomena always affect stops and affricates alike: since both are exclusively [stop], there is no way to refer to all stops to the exclusion of all affricates, and there is no way to refer to all affricates to the exclusion of all stops". (2002:32)

> "As a positive consequence, all alternations between affricates and fricatives receive the same formal account under the GENERALIZED STOP APPROACH, namely 'spirantization'. There is no need for anything like 'deaffrication' to exclude stops; rather, spirantization either targets all stops in a language […], or the subset of MANNER-specified stops only […]". (2002:38)

It is thus predicted that either all stop phonemes of the language are involved in spirantization, or only a specific subset of phonemic, Manner-specified stops.[110]

This view may be potentially problematic for the French facts, if Fouché (1958) is right in saying that deaffrication was a general process, also targeting [dz] in intervocalic position. Recall from section 5.2.2 that voiceless affricates were, just like voiceless plain plosives, voiced in intervocalic position. Afterwards, the voiced plosives were affected by spirantization and turned into fricatives. If, following Fouché, the voiced affricates did not yet take part in this process, spirantization in the fifth and sixth century was apparently limited to simple stops, not involving the Manner-specified (or strident) stops. Yet, this is not an option in Kehrein's view, as follows from the above quotations. If not *all* stops are involved in spirantization, it may be the case that only Manner-specified stops are involved, but the reverse scenario, where simple stops are involved to the exclusion of Manner-specified stops, is ruled out.[111]

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[110] This label "Manner" only exists in Kehrein's taxonomy (cf. (68)), but cannot be retrieved as such in feature geometry (cf. sections 4.4.2 and 4.4.3): reference should be made to features like [strident] and [lateral] to exclude/include specific subsets of manner-specified stops.

[111] Also Pope's (1934) description (cf. section 5.2.2) of spirantization is problematic for Kehrein's view: [dz]<[t+j] behaves like intervocalic [d] (=voiced Classical Latin [t]), whereas intervocalic [dz]<[k+i/e] spirantizes later. The affricates were thus apparently not *all* treated on a par with the

This potentially deviant behaviour of affricates with respect to intervocalic spirantization does not necessarily force us to adopt a contour or complex description. Under a (strident) stop approach of affricates, the difference between plain and affricated stops can be directly accounted for by stipulating that spirantization either targets all stops or, as in the case of French, only the plain stops or the strident stops. If Fouché's view is correct, then all we need to do is slightly modify Kehrein's claims in such a way that the Generalized Stop Approach allows simple stops to spirantize to the exclusion of the Manner-specified stops. It is then probably because of their articulatory complexity that affricates spirantize later than the simple stops, and for French it could be said that there is a first stage of spirantization affecting the simple stops, and a second phase affecting the strident stops.

5.4 Discussion and conclusion

Having seen the rise and fall of affricates in the history of French, let us now return to the main question of this thesis: what does an affricate phonologically look like? Recall from chapters 3 and 4 that the cross-linguistic patterns of affricates did not provide any firm evidence in favour of a contour or complex analysis, nor did they constitute counter-evidence for a stop description. The French facts described in the present chapter appear to go in the same direction. In all the cases we have considered, the emergence of an affricate seems primarily phonetically triggered: specific sounds come to resemble affricates in a specific context, followed by a concomitant adaptation of the phonological representation if a sound change is indeed brought about. Does this affricate representation then look like a combination of [-continuant] and [+continuant] or as a (strident) stop? A contour or complex representation seems to introduce superfluous machinery, and it moreover leads to untrue predictions with respect to the development of the strengthened glides.

Still, the French affricates show that they may possibly behave differently from plain stops, as in the case of spirantization. This behaviour could be accounted for by seeing affricates as contour or complex segments, contrasting with non-affricated stops, each category participating in a different process of spirantization. However, this deviant behaviour can be explained by means of a stop account as well, both in its broad and narrow sense. If affricates are seen as a

plain stops. Still, recall that [tj] palatalized earlier than [k+i/e], which might also explain why the reduction of the resulting affricate took place earlier in this former context.

phonemic category, represented by the features [-continuant, +strident], it is because of this [strident] value that plain plosives and affricates behave differently. If, on the other hand, no fundamental difference between plosives and affricates is assumed, as in Kehrein's Generalized Stop Approach, it has to be assumed that spirantization processes cannot just target either all stops or Manner-specified stops only, but also only the plain stops to the exclusion of the Manner-specified stops.[112] This latter pattern accounts for Fouché's (1958) view on the French facts, where plosives turn into fricatives, but where affricates are left unaffected. As such, this option is not included in Kehrein's analysis, but once this modification is taken into account, the behaviour of French affricates is perfectly in line with this most restrictive view on affricates.

At the same time, though, the discussion of processes involving affricates in French historical phonology still leaves several aspects unexplained and even makes us face an additional number of questions. First of all, even though French affricates can very well be considered strident stops, French does not provide any evidence as far as the location of this feature within feature geometry is concerned. Second, with respect to palatalization before Latin *a*, we stipulated that if phonetic factors are entirely absent or only present in certain contexts, the low, central Latin vowel may take part in the palatalization process because of phonological concerns. There is still no decisive answer to the question of the exact nature of /a/ in Gallo-Romance, but as we will see in the following chapter, synchronic evidence from contemporary French may be helpful here.

[112] Plain stops are [-cont], [-strident], [-lateral] (cf. (86)), whereas Manner-specified stops are [-cont] and [+strident] or [+lateral].

Part III:
A corpus study of modern French

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6

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Data and Methodology

6.1 Introduction

French has lost all the affricates that were created during its development from Latin, but in the contemporary variety, affricates can nevertheless be found in loanwords like *badge*, *bridge*, *chip*, *coach, jazz* or *match*. In some cases minimal pairs arise, as holds for instance for the series *une couleur* ***mate*** [t], *de la* ***mâche*** [ʃ], *un* ***match*** [tʃ] *de football*.[113] The hereditary phoneme inventory of modern standard French contains six plosives (labials, coronals and velars, each with a symmetrical voicing contrast), which are generally characterized as sounds with a pure, neat release by the more classical descriptions, but also by the prescriptive pronunciation manuals (cf. for instance, Grammont 1922, Léon & Léon 1976, Léon 1992, Léon 2003, Malmberg 1969). The release of French plosives does show some variation, though. One source of variation, which is in fact commonly noted (also in the more conservative analyses), is that a velar plosive strongly tends to take a fronted realization when followed by a front vowel or palatal glide. The precise effects of this fronting nevertheless remain unclear, because the phenomenon is often only mentioned in passing, and the more elaborate descriptions are largely or fully based on intuitions. Some (e.g. Gussenhoven & Jacobs 2005) describe contemporary velar palatalization basically as a simple fronting of the velar, whereas others (e.g. Fónagy 2006, Walter 1977) report instances of velars with a secondary palatal articulation, or even instances where the velar is turned into a full palatal stop.

Except for the palatalization effects on velars, the different French plosives may also take an assibilated (or affricated) realization. This is a

[113] 'a matt colour', 'lamb's lettuce', 'a football match'.

characteristic commonly ascribed to the Canadian varieties, but it has occasionally been reported for European French as well (cf. Malécot 1977), even though it has gone largely unnoticed. The actual characteristics and spread of velar palatalization and plosive affrication, two processes affecting the release of French plosives, are not well-known and require further investigation. The second part of this thesis will focus on these two synchronic processes, by examining corpus data from several regions in France. As such, it aims to further our understanding of the phonetic mechanisms underlying the emergence of affricates in a language.

The present chapter serves as a general introduction to the corpus study that will be presented in chapters 7 and 8. Section 6.2 will start out by describing the principal characteristics of the phenomena that will be studied. Afterwards, in section 6.3 we will focus on the problems linguistic research has to face when it comes to the selection of data: we will briefly discuss the advantages and disadvantages of different data sources, and we will provide a more detailed motivation for a corpus study of the two phenomena under discussion. The design of the spoken language corpus that we will explore, the *Phonologie du français contemporain* (henceforth PFC) database, will be presented in section 6.4, and section 6.5 will be concerned with the factors of variation that may come into play in the corpus data. Finally, in order to place the following chapters in the right perspective, we will discuss some limitations of the PFC corpus in section 6.6.

6.2 Phenomena of study

The first process that will be studied is velar palatalization, which, as we have seen in the previous chapter, resulted in affricates in the history of French. Synchronically, this process appears to be active as well, even though it is still in its initial stages. The second process that will be addressed is assibilation, which causes plosives to take a noisy or affricated release in a specific vocalic environment. Both phenomena will be briefly described in the following subsections.

6.2.1 Velar palatalization

The characteristics of velar palatalization, the process where velars get fronted and where their place of articulation shifts towards the palatal region, have been described in chapter 5, when focusing on the diachronic changes in French

resulting in affricates. As noted in that chapter, the French facts are atypical in the sense that palatalization also took place before the low vowel *a*. We proposed an alternative approach where *a*, low and central in Latin, came to behave (at least) phonologically as a front vowel with respect to this process. However, one can only speculate on the exact circumstances of the Second Velar Palatalization, as of course no spoken language material of that period is available.

Front vowels, and especially the palatal glide are well-known for triggering an anteriorization of the place of articulation of a preceding velar plosive. As noted by Price (1991:104), this coarticulatory effect is particularly strong in contemporary French. Gussenhoven & Jacobs (2005:180) note that the palatal glide and high front vowels induce fronting of the preceding velar, which makes [k] change into [k̟]. The effect of the vowel, however, may be more than just fronting, and some descriptions even report velars with a secondary palatal articulation or velars that turn into a palatal stop (cf. among others Fónagy 2006:26-27, Léon & Léon 1976:31, Malmberg 1969:101, Walter 1977:31-33). Fónagy (2006), for instance, reports on cases where coronal and velar plosives turn into "occlusives mouillées", i.e. palatalized or even palatal plosives, if followed by a front vowel. However, although the fronting of the place of articulation of velars is commonly noted as a property of contemporary French, its precise characteristics remain unclear, mainly because the descriptions are not backed up by representative data. We are ignorant about the strength of the fronting process as such, and it is not known whether (the degree of) palatalization solely depends on the linguistic context, or whether the regional background or the age and gender of a speaker are involved as well (and if so, to what extent).

Furthermore, as for the problematic Gallo-Romance context, it is noted by Buckley (2003:11) that some[114] northern varieties seem to reproduce a similar change in contemporary *ka* sequences. These sequences were still pronounced [kʷa] when the Second Velar Palatalization took place, but Buckley points out that nowadays for instance *quatre* [katʁ(ə)] ('four') may be realized as [kʲatʁ(ə)]. Synchronic data of the pronunciation of *ka* could therefore be informative with respect to the diachronic developments: if palatalization of the velar takes place, does the vowel *a* have a fronted realization in this context? If so, is it a general change affecting that vowel, or is it restricted to a specific context? If not, are there some non-phonetic factors that may have caused velar fronting in this context?

[114] Buckley does not specify which varieties are involved.

6.2.2 Plosive affrication

The process of plosive affrication has already briefly been addressed in chapter 2, where we have seen that it was used as an argument in favour of a (strident) stop analysis of affricates. Assibilation of plosive consonants before high vocalic elements has received a considerable amount of attention in both the phonetic and phonological literature (cf., among others, Clements 1999; Kim 2001; Hall & Hamann 2006). The emergence of affrication in this context has been given a phonetically-based motivation. If followed by a high vowel, the air that has been obstructed during the plosive closure has to be released through a relatively narrow channel, yielding a considerable amount of turbulent airflow, which sounds fricative-like. If the plosive is followed by a low vowel, on the contrary, the passage is not sufficiently narrow to create turbulence, and the obstructed air can be freely released.[115] Phonetically, the noise which accompanies the transition from the plosive to the high vowel causes the plosive to be interpreted as affricated.[116] One of the most famous examples of languages displaying this phonetic characteristic is Canadian French, as illustrated in (113).

(113)

		Standard French	**Canadian French**
petit	'little'	pe[ti]t	pe[tˢi]t
dire	'to say'	[di]re	[dᶻi]re
tiens	'(I/you) hold'	[tj]ens	[tˢj]ens
indien	'Indian'	in[dj]en	in[dᶻj]en
tuer	'to kill'	[tɥ]er	[tˢɥ]er
conduire	'to conduct'	con[dɥ]ire	con[dᶻɥ]ire
tube	'tube'	[ty]be	[tˢy]be
durer	'to continue'	[dy]rer	[dᶻy]rer

(cf. Walker 1984:106)

Traditionally, assibilation of plosives in French is seen as emblematic of the Canadian varieties, and has hardly been discussed for metropolitan French. The phenomenon was briefly reported several decades ago by Malécot (1977:13), who noted that affrication also occurs in standard French, but that it is not as strong as in the Quebec variety, and highly subject to variation between speakers; young persons and women were said to be more inclined to produce affricated plosives. In the literature on modern French pronunciation that was published in

[115] cf. (30) for a schematic visualization of these high and low vowel contexts.

[116] Recall from above that both Clements (1999) and Kim (2001) analyze the assibilation process as the insertion of the feature [+strident], reflecting the turbulent noise, onto the feature configuration of the plosive.

the years afterwards, no attention was paid to affrication in European French. However, the process has not disappeared. When exposed to (genuine) Parisian French for instance, a variety that is traditionally nearly always equated with "standard French", one will easily notice that the plosives may indeed take an affricated release. Yet, the exact characteristics and spread of affrication in the metropolitan varieties are still unknown, and require a thorough investigation.

6.3 Linguistic data

As holds for any empirical discipline, linguistics constantly has to face the question as to which data would be ideal or optimal. In the case of linguistics, "ideal data" would mean providing direct access to the linguistic knowledge and the linguistic structures in a speaker's brain, which is clearly impossible. Therefore, the speaker's implicit knowledge of the language he or she speaks has to be made explicit in some way.

In linguistic research, several methods are or have been used, some of them more questionable than others (cf. Chafe 1992). Among the most questionable methods we find introspection, where data are obtained by directly asking a speaker about his or her judgements or intuitions on a specific phenomenon. Even though this procedure makes the data available in a relatively quick and easy way, it entails a large amount of subjectivity and can hardly be considered sufficient nor reliable (not to mention the cases where the data were delivered by linguistically-trained persons or by the researcher himself). Introspective data may be valuable, though, in order to get a basic idea of the phenomenon involved, and may be useful to determine which directions might be worth examining in an empirical approach.

It is more reliable to make speakers' intuitions explicit by means of experiments. This method allows the researcher to compare the performances of a larger, properly selected, group of speakers on a specific linguistic task. Of course, this comes at the cost of losing the naturalness of the data, as some experimental setting will always be involved, which influences the renditions of the participants, for instance their speech, in several important respects. The utterances will be more artificial than they would be in natural speech, and the speaker will pay more attention to his or her utterances, probably yielding more formal speech than he or she would produce in a non-experimental setting. Furthermore, no experimental design to elicit data for any linguistic phenomenon one wants to investigate can entirely conceal the researcher's

intentions, and there is always a risk that this will influence the data that are delivered. Experimental methods are still widely used, and in several situations there is simply no alternative.

In the past decades, however, developments in the field of corpus linguistics have led to the introduction of a new type of data, which does away with the principal disadvantages of experiments, while sharing their principal advantages. Language corpora are large, properly balanced databases of running speech, and contain spoken and/or written language. Contrary to experiments, the different components of a corpus do not aim at the elicitation or presence of a high number of instances of a particular phenomenon, but their aim is to reflect language as naturally as possible.

Still, even though corpus data are superior to other data sources as far as naturalness is concerned, this specific type of data also entails a number of disadvantages. Next to the time-consuming compilation and annotation procedures, there is also a data issue involved. That is, the corpus does not reflect a language in its entirety. Generalisations can be made on the basis of the data in the corpus, but one should always be very careful with respect to conclusions on phenomena that are absent or nearly-absent in the data: relevant cases might be absent just by chance. Therefore, even though it is very likely that a phenomenon is very infrequent if it is rarely or not found in the corpus, one can never be certain that it is non-existent.

In the following two chapters, we will investigate the characteristics of velar palatalization and assibilation in contemporary French by analyzing spoken language data of different metropolitan varieties. We will rely on corpus data in order to circumvent the disadvantages of experimental data described above. Moreover, most existing, synchronic descriptions of the phenomena under discussion either do not specify where their data come from, or they are experimentally-based. Therefore, we believe that a corpus study will be a valuable complement to the existing studies. Fortunately, a well-balanced corpus of spoken language is available for French: the *Phonologie du français contemporain* (PFC) corpus, which, as we will see, constitutes a very suitable database to examine the actual spread of velar palatalization and affrication in modern French. The design of the PFC corpus will be presented in the following section.

6.4 The PFC corpus

The principal goal of the project *La phonologie du français contemporain: usages, varietiés et structures*[117] is to provide a better image of both the unity and the diversity of spoken French (cf. Durand et al. 2002, 2005). As stated in the documentation[118] explaining the general aims of the project and the compilation and annotation policies, a large corpus of spoken language is to be collected in about 75 locations,[119] in France as well as in other countries where French is spoken. The PFC corpus is one of the largest and most varied databases of spoken French actually available, and by adopting the same guidelines for each of the different *points d'enquête*, it contains a uniform set of data, thus enabling direct comparison between speakers of the different subcorpora. Each subcorpus consists of about a dozen speakers, with a more or less equal distribution of male and female speakers, belonging to at least two different generations. In order to capture the language variation displayed in different speech settings, each speaker is recorded in four different situations. First of all, there are two reading tasks where the participant is asked to read aloud a one-page text and a list of 94 randomized words[120] (cf. Appendix B). Spontaneous conversation is recorded during a guided interview and an unguided conversation. The main difference between these two types of dialogues is that during the guided conversation there is an interviewer conducting the conversation, whereas in the unguided conversation, the person responsible for the recording does not intervene at all, or acts as an equal conversation partner. For each participant, about 90 minutes of speech are available.

The recordings, made on DAT tapes and stored as WAV and MP3 files, are transcribed orthographically. For the read aloud text and the guided and unguided conversations, two additional layers of annotation are provided, concerning the presence or absence of schwa and the presence or absence of liaison, respectively. These annotations, made by means of PRAAT,[121] consist of

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[117] The official website of the project: www.projet-pfc.net. The project was initiated by Jacques Durand (University of Toulouse-Le Mirail), Bernard Laks (University Paris Ouest, Nanterre la Défense) and Chantal Lyche (University of Oslo and University of Tromsø).

[118] Cf. *Bulletin PFC* nº 1, available on the PFC website (http://www.projet-pfc.net/bulletins-et-colloques/cat_view/918-bulletins-pfc.html).

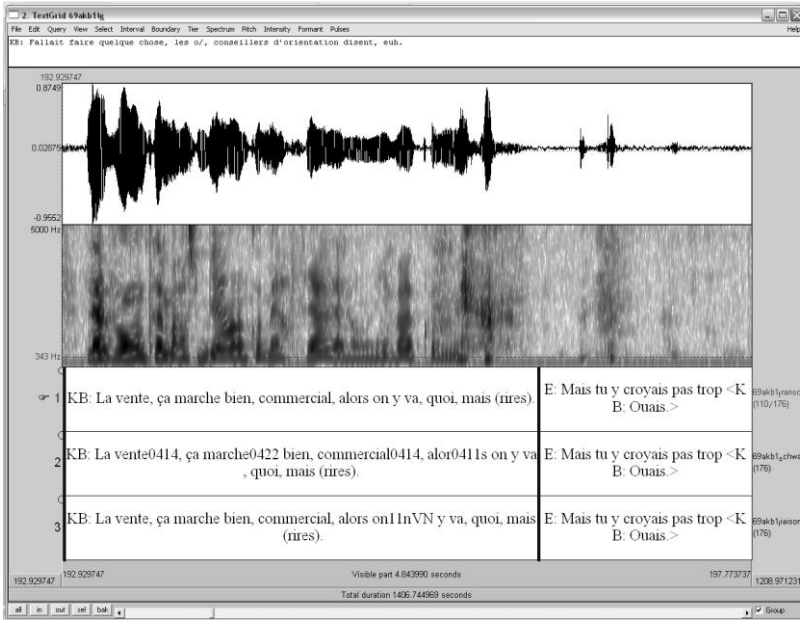
[119] At the time this thesis was written, 36 surveys were already finalized.

[120] This word list consists of both randomly ordered items and sequences of minimal pairs. The order of the words is the same for all the participants.

[121] Developed by Paul Boersma and David Weenink, University of Amsterdam. PRAAT is available for free at www.praat.org.

encodings inserted in duplicated tiers of the orthographic transcription (this is done for the entire read-aloud text, three minutes of both conversations for schwa, and five minutes of both conversations for liaison). As the digits which make up the encodings for schwa and liaison always come in a fixed order, different contexts can be retrieved by making different combinations of the codes. Currently, the process of providing a prosodic annotation of the data has started. The example in (114) shows the actual appearance of the transcriptions (1. orthographic, 2. schwa, 3. liaison), both of the text-grid aligned with the corresponding sound file in PRAAT (114a), as well as of a converted text-grid[122] (114b).

(114) **a. Sound file aligned with the transcriptions in PRAAT, speaker 69akb1 – unguided conversation:**



[122] In order to transform the PRAAT text-grids into plain text, two tools are provided: TRANSPRAAT and the more comprehensive PLATEFORME PFC (developed by A. Meqqori and Julien Eychenne, respectively, University of Toulouse-Le Mirail).

b. PRAAT TextGrid converted into plain text:

69akb1lg_orthographe
KB: La vente, ça marche bien, commercial, alors on y va, quoi, mais (rires).
E: Mais tu y croyais pas trop <KB: Ouais.>
[…]

69akb1lg_schwa
La vente0414, ça marche0422 bien, commercial0414, alor0411s on y va, quoi, mais (rires).
E: Mais tu y croyais pas trop <KB: Ouais.>
[…]

69akb1lg_liaison
La vente, ça marche bien, commercial, alors on11nVN y va, quoi, mais (rires).
E: Mais tu y croyais pas trop <KB: Ouais.>
[…]

The data come with a convenient search engine made available on the PFC website, which the researcher may use to retrieve particular contexts by looking for specific codes, or for specific words or orthographic sequences. However, as the recordings are not accompanied by a (broad) phonetic transcription, the data are not directly suited for research dealing with phenomena of French phonology other than schwa or liaison. For the purposes of the present study, we thus have to provide the data with an annotation ourselves. In the following chapters, where the analyses of velar palatalization and plosive assibilation will be presented, we will also explain the annotation policy adopted, taking into account the specific characteristics of each of the phenomena.

After this brief presentation of the general design and content of the PFC corpus, the next section will motivate the selection of subcorpora and linguistic tasks, and discuss the parameters of variation involved.

6.5 Selection of subcorpora and parameters of variation

6.5.1 Linguistic variation

Every day, people are exposed to a large amount of variation in their language; in the speech of other speakers belonging to the same speech community, as well as in their own utterances. There are numerous factors that bring about this language variation (cf. for instance Labov 1994/2001). Roughly speaking, they can be divided into linguistic and non-linguistic (or extra-linguistic) factors. The former relate to all kinds of variation caused by the physical characteristics of the speech organs or by the specific linguistic context where a sound, word or phrase

finds itself in. The latter category of factors consist of socioeconomic or geographical aspects that may have an impact on linguistic performance. In turn, this category of variation can be divided into three subcategories: diatopic, diastratic and diaphasic variation (cf. Gadet 2007). The first two involve differences between speakers: "diatopic variation" concerns the variation between speakers originating from different areas or regions; "diastratic variation" concerns the differences in speech related to differences in gender or social background of speakers. "Diaphasic variation" is the final type of sociolinguistic variation, and captures the variation displayed by a single speaker. It involves the variation in register in different speech settings, depending on the degree of formality required. The following sections will describe these different parameters of variation in relation to our corpus study, starting with diatopic variation.

6.5.2 Diatopic variation and selection of subcorpora

On the basis of the observations made in the existing literature, it seems sensible to include first of all the surveys conducted in the northern part of France in our selection: Buckley (2003) reports palatalization before *a* in "some northern varieties", and the restricted number of descriptions or manuals mentioning affrication in passing, refer to the standard varieties, which are virtually always equated with Parisian French.[123] For the Parisian region, three subcorpora are actually available. The first one captures the speech of French speakers living in the centre of Paris. The second one contains recordings of a specific group of Parisian residents who moved from the Aveyron region in the south of France to Paris from the mid nineteenth century until the first decades of the twentieth century. This subcorpus does not only contain recordings of the later original migrants, but also of the younger generations who were born in Paris and have parents originating from the Aveyron.[124] The third corpus was recorded in the suburbs Puteaux and Courbevoie, which lie to the west of Paris, near the business quarter *La Défense*. In order not to limit the "northern varieties" to

[123] Grammont (1922:1) for instance states that "[t]outes les personnes compétentes reconnaissent aujourd'hui que [la bonne] prononciation française est celle de la bonne société parisienne, constituée essentiellement par les représentants des vieilles familles de la bourgeoisie" [every competent person will recognize nowadays that the correct French pronunciation is the one of the Parisian upper-class, a class which essentially consists of representatives of old bourgeois families].

[124] For a more detailed description of the characteristics of the Aveyronnais speakers, the reader is referred to Pustka (2007).

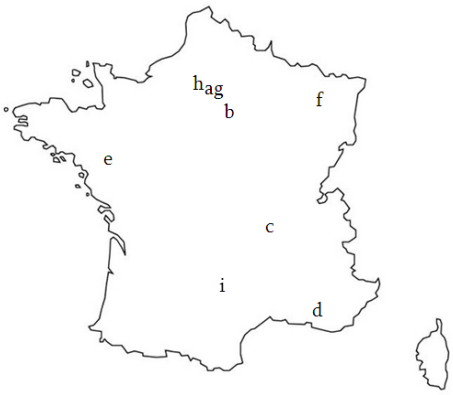
Parisian French, the corpus study also considers speakers from Brunoy and Ogéviller.[125]

It is not only our aim here to present a corpus-based pendant to the existing introspective descriptions and experimental studies, but also to retrieve the exact circumstances of palatalization and affrication. This does not only involve an examination of the segmental characteristics, and the inter- and intra-speaker variation in a specific variety, but also of the geographical dispersion of the sound changes under discussion. Therefore, next to the northern surveys, we will also take into consideration other subcorpora, so as to get a reasonable coverage of metropolitan France. For the mid-west this is the corpus of Nantes, for the mid-southeast Lyon, for the mid-south Rodez and the southern *français du Midi* is represented by Marseille centre ville. An overview of the number of speakers per survey is provided in the table in (115), the geographical spread of the surveys is visualized in (116).

(115) **Survey**	**"Département"**	**Number of speakers**
a. Aveyronnais à Paris	Paris	12
b. Brunoy	Essonne	10
c. Lyon	Rhône	8
d. Marseille centre ville	Bouches-du-Rhône	10
e. Nantes	Loire-Atlantique	10
f. Ogéviller	Meurthe-et-Moselle	10
g. Paris centre	Paris	12
h. Puteaux-Courbevoie	Hauts-de-Seine	5
i. Rodez	Aveyron	7
Total		84

[125] It would have been very interesting to have a survey in the Picard region, as the Picard dialect withstood the historical velar palatalization before *a*. Unfortunately, up to this date, no survey in this region is available.

(116)



This selection contains a total of 84 speakers. In order to provide a better picture of the precise content of the regional subcorpora and their participants, the following section considers the parameters of diastratic and diaphasic variation. A full overview of the background of these speakers is given in Appendix C, listing the speakers' age, gender and profession.

6.5.3 Diastratic and diaphasic variation

The specific design of the PFC database allows us also to determine the influence of specific diastratic or diaphasic factors with respect to the linguistic phenomena in question. The diastratic variation, differences between speakers belonging to different (social) groups, is displayed by the parameters 'gender' and 'age' (cf. (117) and (118) below). Note that the PFC meta data also include information about the socioeconomic background of the speaker, but as this aspect was not used as a criterion for the selection of speakers, it will not be addressed in the following chapters.

(117) **Gender**

	Male	*Female*
Aveyronnais à Paris	5	7
Brunoy	5	5
Lyon	5	3
Marseille centre ville	4	6
Nantes	4	6
Ogéviller	4	6
Paris centre	6	6
Puteaux-Courbevoie	2	3
Rodez	3	4
Total	38	46

(118) **Age**

	≤ 30[126]	*31-54*	*≥ 55*
Aveyronnais à Paris	6	2	4
Brunoy	2	2	6
Lyon	3	4	1
Marseille centre ville	3	4	3
Nantes	3	1	6
Ogéviller	2	3	5
Paris centre	4	4	4
Puteaux-Courbevoie	3	0	2
Rodez	4	0	3
Total	30	20	34

As tables (117) and (118) show, the PFC data provide quite a nicely balanced set of data as far as age and gender are concerned, and it will therefore be possible to make some reliable observations with respect to the potential relation between these parameters and any linguistic variation we will come across.

The final possible source of variation we have to consider is the diaphasic variation, i.e. variation displayed by a single speaker in speech settings where different registers are required. As we have just seen, the speakers were recorded in four different situations, i.e. two reading and two conversation tasks. With respect to the stylistic levels represented in the corpus, Durand et al. (2002, 2005) state that both reading tasks reflect a formal style level. As far as the conversations are concerned, it was hypothesized by the directors of the corpus that the guided conversation would trigger mostly formal speech and only occasionally informal speech, because this conversation is more interview-like, whereas the unguided conversation would reflect informal speech throughout. In practice, however, the stylistic difference between the guided and unguided conversation turns out to be only marginal, and in the guided conversation, we also come across a considerable amount of popular vocabulary.[127] An example from speaker 75clc1 from the Paris centre survey is given in (119), with the relevant items in bold.

(119) "Je ne sais pas euh tu as/ **ben** tu/ tu as les **mecs** euh plutôt un peu tendance euh on va dire **tradi** euh. Oh **ben** un peu **facho** sur les bords **quoi** […] **Ouais ouais** il y en a encore **ouais**. […] ça j'irai quand je **bosserai quoi** "

[126] Includes students and young professionals.

[127] A similar observation is made by Geerts (2008) in a study on schwa deletion.

Our corpus study will mainly concentrate on the two reading tasks, and occasionally turn to the unguided conversation. Even though each of the reading tasks involves a formal level, both of them will be taken into consideration as they are very different from a textual point of view: running text vs. list-reading. As far as the conversations are concerned, we opted to entirely discard the interview, as the guided and unguided conversation are very similar both with respect to their register and their type of data. Given that the unguided conversation is claimed to be the one that should reflect the most natural and spontaneous speech, we will restrict the conversational data to the free conversation.

6.6 The PFC corpus: possibilities and limitations

As has become clear in the preceding sections, the PFC corpus offers numerous possibilities to investigate a given linguistic phenomenon and the possible variation involved. However, an important caveat is in order, related to the specific design of the corpus, or more precisely to the recording procedure. In order to obtain the most natural, most spontaneous speech possible, the participants were not recorded in a sound-proof studio but rather in an environment where the speaker was likely to feel more comfortable, like in his or her own living room. Even though these environments were generally very quiet, this was not always the case, especially during the conversations. A number of recordings therefore cannot compete with studio-data, which will have some repercussions on the (possibility of doing) acoustic analyses. In the following chapters, the specific selection of data and the way the phonetic analyses have been done will be described for each phenomenon separately. Despite this drawback, brought about by the specific focus on naturalness underlying the PFC design, it should be kept in mind that it constitutes a very rich collection of data that will provide without any doubt a good look into the actual dispersion of palatalization and affrication processes in contemporary French, which would have been impossible if we had to rely on experimental data.

6.7 Conclusion

In this chapter, we have introduced the phenomena that will be investigated in the following chapters and we have presented the spoken language corpus that will be explored. As the corpus is balanced for several sociolinguistic factors, a corpus study enables a multidimensional analysis of velar palatalization and plosive assibilation as far as both linguistic and non-linguistic parameters are concerned, while doing away with the principal disadvantages of an experimentally-based approach.

This chapter has also served to place the following chapters in their appropriate perspective. Even though the PFC corpus offers numerous advantages, the recordings are not studio-data and their quality therefore cannot always compete with the data obtained by means of studio-based experiments. However, the PFC data are clearly superior to studio-data as far as their naturalness is concerned. Moreover, the results will give us a good approximation of the spread and strength of the phenomena actually involved and will therefore be a valuable complement to existing descriptions.

The actual corpus study consists of two parts. In the first part, the influence of the vowel quality on the place of articulation of a preceding velar plosive will be examined. We will initially focus purely on the degree of fronting, without examining the quality of the plosive as such. It is in the second part of the corpus study that we will turn to the quality of French plosive releases in different prevocalic contexts. It will not only be examined what the release of a (fronted) velar sounds like, but also to what extent affrication of labial, coronal and velar plosives is active in the different varieties of metropolitan French.

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Velar Fronting

7.1 Introduction

Even though several descriptions of the pronunciation of velars in modern French refer to their strong tendency towards anteriorization in a front vowel context, as we have seen in the preceding chapter, little is known about the actual strength and spread of this fronting. The corpus study that will be presented in this chapter aims at discovering these aspects, by examining the possible linguistic and extra-linguistic factors involved.

Section 7.2 will first of all describe the specific phonetic characteristics of velar plosives. In section 7.3, we will set out the methodology adopted for the treatment of the data and the acoustic analyses. The results for the different vocalic contexts will be presented in section 7.4. In section 7.5, we will zoom in on one context in particular: the low vowel *a*. The diachronic change in this context is problematic from a typological and theoretical point of view, and it has been observed that velar fronting may be active again in this context in contemporary French. It will be considered whether this fronting indeed takes place in modern varieties, and whether synchronic evidence can help to better understand the diachronic change. We will conclude the chapter in section 7.6.

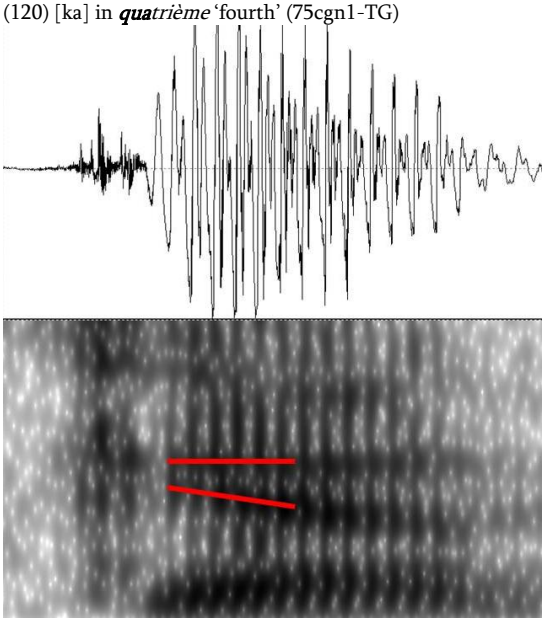
7.2 The phonetics of velars

Like all plosives, velar stops are produced by creating an obstruction in the oral cavity. In the case of velars, this closure is made by moving the tongue body to the soft palate or to the back part of the hard palate. Because of the location of the closure, the cavity in front of the obstruction is relatively long (five to six

cms, cf. Stevens 1998:365), in comparison with labial or coronal plosives, and the length of this cavity may vary considerably, depending on the vowel that follows. Furthermore, velar plosives differ from their labial and coronal counterparts in showing a constriction that extends over a longer area.

As far as their formant tracks are concerned, velar plosives are known for showing the so-called "velar pinch". At the release, with the noise burst centred in the mid-frequency range, the values of the second (F2) and third (F3) formants are very close together, and they seem to originate from a single point, as shown in (120).

(120) [ka] in ***qua****trième* 'fourth' (75cgn1-TG)



7.3 Method

7.3.1 Analysis

To what extent is the place of articulation of a velar influenced by the place of articulation of the vowel that follows? As we have seen, it is commonly assumed that French velars have a more fronted articulation when they are followed by a front vowel than when preceded by a back vowel, and yet, these judgements are often solely based on introspection and solid observations based on empirical data are nearly nonexistent. In order to be able to say something meaningful

about the degree of coarticulation of velars and following vowels, and to be able to add to the existing descriptions, the place of articulation of the plosive in different vocalic contexts has to be examined. The most suitable data for this purpose are obtained by palatography or by making use of ultrasound.[128] Obviously, for a large spoken language corpus such as the PFC database (cf. section 6.4), no palatograms or ultrasound images are available, and therefore, the place of articulation of the velar plosives was examined acoustically.

If the configuration or shape of the vocal tract changes because of movements of the articulators, the vocal tract resonances change. These changes are reflected by the formant values. As for plosives, the value of the first formant is not crucial in this respect: its relatively low value simply reflects the stop closure and thus indicates manner of articulation. Instead, changes in the place of articulation are mainly indicated by the frequency of the second formant (F2),[129] an observation that was first made in a study carried out by Potter et al. (1947). About a decade later, experiments with synthetic speech conducted by Delattre et al. (1955) showed that the frequency values of the second formant serve as a vital parameter for the determination of the place of articulation of consonants. These authors also developed the concept of "locus frequency". This is the fixed frequency of a particular plosive, which is located at some point in the closure, and from where the F2 frequencies at the offset of the vowel seem to originate. Interestingly, for velars no single abstract locus was found. Rather: "there would appear to be a single high-frequency locus for the front vowels *i*, *e*, *ɛ*, and the mid vowel *a*; but for the back vowels *ɔ, o* and *u* the acoustic pattern breaks sharply, and it is obvious that the same […] locus cannot serve for all vowels" (Delattre et al. 1955:770). This observation was ascribed to the fact that the position of the occlusion of the velar shifts, depending on the following vowel.[130] In the years following the publication of Delattre et al.'s study, several experiments showed that these F2 tracks not only constitute an important factor

[128] Palatography is a method where prints or digital plots of the tongue and roof of the mouth are made, showing the exact places where the articulators have been in contact. By using ultrasound, movements of the tongue can be tracked by drawing images on the basis of the echoes of ultrasound waves that pass through the tissues in the oral cavity (for a more detailed description of these techniques, the reader is referred to, among others, Ladefoged 2003:32-53, 185-189).

[129] The movements of F3 values, relative to the F2 trajectories, also mirror place of articulation, cf. Delattre et al. (1955:773). As noted by Kent & Read (1992:118), "the F2-F3 relationship is important for velars, for which the transitions into a following vowel are characterized by an increasing F3-F2 separation", which yields the characteristic "velar pinch" (cf. section 7.2).

[130] Kent & Read (1992:117) note that "[…] velar stops are not produced with a single site of contact but rather with a substantial antero-posterior (front-back) range associated with the vowel context".

in the identification of the place of articulation in synthetic speech, as it turned out that in natural speech, speakers rely on changes in the F2 frequencies as well. By the 1980s a new concept became systematically explored: the "locus equation" (e.g. Klatt 1979, 1987; Krull 1987, 1989; Sussman 1991; Sussman et al. 1995). This concept elaborates on the locus as defined by Delattre et al. (1955), and was proposed as a measure of coarticulation between the plosive and the following vowel.

Roughly speaking, the ingredients for locus equations are the F2 trajectories displayed by plosives belonging to a single category (e.g. labial, coronal, velar) before different vowels. The F2 values are measured at two specific points: at the boundary between the plosive and the vowel and at the vowel nucleus, which is considered the steady state of the vowel, where effects of the preceding and following segments are negligible. For the different vowel contexts, the F2 values at the onset of periodicity are plotted against the F2 values at the vowel nucleus, i.e. with the F2 value of the vowel onset on the y-axis and the F2 value at the nucleus of the vowel on the x-axis. This yields a number of points, which constitute a more or less straight line. As explained in Krull (1989:101) and Duez (1992:419), the resulting line can be described by the following equation:

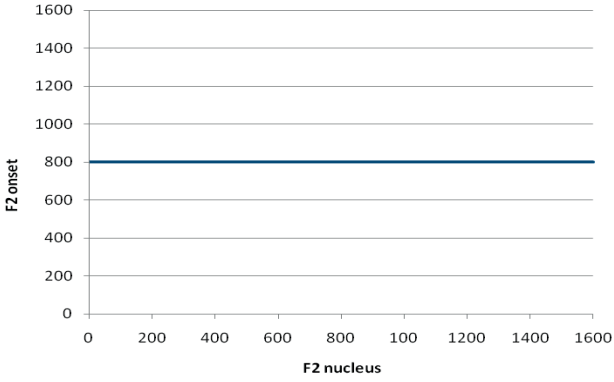
$$F_{2i} = k * F_{2t} + c$$

In this equation, F_{2i} refers to the initial F2 frequency, at the plosive-vowel boundary and F_{2t} reflects the F2 value in the nucleus of the vowel, which is considered its F2 target frequency. The value of c corresponds to the y-intercept, i.e. the value on the y-axis when the value on the x-axis is 0. The slope k of the regression line reflects the degree of coarticulation.[131] In order to clarify this, let us, before moving on to the PFC files, first consider two clear-cut, imaginary, situations. In the first hypothetical scenario, the regression line is a straight horizontal line, with a slope of 0, as illustrated in (121a). If such a line arises, there is absolutely no coarticulation between the plosive and the vowel. That is, the F2 reaches different target values for the different vowels, while the F2 values at the onset are not influenced by the target value of the following vowel, and all converge to the same locus (which in this example is 800 Hz). In the

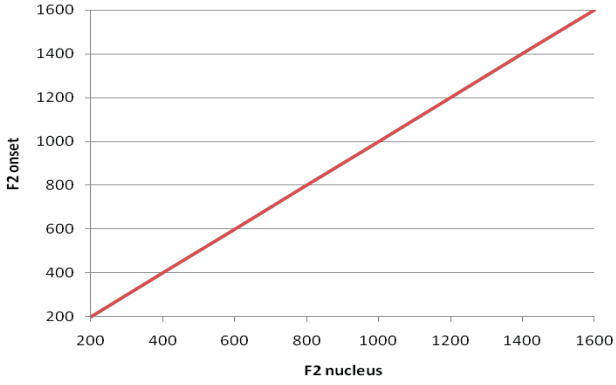
[131] This idea was first expressed in Lindblom (1963). In his study on vowel reduction, he investigated the influence of stress and segmental duration on the formant tracks. By plotting the formant frequencies against the vowel duration, it was claimed that the slope of the regression line reflected the degree of coarticulation.

second scenario, the regression line is a straight diagonal line, with a slope of 1, as shown in (121b). In this case, the F2 value at the onset is identical to the F2 at the vowel nucleus. The F2 value at the onset is entirely determined by the vowel, and no convergence to any locus frequency is detectable. Therefore, the slope of the regression line that results from the different $F2_{onset}$-$F2_{nucleus}$ points, is a measure of the degree of coarticulation between the plosive and the following vowel. If the slope (the value of *k* in the equation) is 1 or close to 1, the F2 values at the plosive release and the vowel nucleus are equal or almost equal, which indicates a greater degree of coarticulation. If, on the other hand, the slope is 0 or close(r) to 0, i.e. (almost) a flat line, the difference between the F2 values at the two points is larger, meaning that there is less coarticulation between the plosive and the vowel.

(121) a. *No coarticulation*



b. *Full coarticulation*



As we have just seen, Delattre et al. (1955) argued that for velars, no single locus could be detected. Rather, there appeared to be two different loci, one for velars followed by front vowels and another one for velars followed by back vowels. When computing locus equations for velar consonants, two different practices are in use (cf. Sussman 1991). In some studies two separate regression lines are drawn, i.e. one for velars followed by back vowels, and another one for velars followed by front vowels. Other studies, on the other hand, link all points to a single regression line. These two possibilities are simply different ways of presenting the data, and the choice for one of them does not change the essence of the results. That is, if there is more coarticulation the differences between F2 onset and F2 nucleus will be smaller, irrespective of the fact whether one or two regression line(s) is/are drawn.

The computation of locus equations is a technique commonly applied as acoustic evidence for the place of articulation of stop consonants and has been used for various languages (cf. for instance, Sussman 1991, Duez 1992, Sussman et al. 1993, Eek & Meister 1995, Fruchter & Sussman 1997, Everett 2008, Harrington 2010), which we also used for the PFC data. Before considering the details of the measurements, let us first consider the exact content of the PFC recordings and a number of particularities of French that need to be taken into account.

7.3.2 Material and measurements

The place of articulation of velars was examined on the basis of the two reading tasks (word list (MG) and short text (TG)). These recordings provide the best quality, which is required to be able to analyze cues as subtle as shifts in the place of articulation of a velar plosive. Moreover, these two tasks were identical for all participants in the surveys that were considered, contrary to the conversations, which differ from one speaker to another. We thus have, in principle, (approximately) the same number of contexts per speaker, which, moreover, allows for reliable statistical analyses.

The analysis concerned all velar plosives followed by a palatal glide or non-nasal vowel (except [ə]).[132] The identification of these contexts was primarily based on the actual recordings of the speakers, in order to control for deviant realizations or realizations that could not be predicted by relying on the orthographic transcription. For instance, on the basis of the orthographic transcription, it is expected that the context [ki] arises in the sequence *ce **qu'il***

[132] Nasal vowels preceded by a velar were not included as the nasal venting of air greatly affects the spectral characteristics of the vowel, which would introduce an undesired source of variation.

appelle ('what he calls'). If, however, a speaker for some reason hesitates or produces a pause inside that sequence, and consequently does not elide the vowel, the sequence [sə **kə** il apɛl] arises, creating a different context. Next, there are the linking phenomena *liaison* and *enchaînement* that could potentially influence the number of Velar+Vowel contexts. If, for some reason, a word-final velar is realized as the onset consonant of the next vowel-initial word (resyllabification), a Velar+Vowel sequence arises.[133] A final phenomenon that needed to be taken into account is the "Loi de Position" (cf. Grammont 1922, Léon 1992, Durand & Lyche 2004): the fact that the quality of mid vowels in stressed position may vary, depending on the syllable structure (open vs. closed). In open syllables, open mid vowels tend to close, and in closed syllables, closed mid vowels tend to open, as illustrated by the items in bold in (122).[134]

As shown by Durand & Lyche (2004), this phenomenon is variable, and tends to be applied more consistently in the southern varieties. For all PFC participants, we checked what the precise realization of the vowel in the *Loi de Position* contexts was, and these individual realizations were used in the subsequent analyses.

[133] No contexts where these particular enchaînements/liaisons may arise were present in the reading tasks, except in the sentence *Le maire de Beaulieu – Marc Blan**c** – **e**st en revanche très inquiet* ('The mayor of Beaulieu – Marc Blanc – is, on the other hand, very worried'). Liaison with the velar is highly unlikely and hypercorrect here, as liaison is normally excluded between a noun and the following verb, but it may arise if speakers, for some reason, ignore the pause(s) indicated by the dashes. In case of liaison, only instances where resyllabification actually took place were considered: [blãk.ɛ.tã ...]→[blã.kɛ.tã ...].

[134] The contrast between French /e-ɛ/, /ø-œ/ and /o-ɔ/ is sometimes considered a difference in height: /e,ø,o/ being mid-high, and /ɛ,œ,ɔ/ mid-low. Others, however, describe the difference as a difference in tenseness of the vowel, and interpret the *Loi de Position* in terms of syllable weight. We will not elaborate on this issue here, for further discussion we refer to Tranel (1987), Wioland (1991), Léon (1992), Durand & Lyche (2004).

(122)	e,ɛ		ø,œ		o,ɔ	
Closed syllable	*fermière* [fɛʁmjɛʁ]	' woman farmer'	*peur* [pœʁ]	'fear'	*sotte* [sɔt]	'stupid(Adj), fool(N), F'
			vendeuse **[vɑ̃døz]** **[vɑ̃dœz]**	'saleswoman'	***chose*** **[ʃoz]** **[ʃɔz]**	'thing'
Open syllable	*fermier* [fɛʁmje]	'farmer'	*peu* [pø]	'little'	*sot* [so]	'stupid (Adj), fool(N), M'
	épée [epe]	'sword'				
	épais **[epɛ]** **[epe]**	'thick'				
	j'irai[135] [jiʁe]	'to go, 1sg., future'				
	j'irais **[jiʁɛ]** **[jiʁe]**	'to go, 1sg., cond.'				

The lexical items in the word list only provided a limited number of target contexts; therefore, the digits preceding the lexical items were taken into account as well.[136] In order to give the reader a rough idea of the velar contexts present in both reading tasks, an overview of the different contexts in the word list and the text is provided in (123) and (124),[137] assuming a flawless, citation pronunciation. *Liaison* and *enchaînement* contexts are put in parentheses. In our discussion of the results below, we will obviously rely on the exact individual realizations, taking into account the actual mispronunciations etc. A full overview of the velar tokens is given in Appendix E.

[135] In colloquial contemporary French, the mid open vowel may also be found in the future tense.

[136] These additional target contexts are all of the *k+a* type (the target syllables are indicated in bold): ***qua****tre, **qua**torze, vingt-**qua**tre, trente-**qua**tre, **qua**rante, **qua**rante-deux, **qua**rante-**qua**tre, cinquante-**qua**tre, soixante-**qua**tre, soixante-**qua**torze, **qua**tre-vingts, **qua**tre-vingt-**qua**tre, **qua**tre-vingt-dix, **qua**tre-vingt-**qua**torze*. By including these instances, the number of *k*+Vowel tokens increases, and more importantly, it yields a larger number of occurrences of *quatre* or a cognate, a context where, according to Buckley (2003), palatalization actually occurs in some modern varieties.

[137] The word list and the text are identical for all the PFC surveys, although, for some reason, the order of the items in the word list used in the Lyon corpus differs from the order in other surveys, and also the version of the read text used in this city is slightly different. Nevertheless, these variations do not have any impact on the number of Velar+Vowel contexts.

(123) *Word list (MG)*

a. Voiceless velars

[k+j/i]	1	[k+y]	-	[k+u]	-
[k+e/ɛ]	4	[k+ø/œ]	-	[k+o/ɔ]	-
[k+a/ɑ]	18				
	23		-		-

b. Voiced velars: -

(124) *Read text (TG)*

a. Voiceless velars

[k+j/i]	9	[k+y]	1	[k+u]	3
[k+e/ɛ]	5 (1)	[k+ø/œ]	-	[k+o/ɔ]	11
[k+a/ɑ]	5				
	19 (1)		1		14

b. Voiced velars

[g+j/i]	-	[g+y]	-	[g+u]	1
[g+e/ɛ]	-	[g+ø/œ]	-	[g+o/ɔ]	-
[g+a/ɑ]	1				
	1		-		1

Let us return now to the acoustic analysis of the PFC sound files. The Velar+Vowel contexts in the selected sound files were manually labelled in PRAAT (Boersma & Weenink 2010). The boundaries of the plosive and the vowel were indicated, and both segments were coded for quality. Moreover, the labels added to the velars contained information about the position of the Velar+Vowel sequence in the word and intonation phrase (initial, medial, final). The intervals indicating the Voice Onset Time (VOT)[138] of the voiceless plosives were represented on a separate tier.

By means of a PRAAT script, the F2 values at the plosive-vowel boundary and in the vowel nucleus were extracted. Following Harrington (2010), the F2 frequency of the vowel nucleus was measured at the vowel midpoint, and the F2 at the plosive-vowel boundary was derived from the first detectable glottal pulse of the vowel. The maximum formant frequency was set at 5000 Hertz for the male speakers, and at 5500 Hertz for the female speakers; the maximum number

[138] Following Cho & Ladefoged (1999:215), VOT was defined as the interval between the onset of the plosive release and the start of the first complete glottal pulse in the waveform. The boundaries were positioned at the zero crossing.

of formants to be detected was fixed at 5. Outliers in the extracted values were manually checked, and corrected if necessary.

After having described the exact content of the recordings and the methodology adopted for the acoustic analyses, let us now turn to the results. First, we will consider the front and back vowels in general. Afterwards, we will have a detailed look at the impact of *a* on the place of articulation of the preceding velar.

7.4 Velars before front and back vowels[139]

7.4.1 Linguistic factors

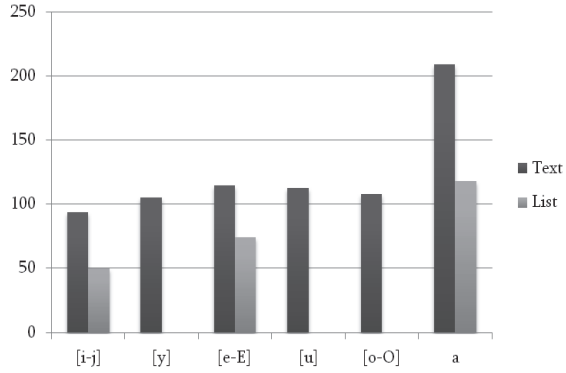
In line with existing observations, the results first of all show that the release locus of the velar plosive is highly variable, and that it is dependent on the place of articulation of the following vowel. Roughly speaking, the velar is back when followed by a back vowel, but it strongly tends to centralize when followed by a central vowel, and to become front when followed by a front vowel. The following overview gives the mean $F2_{onset}$-$F2_{nucleus}$ differences[140] (in Hz) of the different vowel contexts in the read text and the word list respectively, generalizing over all tokens, speakers and regions.

(125) *Average $F2_{onset}$-$F2_{nucleus}$ differences*

	High front [i-j]	[y]	**Mid front** [e-ɛ]	**High back** [u]	**Mid back** [o-ɔ]	*a*
Text	$\bar{X}$ = 93.60 SD = 31.89	$\bar{X}$ = 105.11 SD = 90.47	$\bar{X}$ = 114.40 SD = 54.89	$\bar{X}$ = 112.87 SD = 51.95	$\bar{X}$ = 107.84 SD = 32.40	$\bar{X}$ = 208.91 SD =76.61
List	$\bar{X}$ = 50.10 SD = 43.18		$\bar{X}$ = 74.32 SD = 54.36			$\bar{X}$ = 118.06 SD = 45.15

[139] A concise version of sections 7.4 and 7.5 can be found in Berns (2013).

[140] Because we are not directly comparing absolute formant values of different speakers, but only bare $F2_{onset}$-$F2_{nucleus}$ *differences* realized by the participants, no vowel normalization was applied.



To put it very generally, the mean F2 differences of the front and back vowels are relatively close together, which would not be expected if the velar only had a single place of articulation: the distance to some vowels would then be larger than the distance to vowels articulated at places closer to the velar locus. The values in (125) rather suggest that the position of the velar shifts according to the following vowel. Two categories, however, seem to stand apart. This holds to a minor degree for the high unrounded vocalic segments [i] and [j], which show a somewhat smaller F2 difference than the vowels [y,e,ɛ,u,o,ɔ]. More striking, however, is the F2 difference realized before *a*, which is very large in comparison with the other vocalic contexts.

The place of articulation of the velar thus seems to move towards the following vowel, most strongly in the case of the front unrounded vowels. This effect, however, seems virtually absent in the case of *a*, the context with the largest F2 differences, and the velar generally appears to maintain its back locus. In order to check whether the vowel quality as such influences the F2 differences, an Analysis of Variance (ANOVA) was carried out in SPSS, using the tokens of the read text (as it includes more vowel contexts than the word list). The individual $F2_{onset}$-$F2_{nucleus}$ difference was defined as dependent variable and the vowel quality as independent variable. The outcomes show a very significant effect of the vowel quality: $n = 3016$, $F_{5,3010} = 99.83$, $p = 0.00$. Subsequent post-hoc tests (Games-Howell) indicate that not all vowels differ significantly from each other. The front vowels [i/j] differ significantly from all other vowels, except from their front rounded counterpart [y]. In turn, this latter vowel only differs substantially from *a*. The mid front vowels [e/ɛ] and the back vowels [u] and [o/ɔ] differ significantly from both [i] and *a*. Finally, the F2 differences of *a* significantly differ from all other vowels. An overview of the *p* values is given in (126), where the shaded cells indicate the significant differences.

(126) *Differences between vowels: post-hoc tests*

	p		*p*		*p*
[i/j] + [y]	0.839	[y] + [i]	0.839	[e/ɛ] + [i]	0.002
[i/j] + [e/ɛ]	0.002	[y] + [e/ɛ]	0.966	[e/ɛ] + [y]	0.966
[i/j] + [u]	0.020	[y] + [u]	0.987	[e/ɛ] + [u]	1.000
[i/j] + [o/ɔ]	0.005	[y] + [o/ɔ]	1.000	[e/ɛ] + [o/ɔ]	0.867
[i/j] + *a*	0.000	[y] + *a*	0.000	[e/ɛ] + *a*	0.000

	p		*p*		*p*
[u] + [i]	0.020	[o/ɔ] + [i]	0.005	*a* + [i]	0.000
[u] + [y]	0.987	[o/ɔ] + [y]	1.000	*a* + [y]	0.000
[u] + [e/ɛ]	1.000	[o/ɔ] + [e/ɛ]	0.867	*a* + [e/ɛ]	0.000
[u] + [o/ɔ]	0.976	[o/ɔ] + [u]	0.976	*a* + [u]	0.000
[u] + *a*	0.000	[o/ɔ] + *a*	0.000	*a* + [o/ɔ]	0.000

The numbers in (126) and the one-way ANOVA give a first approximation of the Velar+Vowel coarticulation, but let us examine in more detail a number of linguistic and extra-linguistic factors that may condition the actual degree of coarticulation. A Repeated Measures Analysis of Variance was carried out (GLM, Repeated Measures procedure in SPSS), taking the average $F2_{onset}$-$F2_{nucleus}$ per speaker for each vowel context as dependent variable. Vowel quality was defined as a within-subject factor and regional background, age and gender of the speaker, which will be discussed in the following section, were included as between-subject variables. Two separate ANOVAs were carried out, for the read-aloud text (TG) and the word list (MG), respectively, as the two tasks did not contain the same vocalic contexts.

As far as the linguistic factors are concerned, the results first of all again show a significant effect of the vowel quality (TG: $F_{5,185} = 36.64$, $p = 0.00$, MG: $F_{2,74} = 119.13$, $p = 0.00$). Other linguistic variables, like syllable structure, word length and phrasal position, were not included in the design as such, because this would yield an unbalanced and insufficient number of cases. In order to get a rough impression of these factors, let us nevertheless give a brief overview of the different contexts (based on the more comprehensive set of tokens in the read text). We will not consider the difference between voiced and voiceless velars, as the number of voiced velars is too small to be able to detect any effect.

(127) *Open vs. closed syllable*

	open	closed
[i/j]	n = 414 $\bar{X}$ = 100.31 SD = 88.23	n = 335 $\bar{X}$ = 83.45 SD = 76.73
[y]	n = 84 $\bar{X}$ = 105.11 SD = 90.47	n = 0
[e/ɛ]	n = 84 $\bar{X}$ = 69.26 SD = 56.93	n = 336 $\bar{X}$ = 125.03 SD = 96.29
[u]	n = 168 $\bar{X}$ = 109.46 SD = 99.62	n = 167 $\bar{X}$ = 115.28 SD = 97.39
[o/ɔ]	n = 588 $\bar{X}$ = 114.13 SD = 92.96	n = 336 $\bar{X}$ = 96.71 SD = 76.81
a	n = 252 $\bar{X}$ = 209.83 SD = 119.39	n = 252 $\bar{X}$ = 205.02 SD = 129.85
Total	n = 1590 $\bar{X}$ = 122.36 SD = 103.22	n = 1426 $\bar{X}$ = 121.58 SD = 103.67

(128) *Monosyllabic vs. polysyllabic tokens*

	monosyllabic	polysyllabic
[i/j]	n = 415 $\bar{X}$ = 97.64 SD = 82.19	n = 334 $\bar{X}$ = 86.72 SD = 85.16
[y]	n = 0	n = 84 $\bar{X}$ = 105.11 SD = 90.47
[e/ɛ]	n = 84 $\bar{X}$ = 107.49 SD = 73.45	n = 336 $\bar{X}$ = 115.47 SD = 96.70
[u]	n = 167 $\bar{X}$ = 115.28 SD = 97.39	n = 168 $\bar{X}$ = 109.46 SD = 99.62
[o/ɔ]	n = 336 $\bar{X}$ = 96.71 SD = 76.81	n = 588 $\bar{X}$ = 114.13 SD = 92.96
a	n = 84 $\bar{X}$ = 217.23 SD = 133.08	n = 420 $\bar{X}$ = 205.46 SD = 122.95
Total	n = 1086 $\bar{X}$ = 110.07 SD = 92.88	n = 1930 $\bar{X}$ = 128.70 SD = 108.35

(129) *(Intonation) Phrase-initial/medial/final*

	phrase-initial	phrase-medial	phrase-final
[i/j]	n = 0	n = 498 $\bar{X}$ = 96.02 SD = 80.36	n = 251 $\bar{X}$ = 86.31 SD = 89.64
[y]	n = 0	n = 84 $\bar{X}$ = 105.11 SD = 90.47	n = 0
[e/ɛ]	n = 252 $\bar{X}$ = 130.88 SD = 102.25	n = 168 $\bar{X}$ = 88.38 SD = 68.26	n = 0
[u]	n = 0	n = 335 $\bar{X}$ = 112.36 SD = 98.41	n = 0
[o/ɔ]	n = 168 $\bar{X}$ = 92.63 SD = 77.68	n = 672 $\bar{X}$ = 112.43 SD = 90.60	n = 84 $\bar{X}$ = 101.02 SD = 80.80
a	n = 168 $\bar{X}$ = 203.19 SD = 121.06	n = 336 $\bar{X}$ = 209.54 SD = 126.50	n = 0
Total	n = 588 $\bar{X}$ = 140.61 SD = 110.35	n = 2093 $\bar{X}$ = 121.88 SD = 102.52	n = 335 $\bar{X}$ = 90.00 SD = 87.62

Considering the overall picture, the mean values are quite stable across the different contexts, and where differences arise, it is in fact impossible to draw any conclusions because a considerable difference in the number of contexts is involved (for instance [e,ɛ] in open/closed syllable). For our speakers and our contexts at least, the syllabic and phrasal structure do not seem to have a noticeable influence on the realized F2 differences.

Except for the contextual aspects of the Velar+Vowel sequence, speech rate may also influence the actual F2 difference between the plosive release and the vowel nucleus. That is, when speakers speak more slowly and pay more attention to their articulation, it is expected that there will be less coarticulation than when they speak faster and pay less attention to their speech. In this respect, it is also worth taking into consideration how the length of the VOT (also reflecting the length of the release) of the velar relates to the degree of coarticulation. In our analysis, speech rate was expressed as the number of syllables realized per second; the VOT reflects the interval between the start of the release of the plosive closure and the first glottal pulse of the vowel, and was based on the voiceless tokens. Correlating these three variables for the read text results (Pearson correlation in SPSS) shows that there is a negative relation between both speech rate and the Velar+Vowel difference, and the VOT length

and this F2 difference. The higher the speech rate, the smaller the F2 difference, and the higher the degree of coarticulation between the velar and the vowel. A longer VOT also implies a smaller F2 difference between the vowel onset and the vowel nucleus: the articulation of the plosive takes longer and a considerable portion of the required transition can be realized already during the longer phase preceding the vowel onset. The relevant values are given in (130).

(130)

Speech rate – Velar+Vowel F2 difference	r = -0.156 r^2 = 0.024	p = 0.00
VOT – Velar+Vowel F2 difference	r = -0.165 r^2 = 0.027	p = 0.00

As far as our data are concerned, vowel quality appears to be the strongest linguistic factor conditioning the F2 difference between the vowel onset and the vowel nucleus, and this F2 difference seems further related to the speech rate and the length of the plosive release.[141] Let us now consider whether next to these linguistic factors, sociolinguistic aspects also play a role in the degree of Velar+Vowel coarticulation.

7.4.2 Sociolinguistic factors

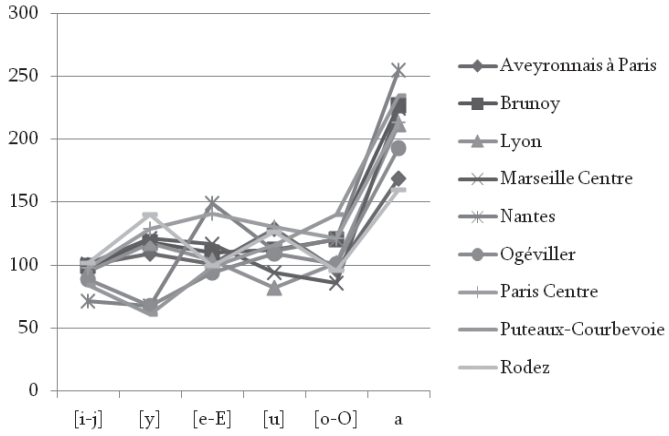
As indicated in the previous section, the extra-linguistic factors included in our study are the participants' regional background, age and gender. For each of these factors, the tables and figures in (131)-(133) provide an overview of the average F2 differences, showing the inter- and intra-group variation.

[141] It is important to keep in mind that the length of the release as such varies with the quality of the vowel that follows.

(131) *Average $F2_{onset}$-$F2_{nucleus}$ difference per region*

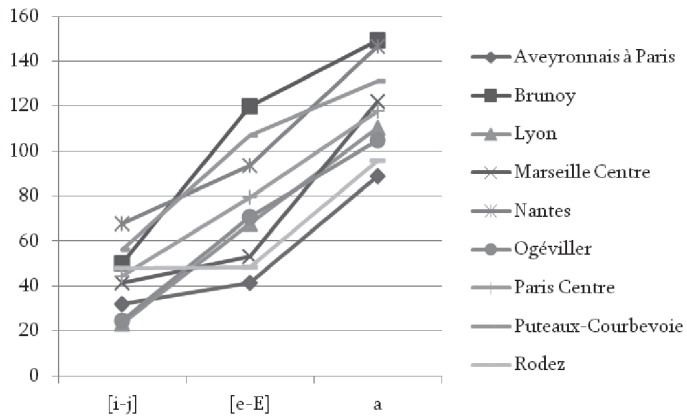
a. Read text

	High front [i-j]	[y]	**Mid front** [e-ɛ]	**High back** [u]	**Mid back** [o-ɔ]	*a*
Aveyronnais à Paris	$\bar{X}$ = 100.22 SD = 30.18	$\bar{X}$ = 109.17 SD = 121.06	$\bar{X}$ = 100.82 SD = 25.19	$\bar{X}$ = 128.42 SD = 60.38	$\bar{X}$ = 96.21 SD = 29.65	$\bar{X}$ = 168.79 SD = 59.54
Brunoy	$\bar{X}$ = 99.29 SD = 21.70	$\bar{X}$ = 118.30 SD = 97.97	$\bar{X}$ = 109.80 SD = 45.13	$\bar{X}$ = 111.98 SD = 62.14	$\bar{X}$ = 120.47 SD = 34.48	$\bar{X}$ = 226.65 SD = 87.08
Lyon	$\bar{X}$ = 94.90 SD = 33.86	$\bar{X}$ = 117.50 SD = 112.02	$\bar{X}$ = 103.68 SD = 42.58	$\bar{X}$ = 81.94 SD = 29.22	$\bar{X}$ = 101.25 SD = 34.65	$\bar{X}$ = 211.46 SD = 53.76
Marseille centre	$\bar{X}$ = 100.54 SD = 35.40	$\bar{X}$ = 121.30 SD = 99.15	$\bar{X}$ = 116.70 SD = 58.42	$\bar{X}$ = 93.68 SD = 46.97	$\bar{X}$ = 85.66 SD = 20.19	$\bar{X}$ = 224.68 SD = 75.87
Nantes	$\bar{X}$ = 71.49 SD = 18.35	$\bar{X}$ = 67.40 SD = 23.37	$\bar{X}$ = 148.88 SD = 49.73	$\bar{X}$ = 111.05 SD = 32.34	$\bar{X}$ = 120.73 SD = 31.56	$\bar{X}$ = 254.87 SD = 79.79
Ogéviller	$\bar{X}$ = 88.43 SD = 24.60	$\bar{X}$ = 67.60 SD = 79.04	$\bar{X}$ = 94.12 SD = 36.70	$\bar{X}$ = 109.40 SD = 54.42	$\bar{X}$ = 100.81 SD = 15.88	$\bar{X}$ = 192.73 SD = 63.41
Paris centre	$\bar{X}$ = 97.73 SD = 53.04	$\bar{X}$ = 129.08 SD = 100.19	$\bar{X}$ = 140.50 SD = 95.32	$\bar{X}$ = 129.98 SD = 64.35	$\bar{X}$ = 120.87 SD = 37.20	$\bar{X}$ = 212.95 SD = 97.00
Puteaux-Courbevoie	$\bar{X}$ = 84.25 SD = 20.67	$\bar{X}$ = 61.20 SD = 57.78	$\bar{X}$ = 98.56 SD = 41.06	$\bar{X}$ = 115.60 SD = 30.80	$\bar{X}$ = 139.96 SD = 28.97	$\bar{X}$ = 234.07 SD = 81.07
Rodez	$\bar{X}$ = 101.32 SD = 18.81	$\bar{X}$ = 139.71 SD = 43.79	$\bar{X}$ = 99.57 SD = 40.70	$\bar{X}$ = 126.56 SD = 55.68	$\bar{X}$ = 95.29 SD = 31.50	$\bar{X}$ = 159.52 SD = 50.57



b. Word list

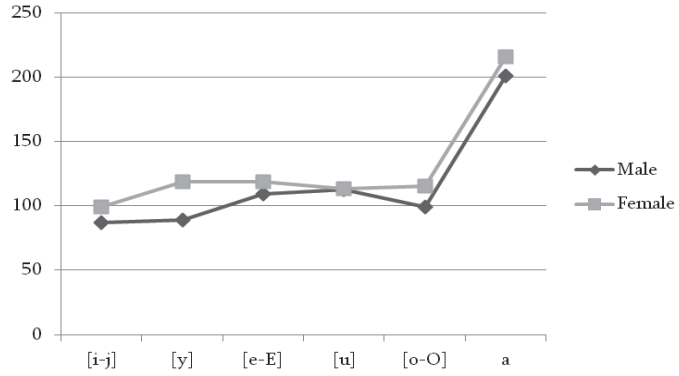
	High front [i-j]	**Mid front** [e-ɛ]	*a*
Aveyronnais à Paris	$\bar{X}$ = 32.08 SD = 22.59	$\bar{X}$ = 41.44 SD = 16.90	$\bar{X}$ = 88.74 SD = 19.87
Brunoy	$\bar{X}$ = 49.88 SD = 44.76	$\bar{X}$ = 120.08 SD = 66.86	$\bar{X}$ = 149.38 SD = 47.29
Lyon	$\bar{X}$ = 23.50 SD = 19.24	$\bar{X}$ = 67.81 SD = 28.45	$\bar{X}$ = 110.63 SD = 21.95
Marseille centre	$\bar{X}$ = 41.40 SD = 35.97	$\bar{X}$ = 53.10 SD = 20.11	$\bar{X}$ = 122.00 SD = 32.55
Nantes	$\bar{X}$ = 67.90 SD = 67.14	$\bar{X}$ = 93.65 SD = 42.76	$\bar{X}$ = 146.57 SD = 57.89
Ogéviller	$\bar{X}$ = 24.50 SD = 46.13	$\bar{X}$ = 70.84 SD = 49.37	$\bar{X}$ = 104.66 SD = 41.22
Paris centre	$\bar{X}$ = 44.50 SD = 43.85	$\bar{X}$ = 79.48 SD = 81.47	$\bar{X}$ = 117.87 SD = 59.96
Puteaux-Courbevoie	$\bar{X}$ = 55.95 SD = 45.19	$\bar{X}$ = 107.05 SD = 74.66	$\bar{X}$ = 131.37 SD = 43.75
Rodez	$\bar{X}$ = 47.86 SD = 22.70	$\bar{X}$ = 48.18 SD = 31.05	$\bar{X}$ = 95.68 SD = 26.30



(132) *Average $F2_{onset}$-$F2_{nucleus}$ difference per gender*

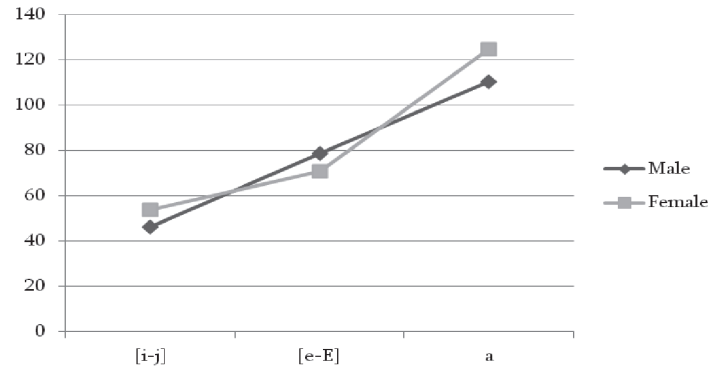
a. Read text

	High front [i-j]	[y]	**Mid front** [e-ɛ]	**High back** [u]	**Mid back** [o-ɔ]	*a*
Male	$\bar{X}$ = 86.92	$\bar{X}$ = 89.03	$\bar{X}$ = 109.24	$\bar{X}$ = 112.63	$\bar{X}$ = 98.95	$\bar{X}$ = 201.08
	SD = 29.41	SD = 77.22	SD = 47.06	SD = 60.31	SD = 30.36	SD = 76.85
Female	$\bar{X}$ = 99.12	$\bar{X}$ = 118.39	$\bar{X}$ = 118.67	$\bar{X}$ = 113.08	$\bar{X}$ = 115.18	$\bar{X}$ = 215.38
	SD = 33.09	SD = 98.97	SD = 60.79	SD = 44.57	SD = 32.51	SD = 76.64



b. Word list

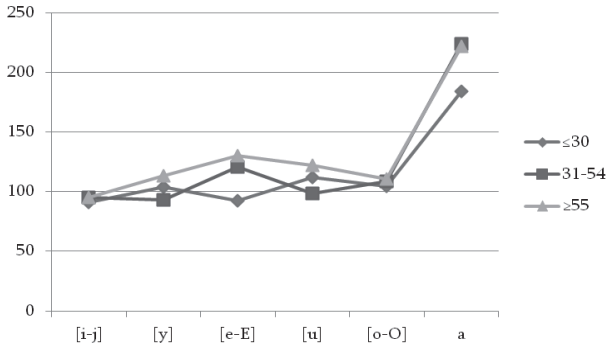
	High front [i-j]	**Mid front** [e-ɛ]	*a*
Male	$\bar{X}$ = 46.08	$\bar{X}$ = 78.67	$\bar{X}$ = 110.06
	SD = 41.99	SD = 52.64	SD = 41.49
Female	$\bar{X}$ = 53.43	$\bar{X}$ = 70.72	$\bar{X}$ = 124.67
	SD = 44.31	SD = 56.05	SD = 47.40



(133) *Average $F2_{onset}$-$F2_{nucleus}$ difference per generation*

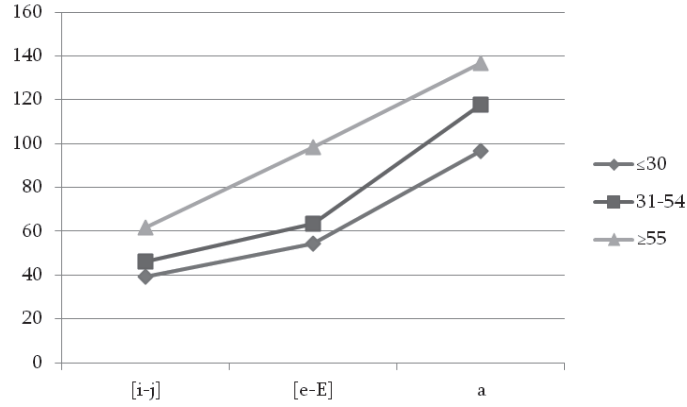
a. Read text

	High front [i-j]	[y]	**Mid front** [e-ɛ]	**High back** [u]	**Mid back** [o-ɔ]	*a*
≤30	$\bar{X}$ = 90.81	$\bar{X}$ = 103.77	$\bar{X}$ = 92.29	$\bar{X}$ = 112.08	$\bar{X}$ = 104.37	$\bar{X}$ = 184.37
	SD = 26.36	SD = 91.64	SD = 38.89	SD = 44.29	SD = 32.37	SD = 50.33
31-54	$\bar{X}$ = 94.97	$\bar{X}$ = 92.85	$\bar{X}$ = 120.46	$\bar{X}$ = 98.24	$\bar{X}$ = 108.79	$\bar{X}$ = 224.06
	SD = 38.01	SD = 93.24	SD = 63.38	SD = 51.18	SD = 33.70	SD = 94.03
≥55	$\bar{X}$ = 95.26	$\bar{X}$ = 113.50	$\bar{X}$ = 130.36	$\bar{X}$ = 122.18	$\bar{X}$ = 110.34	$\bar{X}$ = 221.67
	SD = 33.22	SD = 89.64	SD = 56.63	SD = 57.76	SD = 32.37	SD = 81.17



b. Word list

	High front [i-j]	**Mid front** [e-ɛ]	*a*
≤30	$\bar{X}$ = 39.46	$\bar{X}$ = 54.53	$\bar{X}$ = 96.81
	SD = 32.30	SD = 38.92	SD = 29.49
31-54	$\bar{X}$ = 46.00	$\bar{X}$ = 63.39	$\bar{X}$ = 117.78
	SD = 41.46	SD = 38.99	SD = 38.23
≥55	$\bar{X}$ = 61.91	$\bar{X}$ = 98.21	$\bar{X}$ = 136.97
	SD = 50.26	SD = 64.87	SD = 52.38



The results show first of all quite a consistent pattern across the different regions for the read text (131a). For the word list, the picture is more variable, but the same basic pattern arises. Grouping the mean F2 differences according to the generation or to the gender of the speaker, shows that the patterns across the vowel contexts are quite similar, but that there is nevertheless variation between the different subgroups.

As a matter of fact, the repeated measures analysis based on the results of the read text shows that the regional background does not influence the realized F2 difference ($F_{8,37}$: 1.345, p = 0.253). Next to 'vowel quality', the factors 'age' and 'gender', however, do significantly contribute to the realized F2 differences ($F_{2,37}$: 3.706, p = 0.034 and $F_{1,37}$: 8.910, p = 0.005 respectively). Across the different vocalic contexts, women tend to produce larger F2 differences than men, and post-hoc tests (Games-Howell in SPSS)[142] show that there is a difference between the youngest and the oldest generation, but that the group of speakers aged between 31 and 54 does not differ significantly from the other two generations. To be more precise, the F2 difference realized by the oldest generation is substantially larger in comparison with the youngest group of PFC speakers.

More or less the same holds for the vocalic contexts in the word list, although the patterns are less neat than the patterns of the read text. All three between-subject factors, especially 'region' ($F_{8,37}$: 1.351, p = 0.250) and 'gender' ($F_{1,37}$: 0.114, p = 0.738), but also 'age' ($F_{2,37}$: 3.211, p = 0.052), turn out to be insignificant. The combination of the factors 'vowel quality' and 'age', however,

[142] Levene's test for equality of variances turned out significant, and therefore homogeneity of variances could not be assumed.

does give a significant result ($F_{2,37}$: 4.681, $p = 0.015$): the F2 difference appears to increase with age and is smallest with the high front vowel.

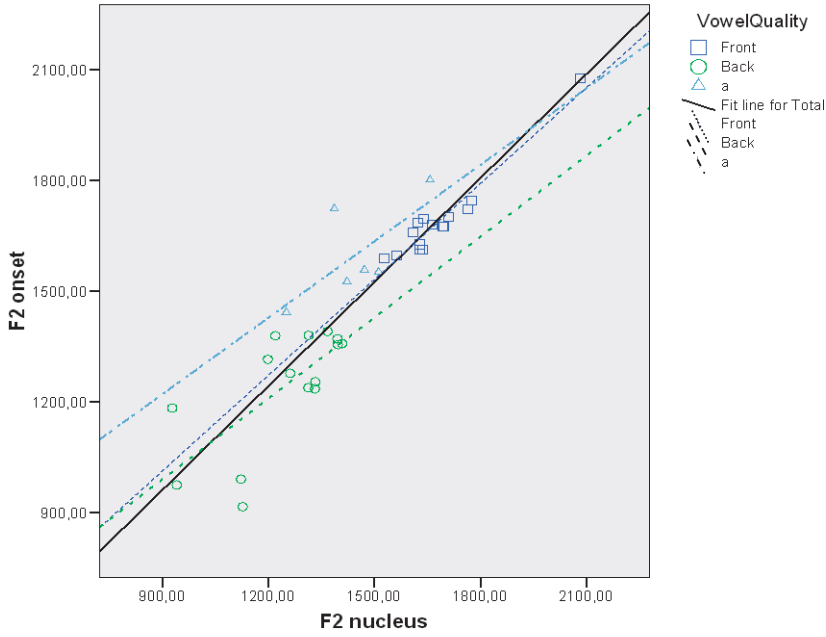
Variation in the degree of Velar+Vowel coarticulation can be found in all regions in France. When compared to men, women tend to minimize this coarticulation, which might be an effect of the quite often recurring desire of female speakers to conform to a (prestige) norm (cf. Labov 2001:261-293), and to produce neatly articulated forms. At the same time, substantial Velar+Vowel coarticulation is found among the generation of students and young professionals. This tendency might on the one hand simply be a characteristic of popular youth language, which disappears when they grow older (i.e. "age-grading", cf. Labov 1994:73-112) and when they (have to) start paying more attention to their articulation in their professional lives. On the other hand, it might be a speech habit adopted and internalized by this specific generation, and which will be characteristic of this and younger generations for the rest of their lives, thus ultimately bringing about a sound change. Further research may shed light onto this.

7.4.3 Locus equation of the PFC velars

Up to now, we have discussed the F2 differences in relation to different linguistic and sociolinguistic variables. We have limited the description to the bare F2 differences in the various vocalic contexts. As we have seen in section 7.3.1, the actual degree of coarticulation of a speaker can be indicated by the locus equation; a linear regression between the different $F2_{onset}$-$F2_{nucleus}$ values of the different vowels preceded by a specific plosive. The steeper the regression line (thus the smaller the difference between the F2 values at the two moments), the higher the degree of coarticulation. The description set out above relies on these F2 differences, but without transforming them into locus equations. As a matter of fact, however, the underlying principle remains the same: the smaller the F2 difference between the onset and the nucleus, the larger the coarticulation. Besides, our description is to a certain extent more informative than a locus equation, as a smaller F2 difference between the onset and the nucleus in a specific vocalic context more directly reflects the coarticulation of the plosive and the vowel in a specific context than a slope coefficient, which is based on multiple vocalic environments at the same time. Yet, in order to give a general picture of the actual appearance of a locus equation, (134a) below shows a graph of the different F2 onset and nucleus values of the different vowels (i.e. front vowels, back vowels, *a*) realized by a Parisian speaker. Four regression lines have been drawn: one based on all vowels, and the other three on the front vowels,

the back vowels and the *a* tokens respectively. The slopes of these lines of best fit are given in (134b).

(134) **a. Locus equation – speaker 75ccm1TG**



b. Slopes of the regression lines

Total: 0.940
Front vowels: 0.867
Back vowels: 0.732
a: 0.692

The total regression line has a slope which is very close to 1, which indicates a strong coarticulation between the velar and the following vowel. This total line of fit generalizes over the different vocalic contexts. The regression lines drawn for the three subcontexts (front, back, *a*) indicate that this speaker manifests a considerable coarticulation between the velar and the following vowel in all contexts, as all slope values are far closer to 1 than to 0. Speaker 75ccm1 shows the largest coarticulation in the front vowel context; the coefficients of the back vowels and *a* are somewhat lower and quite close together, but still indicate an important coarticulation.

In this section, we have considered the place of articulation of velars in different prevocalic contexts, with respect to both linguistic and extra-linguistic factors. The front vowels generally induce an anteriorization of the place of articulation of the preceding velar, whereas the velar clearly remains back if followed by a back vowel. For *a*, the largest F2 differences were realized, but nevertheless, the speakers turn out to differ substantially as to the actual F2 difference displayed in a *k*+*a* context, contrary to the neat picture for the high front unrounded vowels for instance. The following section will therefore focus on the quality of *a*, in relation to the place of articulation of the preceding velar plosive. We will also return to Buckley's observation of synchronic velar fronting in this context and consider to what extent it is indeed reflected in the PFC surveys.

7.5 A closer look at *a*

7.5.1 /a/ vs. /ɑ/

Conservative descriptions of the modern French vowel inventory make a distinction between two low vowels: anterior /a/ and posterior /ɑ/,[143] the front vowel being by far the lexically most frequently occurring token.[144] Up to the middle of the twentieth century, these two vowels were clearly pronounced distinctly, and as Walter (1988:256) states, the *a* in *patte* had a very fronted realization, close to [ɛ], and the place of articulation of the *a* in *pâte* was situated in the back of the mouth, close to [ɔ]. During the following decades, the distinction gradually lost ground in favour of anterior [a]. If the contrast is maintained, it is generally found in word-final (i.e. stressed) syllables. In non-final syllables, the contrast has been virtually neutralized[145] (cf. Tranel 1987:62-65), and the [ɑ] tokens have merged with [a].[146] Buckley (2003) hypothesized that palatalization in contemporary French could be related to this anterior – posterior distinction, which he considers a "socially marked variable in Paris" (2003:11). Before discussing velar fronting in this low vowel context in more detail, let us therefore consider first to what extent the qualitative aspect of the

[143] This opposition reflects the earlier contrast between short /a/ and long /a:/, cf. Martinet & Walter (1973:32).

[144] Léon (1966:61) estimates that 95% of the lexical *a* tokens are instances of [a], in a later study (1992:87), he reports that 97.6% of all occurrences of *a* are of the anterior [a] type.

[145] As a matter of fact, the further the [ɑ] is removed from the accented position, the more likely it is to be neutralized with [a] (cf. Léon 1966:64, Tranel 1987:62-65).

[146] As noted by Martinet & Walter (1973:32), numerous speakers still maintain a quantitative contrast reflecting the former opposition.

anterior – posterior contrast is preserved by the speakers in our corpus. The word list contains a minimal pair *patte* (/a/ 'paw') – *pâte* (/ɑ/ 'pastry'), with both tokens figuring twice in the list: once randomly ordered among the other items, and once directly in sequence. For each of the tokens, the F1 and F2 values were measured at the temporal mid of the vowel.[147] An overview of the absolute F2 differences[148] (in Hz) between *patte* and *pâte*, realized by the speakers of the 9 regions, is given in (135).[149]

(135) F2 difference *patte* - *pâte*

a. Random order

$\bar{X}$ = 124.0 Hz
SD = 114.96 Hz

	0-10	11-25	26-50	51-75	76-100	101-150	151-200	201-250	≥251	*Total*
a. Aveyronnais à Paris	1	3	3		5					12
b. Brunoy	1	2		1	2	1	1		2	10
c. Lyon		1	1			2		3		7[150]
d. Marseille centre	2	1	4		1	2				10
e. Nantes	1			1		1	2	2	3	10
f. Ogéviller	1			1	1	1	2	1	3	10
g. Paris centre	1	2	1	2		3	1	1	1	12
h. Puteaux-Courbevoie			1	1		1			2	5
i. Rodez	1	2	1			2			1	7
Total	8	11	11	6	9	13	6	7	12	83

[147] In order to get the most reliable formant values of the vowel as such, which are not, or as little as possible, influenced by the preceding and/or following segment(s), three methods (which may coincide) are generally used. The first one measures the formant values at the point where the intensity of the vowel is maximal, a second possibility is to extract the formants at the F1 maximum of the vowel, and a third and final procedure is to derive the values from the temporal midpoint of the vowel. The advantage of this latter method is that the mid of the vowel is rather straightforward to locate, and it is the most reliable one in our case, since we are not dealing with studio-data.

[148] Again, as we are not directly comparing raw formant frequencies of different speakers, no normalization was applied.

[149] Please note that the scale division gets more condensed the higher the formant values get.

[150] Speaker 69ajd1 was laughing when pronouncing *pâte,* and therefore her /a/–/ɑ/ tokens in the random sequence have not been taken into consideration. For reasons of illustration, her F2 difference in the minimal sequence has been included in table (135b), but it has not been incorporated in the statistical analyses.

b. Minimal sequence

$\bar{X}$ = 160.02 Hz

SD = 146.49 Hz

	0-10	11-25	26-50	51-75	76-100	101-150	151-200	201-250	≥251	*Total*
a. Aveyronnais à Paris		4	3	2	1	2				12
b. Brunoy			2		1		3		4	10
c. Lyon		1		1		4		1	1	8
d. Marseille centre	2	3	1			3			1	10
e. Nantes				2			1		7	10
f. Ogéviller			1		1	2		3	3	10
g. Paris centre	1		3	1		1		3	3	12
h. Puteaux-Courbevoie			1			1		1	2	5
i. Rodez		2	2		2	1				7
Total	3	10	13	6	5	14	4	8	21	84

These tables classify the bare formant differences and indicate to what extent the contrast is maintained or reduced. For a hearer to be able to perceive a qualitative difference between two vowels, the F2 difference should be at least 1.5% (cf. Rietveld & van Heuven 2001:202). With respect to the /a/-/ɑ/ difference in the above tables, this holds, roughly speaking, for differences larger than 25 Hz.

If *patte* and *pâte* are read aloud in random order, speakers show very different realizations. A considerable number of them (38 out of the 83) maintain a very large difference of more than 100 Hz, a second group (19 out of the 83) preserves no or only a negligible F2 difference, smaller than 26 Hz. Then there is also a third group (26 out of the 83) that lies in between the two extremes, with a F2 difference between 26 and 100 Hz. If the two tokens are read in direct succession, the picture changes. A comparison between (135a) and (135b) shows that most speakers realize larger F2 differences in the minimal sequence than in the random condition. The number of speakers in (135b) with a difference smaller than 26 Hz is somewhat lower than in (135a) and the number of speakers in the mid-category remains more or less stable.[151] Most importantly, when directly confronted with the contrast, more speakers fall into the upper category

[151] 35 out of the 83 speakers realized an F2 difference in the minimal sequence that was larger than the F2 difference in the random order, for 29 participants the F2 difference produced in the minimal and random was about equal, and 19 speakers displayed a smaller F2 difference in the minimal context.

with differences larger than 100 Hz, and even more striking is the near doubling of the number of speakers who produce a difference larger than 251 Hz.

In most cases when a large(r) F2 difference between /a/-/ɑ/ is maintained, /a/ has a more anterior place of articulation than /ɑ/. However, especially in the minimal sequence, speakers are often uncertain. The realization of the tokens is preceded by a longer pause or hesitation, and/or the pronunciation sounds hesitantly. Besides, it also occasionally occurs that the contrast is reversed: *pâte* is realized with a front vowel and *patte* with a back one. Another phenomenon that was noticeable but which we will not discuss in detail here, is the realization of a length distinction between the two vowels, either with or without a reduction of a qualitative contrast.

The tables in (135) give an indication of the spread and degree of contrast preservation. Overviews (136)-(138) provide more detailed information, in order to better compare the different regions, and to take also the possible effects of gender and age into consideration.

(136) *Mean F2 difference (Hz) and standard deviation per region*

Survey	Random order		Minimal sequence	
a. Aveyronnais à Paris	$\bar{X}$ = 52.67	SD = 34.67	$\bar{X}$ = 56.92	SD = 41.14
b. Brunoy	$\bar{X}$ = 146.10	SD = 150.71	$\bar{X}$ = 229.30	SD = 185.74
c. Lyon	$\bar{X}$ = 143.57	SD = 90.61	$\bar{X}$ = 120.86	SD = 63.69
d. Marseille centre ville	$\bar{X}$ = 51.50	SD = 41.65	$\bar{X}$ = 86.30	SD = 115.01
e. Nantes	$\bar{X}$ = 197.90	SD = 118.13	$\bar{X}$ = 272.80	SD = 156.22
f. Ogéviller	$\bar{X}$ = 184.20	SD = 128.22	$\bar{X}$ = 226.10	SD = 152.45
g. Paris centre	$\bar{X}$ = 107.17	SD = 98.04	$\bar{X}$ = 168.00	SD = 141.17
h. Puteaux-Courbevoie	$\bar{X}$ = 171.20	SD = 141.69	$\bar{X}$ = 240.00	SD = 166.58
i. Rodez	$\bar{X}$ = 102.29	SD = 136.45	$\bar{X}$ = 56.00	SD = 36.91

(137) *Mean F2 difference (Hz) and standard deviation per gender*

Gender	Random order		Minimal sequence	
M	$\bar{X}$ = 109.74	SD = 15.71	$\bar{X}$ = 173.95	SD = 176.10
F	$\bar{X}$ = 136.04	SD = 19.10	$\bar{X}$ = 148.27	SD = 116.65

(138) *Mean F2 difference (Hz) and standard deviation per generation*

Generation	Random order		Minimal sequence	
≤30	$\bar{X}$ = 101.93	SD = 103.02	$\bar{X}$ = 102.70	SD = 107.59
31-54	$\bar{X}$ = 86.26	SD = 66.65	$\bar{X}$ = 118.58	SD = 113.71
≥55	$\bar{X}$ = 164.56	SD = 134.65	$\bar{X}$ = 233.76	SD = 162.85

The differences between the two *a* tokens realized by the 83 speakers in the random order and minimal sequence were analyzed with the GLM Repeated Measures procedure in SPSS, with the α level set at 0.05. This test yielded a

significant effect of the within-subject factor 'context' (i.e. minimal pair and random order): $F_{1,37} = 4.282$ ($p = 0.046$), and we may thus conclude that the qualitative contrast between /a/ and /ɑ/ indeed tends to be substantially neutralized in random order, and that the posterior token shifts towards the anterior region. The above tables also show that there is a considerable variation among speakers within the different conditions. Let us therefore next consider the potential effect of the factors 'regional background', 'gender' and 'generation', which were included as between-subject variables in the repeated measures computation. Two of these three factors turn out to play a significant conditioning role, i.e. 'region' ($F_{8,37} = 4.134$, $p = 0.001$) and 'generation' ($F_{2,37} = 6.501$, $p = 0.004$). The variable 'gender', on the other hand, does not contribute significantly to the realized /a/–/ɑ/ difference ($F_{1,37} = 0.018$, $p = 0.893$), and moreover, none of the interactions between the included variables yield a significant result.

Even though the phenomenon is found in all different regions taken into consideration here, this does not mean that all regions and all generations substantially differ from each other; as tables (136) and (138) already show, some regions differ more from each other than others, and the same holds for the generations. Subsequent post-hoc comparisons (The Games-Howell Pairwise Comparison test in SPSS,[152] again with α set at 0.05) show that two regions differ importantly from a third region. The /a/–/ɑ/ difference realized by the speakers in the Aveyronnais à Paris and Marseille surveys is significantly smaller than the differences realized by the speakers in Nantes (Aveyronnais à Paris $p = 0.024$, Marseille $p = 0.049$). As far as the other regions are concerned, no significant effects were noted, and they lie in between the two extremes: they are not as conservative as in Nantes, but less extreme than the Aveyronnais Parisians or the speakers from Marseille.

With respect to the factor 'generation', the analyses show that both generations 1 and 2 differ significantly from generation 3 ($p = 0.001$ and $p = 0.002$ respectively), while no relevant difference was found between generations 1 and 2. The likelihood of qualitative neutralization is thus conditioned by the age of the speaker: especially the speakers of the third generation tend to maintain the contrast, while the two youngest generations are less conservative. This might be an effect of age-grading (cf. Labov 1994:73-112), but it is of course more likely that it is an ongoing change, which is gradually proceeding in the different areas of France and that will be completed once the third generation has passed away.

[152] Levene's test for equality of variances turned out significant, and therefore, homogeneity of variances could not be assumed.

A final aspect that needs to be considered before turning to the effects of *a* on the preceding velar, is the position of this vowel with respect to the other French front and back vowels. That is, given the individual vowel spaces of the speakers in our corpus, are the [a] and [ɑ] tokens located in the same range as front vowels, as back vowels, or are they relatively central? In order to get an image of the acoustic spaces, a mean F2 value was derived for the vowels [i] and [u] for every speaker individually. These values were obtained by averaging the F2 values (measured at 50%) of all tokens of a particular vowel instance figuring in the word list. The F2 values of [i] and [u] give an approximation of the upper and lower bounds of the anterior-posterior dimension. By positioning the F2 values of the [a] and [ɑ] tokens with respect to the F2 values of the extreme front and extreme back vocalic segments, we get a reasonable indication of the degree of frontness or backness of these vowels. A full overview of the respective vowel spaces of the individual speakers is given in appendix D.

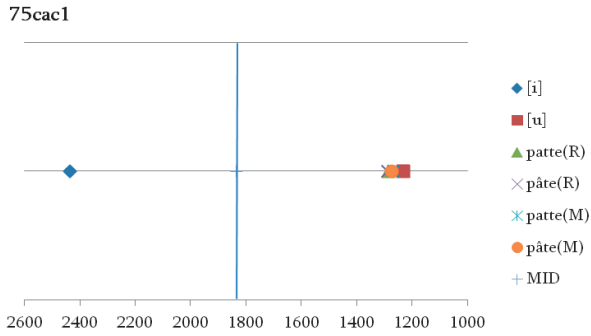
The relative position of the *a* tokens with respect to the front and back vowels shows a considerable amount of variation between the minimal and random contexts, but also between the individual speakers. In the more natural random order, some speakers articulate /a/ and /ɑ/ in the same range as the back vowels, for others the /a/ tokens are central whereas /ɑ/ is a back vowel, yet others realize both /a/ and /ɑ/ as centralized or genuine central vowels, or even as tokens that tend to move towards the front vowel region. The overall patterns are given in (139) and are illustrated in (140) by plots of the F2 values of the random sequence (R) and the minimal pair (M). The F2 values (in Hz) are given on the x-axis, the vertical line indicates the arithmetic midpoint between the [i] and [u] values.

(139) /a/ - /ɑ/ *realizations*

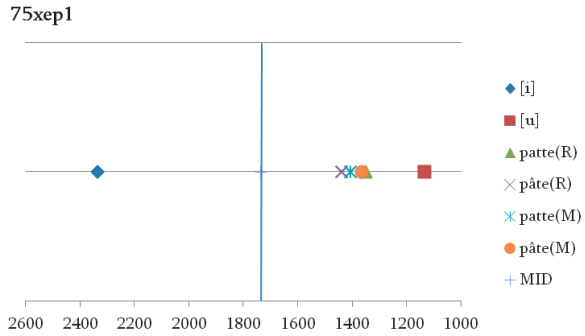
	Front	**Central**	**Back**
patte (R):	1	65	17
pâte (R):	1	52	30
patte (M):	0	70	14
pâte (M):	0	45	39
Total	2	232	100

(140) /a/ - /ɑ/ *realizations*

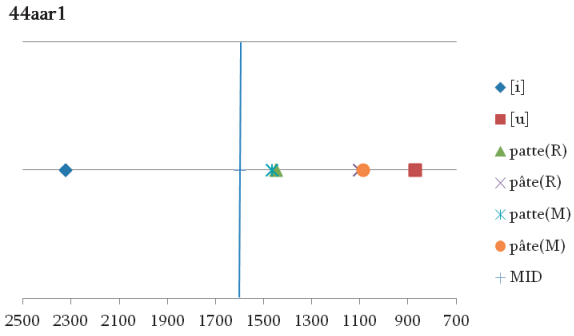
a. Back /a/ and /ɑ/



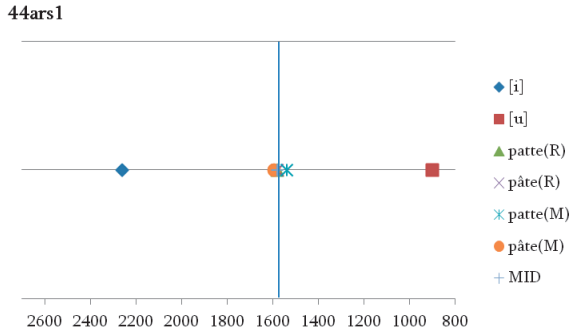
b. /a/ and /ɑ/ between back and central



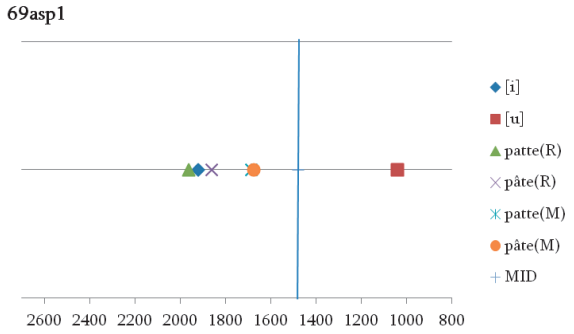
c. Central /a/, back /ɑ/



d. Central /a/ and /ɑ/



e. /a/ and /ɑ/ front, or between central and front



The examination of the /a/–/ɑ/ contrast realized by the PFC speakers confirms that a large degree of variation exists with respect to the actual preservation of the qualitative F2 contrast, and as such, the data clearly demonstrate that the phonetic and phonemic contrast between the two low vowels is far from stable in contemporary varieties. The inter- and intra-speaker variation is such that the existence of two types of *a* in the sound system of French can no longer be assumed. The variable nature of the realization of *a* is likely to have an impact on the actual realization of a preceding velar, which we will examine more closely in the following section.

7.5.2 Velars before a

The place of articulation of *a* indeed turns out to influence the position of the preceding velar. If *a* is realized as a back vowel, the velar maintains a posterior place of articulation. The situation gets more intriguing if *a* takes a more anterior place of articulation. That is, in the large majority of cases, *a* is not realized as a

back vowel but rather as a central(ized) vowel, as a vowel that is between a central and a front vowel, or even as a front vowel with F2 values in the same range as front [i] (again based on the individual vocalic spaces of the participants). Outside the minimal pair *patte-pâte*, the position of *a* thus appears to be even more variable. In the Velar+*a* contexts, different realizations arise, but what they have in common is that the more anterior the place of articulation of the vowel, the more anterior the velar becomes. Speakers differ, however, as to the actual degree of coarticulation realized in this particular context, and hence as to the degree of fronting. The following scenarios emerge:

(141) **1. *a* back**
- back velar

2. *a* between back and central
- velar between back and central
- central velar

3. *a* central
- central velar
- velar between central and front
- front velar

4. *a* between central and front
- velar between central and front
- front velar

5. *a* front
- front velar

As this overview shows, the velar does not maintain a back locus when a non-back instance of *a* follows. Instead, the velar is fronted. The actual degree of fronting is dependent on the position of the vowel, but there is also variation between and within speakers: sometimes a larger difference is maintained, whereas in other cases the difference is substantially smaller. In this respect, the Velar+*a* coarticulation is different from the Velar+[i] coarticulation for instance, which shows a far more uniform pattern, both within as well as between speakers (cf. (125) above). A second important aspect that follows from (141) is that fronting of the velar does not necessarily mean that it shifts to the exact same range of articulation as the vowel. That is, the velar may become between central and back before a central-back vowel, central before a central vowel, between central and front when followed by a central-front vowel or front before a front *a*, but the velar may also become (substantially) *more* anterior than

the vowel. In such cases we find for instance a central vowel preceded by a velar which is rather front or between central and front, instead of a truly centralized velar.

The Velar+*a* patterns described thus far are based on all the occurrences in the word list and the read text. Recall from section 7.3.2 that we deliberately included a number of instances of *quatre* and its cognates, where according to Buckley (2003) synchronic velar palatalization could possibly be found. As a matter of fact, these instances do not stand out in a specific way, and they show the same patterns as the other Velar+*a* contexts. Depending on the location of the vowel, the velar will shift and take a more or less fronted realization. With respect to Buckley's observations, we may thus conclude that the /a/-/ɑ/ distinction is indeed "a socially marked variable", not only in Parisian French, but in metropolitan French in general. Fronting of velars does occur before contemporary French *a*, but this fronting is crucially dependent on the degree of anteriority of the vowel. The velar remains back before a back *a*, but the more central or the more anterior the position of *a*, the more likely it is to get a fronted velar. This fronted velar may often have a place of articulation which is more anterior than the vowel itself. It is therefore very well possible that the historical process of velar palatalization before *a* was also triggered by an anteriorization of the place of articulation of this vowel, either of all tokens of this phoneme or of only a subset. A fronted vowel yields a fronted velar, and the process of velar palatalization may gradually proceed.

As to date, velar fronting before a front or central *a* in contemporary French is not as manifest in all regions and even within a single region large differences arise, both within as well as between speakers (cf. (131)-(133)). The developments in the coming decades, depending on the strength and the spread of fronting throughout the speech community, will tell whether the full diachronic development will indeed be reproduced in modern French, and possibly provide additional evidence for the circumstances of the historical change.

7.6 Discussion and conclusion

In this chapter we have considered the place of articulation of velar plosives in different pre-vocalic contexts. It has turned out that the place of articulation of velars is greatly influenced by the quality of the following vowel. This phenomenon is commonly observed in existing descriptions, but these generally

rely on intuitions and are not backed up by representative language data. The corpus data have revealed that the degree of velar fronting is primarily conditioned by the vowel quality, but at the same time they have revealed that sociolinguistic variation is involved as well. Women tend to coarticulate less than the male speakers, and the eldest generation shows neater realizations with larger F2 differences between the velars and the different vowels than the younger generations. Another valuable addition of the present chapter to the existing studies is the examination of the influence of the vowel *a* on velars. Our investigation revealed the instability of the /a/-/ɑ/ contrast, and depending on its position in the horizontal dimension of the vowel space, this low vowel induces a change in the place of articulation of the preceding velar. Speakers do display considerable variation, though, as to the actual degree of coarticulation between the velar and the following *a*, as reflected by smaller or larger F2 differences.

What still needs to be explored, however, is the exact quality of the velar release. That is, even though fronted, it has not been considered here what this fronted velar exactly looks like. This aspect will be addressed in the following chapter, which will focus on the release of French plosives in general.

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Plosive Releases

8.1 Introduction

The variable nature of French velar plosives has been illustrated and confirmed in the previous chapter. The present chapter will not only look at the release of velars in a palatalization context, but will focus on the overall quality of the release of the different French plosives (labials, coronals, velars). In the more conservative and the more prescriptive descriptions of French, the plosives are described as pure, neatly articulated sounds. Grammont (1922:59), for instance, characterizes the French consonants as follows:

> "Les consonnes françaises se distinguent par leur netteté, qui tient d'une part à l'énergie, voire à la violence avec laquelle elles sont articulées, et d'autre part à la différence entre les sourdes et les sonores, qui est aussi accusée que possible".[153]

French plosives are distinct from the sounds in Germanic languages such as German or English, where the plosive release may be accompanied by a clearly audible puff of air, yielding an aspirated stop. The metropolitan plosive articulation also differs from more closely related sound systems like Canadian French, where a plosive generally takes an assibilated or affricated release when followed by a high front vowel (cf. chapter 6).

When wandering around in some village or city in France and listening to the local citizens, however, one will quite quickly notice that the plosive releases in colloquial European French are subject to variation. French plosives indeed often have a very neat release, but at the same time, numerous releases can be

[153] The French consonants distinguish themselves by their neatness, which is on the one hand due to the energy, or even the violence of their articulation, and on the other hand to the difference between voiceless and voiced segments, which is as marked as possible.

found where the burst may take a more or less noisy nature. As has been observed in chapter 6, the exact circumstances and spread of the emergence of these more turbulent releases in metropolitan French are unclear and require further investigation.

This chapter examines the quality of the French plosives in different contexts on the basis of the PFC subcorpora described in chapter 6. In section 8.2 we will first of all provide a more detailed characterization of the French plosives, and section 8.3 will describe the methodology adopted. The subsequent sections will present the results of the word lists and the read texts, and discuss the release patterns that emerge. We will conclude in section 8.7 by summarizing the principal findings and by discussing some interesting aspects for further research on the phonetics and phonology of contemporary French.

8.2 The French plosives

8.2.1 Frequencies of occurrence

The consonantal segment inventory of standard French contains six plosives, which occur at three different places of articulation (bilabial, dental and velar), each with a symmetrical voiceless-voiced contrast. An overview is given in (142).

(142)

Bilabial	Dental	Velar
/p/	/t/	/k/
/b/	/d/	/g/

These six segments appear to differ considerably from each other as far as their frequency of occurrence is concerned. Léon (1966:78) obtained the following frequency rates of the different plosives in written and oral language on the basis of corpus data:

(143)

	Frequency of occurrence (%)			Frequency of occurrence (%)	
	written language	*spoken language*		*written language*	*spoken language*
p	3.37%	4.3%	**b**	1.14%	1.2%
t	5.36%	4.5%	**d**	4.52%	3.5%
k	3.81%	4.5%	**g**	0.52%	0.3%

In both written and spoken language, the voiceless plosives are more frequent than their voiced counterparts. In spoken language, the distribution of the different voiceless stops is about equal, while the voiced stops show more

variability: [d] is the most frequent, followed by [b], and [g] is by far the most infrequent French plosive.[154]

8.2.2 Articulatory and acoustic characteristics

The articulation of a plosive consists of a number of consecutive stages. The full closure of the oral cavity, which is held for a brief period, is followed by a release of the obstructed air (cf. section 1.2). As for French, this release is generally said to be simultaneous or almost simultaneous with the start of vocal fold vibration in the case of voiceless plosives (VOT of 0 or with a very small positive value), and in the case of voiced plosives the vibration of the vocal folds generally already starts during the closure (negative VOT). It is with respect to this VOT that the French plosives crucially differ from English voiceless stops for instance, where there is a lapse of several tenths of a second between the plosive release and the start of vocal fold vibration. During this interval, the vocal folds are still apart, while air is being expelled from the lungs and released through the oral cavity, which causes aspiration of the plosive. When learning French as a foreign or second language, the unaspirated nature of French stops represents a challenge for the learner with aspirated plosives in his or her mother tongue, as commonly stressed by learner's pronunciation manuals (e.g. Léon & Léon 1976, Léon 1976/2003, Price 1991).[155] Worth mentioning in this respect are the observations made by Grammont (1922) and Malmberg (1969), with respect to the emergence of aspirated plosives in the speech of non-natives speaking French:

> "Les occlusives sourdes des étrangers sont souvent défectueuses en français. Parmi les plus curieuses on peut signaler celles de provenance germanique. Leur mode d'articulation est très différent du français : la glotte est largement ouverte. Ce n'est pas la compression de l'air enfermé dans les cavités buccales qui détermine l'explosion, mais la colonne d'air qui continue à venir des poumons. Il en résulte qu'après cette explosion la colonne d'air sort par l'orifice buccal sous forme d'un souffle sourd jusqu'à ce que les cordes vocales aient eu le temps de se resserrer assez pour mettre en vibration l'air venant de la trachée. Si une voyelle suit, elle ne peut commencer à vibrer qu'au moment où cesse ce souffle sourd".[156]
>
> (Grammont 1922:84)

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[154] The French pattern corresponds to the typologically common patterns, cf. Maddieson (1984).

[155] Léon (2003) notes for the voiceless plosive stops that speakers of Germanic languages should avoid to produce a puff of air following the plosive release, and Price (1991:102) notes that "[...] native speakers of English should make a conscious effort to avoid using aspirated stops when speaking French".

[156] The French voiceless plosives are often incorrectly pronounced by foreigners. Among the most curious realizations are those produced by speakers from a Germanic language speaking origin. Their way of articulating is very different from French: the glottis is widely opened. It is not the compressed air in the oral cavity that determines the explosion, but the column of air which is

> "Le caractère non-aspiré des occlusives sourdes en toute position est une particularité phonétique pour bien prononcer le français. C'est surtout devant une voyelle accentuée qu'une prononciation aspirée choque le Français par sa force".[157]
>
> (Malmberg 1969:97)

Moreover, the articulation of French sounds in general is characterized by a relatively high tension and the tendency to concentrate the articulation in the more anterior parts of the mouth. Grammont described this characteristic, in a rather awkward way, as follows:

> "La prononciation française se distingue de la plupart des autres par sa netteté : les voyelles sont toutes bien timbrées, même en syllabe inaccentuée, et il n'y a pas de voyelles moyennes ou indécises ; la différence entre les consonnes sourdes et les consonnes sonores est très accusée ; enfin la majorité des phonèmes sont articulés dans la partie antérieure de la bouche, ce qui les fait mieux porter.
>
> Certains étrangers, particulièrement des Allemands, ont un jeu des lèvres et des joues extraordinaire, comme s'ils mâchaient quelque chose avec effort ; il semble qu'ils font un travail énorme pour articuler les sons. Mais tout cela est purement extérieur, leurs muscles ne sont pas tendus, et le travail intérieur est très faible. En français, le travail se fait presque entièrement à l'intérieur, et il y est intense, les muscles étant tendus à outrance ; mais presque rien n'en apparaît au dehors, les joues sont presque immobiles, les lèvres ne font que s'entrouvrir, le visage reste calme, et tout cela contribue à la suprême élégance de la diction française".[158] (Grammont 1922:5)

In section 7.2, we have already set out the basic articulatory and acoustic characteristics of velar plosives. As the scope is extended to all French plosives in

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continuously expelled from the lungs. After this explosion, the column of air is released through the oral cavity, yielding a voiceless whisper, until the moment the vocal folds are able to get sufficiently adducted to put the air coming from the trachea into vibration. If a vowel follows, it can only be voiced when this voiceless whisper ends.

[157] The non-aspirated character of the voiceless plosives in any position is a phonetic characteristic required to pronounce French correctly. Especially when a stressed vowel follows, the French are shocked by an aspirated pronunciation, because of its strength.

[158] French pronunciation differs from the majority of other languages by its neatness: the vowels all have a clear colour, even in unstressed syllables, and there are no intermediary or unclear vowels; the difference between voiceless and voiced consonants is very sharp; and most phonemes are articulated in the anterior part of the mouth, which makes them sound more clearly.

Some foreigners, Germans in particular, display extraordinary movements of the lips and the cheeks, as if they were chewing on something with force; it looks like they are working very hard to articulate their sounds. But this is only on the outside, their muscles are not tight, and the activity inside is very weak. In French, almost all activity takes place inside, with the muscles held extremely tight; but on the outside almost nothing of this activity is visible, the cheeks are almost motionless, the lips only open a little, the face remains calm, and all this contributes to the supreme elegance of French diction.

the present chapter, we will also briefly consider the properties of the labial and coronal stops.

The spectrum of the burst varies according to the place of articulation of the plosive.[159] The labial plosives [p,b], with no resonance cavity in front of the constriction, tend to have their energy concentrated in the lower frequency regions, whereas the coronals [t,d], with a small space in front of the constriction, generally show a strong concentration of energy in the higher frequencies. The velar plosives [k,g], with a long vocal tract area in front of the velar constriction, have a concentration of energy in between these two extremes, in the mid-frequency range.

The length of the VOT differs with the place of articulation of the plosive and with the quality of the following vowel (cf., among others, Cho & Ladefoged 1999, Kent & Read 1992, Ladefoged 2005). VOT is generally shortest for [p,b], of intermediate length for [t,d] and longest for velars [k,g]. As far as the bilabials are concerned, the closure is quite rapidly released and as there is no extended contact area involved, the VOT is relatively short. Velars, on the other hand, have the largest cavity in front of the constriction. This causes a more rapid increase of oral air pressure, and as the tongue body is involved, the constriction will extend over a larger surface, especially in the case of high front vowels. The VOT of coronals lies in between the values of labials and velars, as there is a larger back cavity involved than in the case of velars, but with the tongue-tip being the active articulator, the surface of the constriction may still be more or less extensive.

After having described the principal phonetic characteristics of the French plosives, let us next consider the data and methodology used for the corpus study.

8.3 Material and measurements

The analysis of the French plosives is based on the two PFC reading tasks, and concerns all Plosive+Vowel sequences (except [ə] and nasal vowels).[160] A full overview of the tokens involved is given in appendix E; (144) and (145) below give a more concise overview by listing the number of tokens in each context,

[159] The voiced plosives additionally show a concentration of energy in the lower frequencies, which in spectrograms is generally referred to as the "voice bar".
[160] Cf. section 7.3.2.

assuming a flawless, citation pronunciation of the text and list. *Liaison* and *enchaînement* contexts are indicated in parentheses.

(144) *Word list (MG)*[161]

[pj/i]	5	[py]	-	[pu]	-	[bj/i]	-	[by]	-	[bu]	1
[pe/ɛ]	7	[pø/œ]	1	[po/ɔ]	2	[be/ɛ]	2	[bø/œ]	-	[bo/ɔ]	4
[pa/ɑ]	6					[ba/ɑ]	-				

[tj/i]	1	[ty]	-	[tu]	-	[dj/i]	1	[dy]	-	[du]	-
[te/ɛ]	5	[tø/œ]	-	[to/ɔ]	-	[de/ɛ]	4	[dø/œ]	-	[do/ɔ]	-
[ta/ɑ]	2					[da/ɑ]	-				

[kj/i]	1	[ky]	-	[ku]	-	[gj/i]	-	[gy]	-	[gu]	-
[ke/ɛ]	4	[kø/œ]	-	[ko/ɔ]	-	[ge/ɛ]	-	[gø/œ]	-	[go/ɔ]	-
[ka/ɑ]	18					[ga/ɑ]	-				

(145) *Read text (TG)*

[pj/i]	5	[py]	-	[pu]	3	[bj/i]	1	[by]	-	[bu]	-
[pe/ɛ]	4	[pø/œ]	-	[po/ɔ]	4	[be/ɛ]	5	[bø/œ]	-	[bo/ɔ]	8
[pa/ɑ]	9					[ba/ɑ]	2				

[tj/i]	12	[ty]	3 (+3)	[tu]	8	[dj/i]	2	[dy]	7	[du]	-
[te/ɛ]	10 (+3)	[tø/œ]	2	[to/ɔ]	1 (+1)	[de/ɛ]	17 (+1)	[dø/œ]	-	[do/ɔ]	- (+1)
[ta/ɑ]	8 (+1)					[da/ɑ]	1				

[kj/i]	9	[ky]	1	[ku]	3	[gj/i]	-	[gy]	-	[gu]	1
[ke/ɛ]	5 (+1)	[kø/œ]	-	[ko/ɔ]	11	[ge/ɛ]	-	[gø/œ]	-	[go/ɔ]	-
[ka/ɑ]	5					[ga/ɑ]	1				

The analysis presented below concerns the plosives in the word lists of all participants, but because of practical limitations, not all 84 read text files could be analysed. Instead, for the read text, a case-study of the Puteaux-Courbevoie[162] survey will be presented.

During the actual treatment of the data, all cases where the recording was suffering from background noise or where speech was not clearly intelligible

[161] Recall from the previous chapter (cf. section 7.3.2) that a number of *K+a* tokens of the digits preceding the lexical items have been taken into account in order to obtain more tokens of the problematic Velar+*a* (e.g. *quatre*) contexts.

[162] Puteaux-Courbevoie is a Parisian suburb which, contrary to the Paris centre survey, does not only contain speakers from the higher upper class.

because two speakers were talking simultaneously, were discarded. The remaining Plosive+Vowel sequences were manually labelled in PRAAT.[163] The boundaries of the plosive and the vowel were indicated, and both elements were coded for quality (i.e. place of articulation and voicing for plosives, quality for vowels). The position of the Plosive+Vowel combination in the word (initial, medial, final) and the syllable structure were also specified in the annotation, and analogously to the analysis of velars described in the previous chapter, an additional layer of annotation indicating the VOT[164] was added. The length of these different intervals was automatically measured by means of a PRAAT script. The quality of the release (voicing, aspiration, frication) was manually analyzed by combining both an acoustic (examination of the sound wave and the spectrogram) and an auditory analysis (as a supplementary confirmation of the visual cues).

8.4 Results

The PFC plosives reveal a number of interesting phenomena. In order to describe them all properly, a separate section will be dedicated to the word lists and the Puteaux-Courbevoie read texts, respectively. In each section a further subdivision will be made with respect to the place of articulation of the plosives.

8.4.1 Word lists

8.4.1.1 Labials

The labial plosives are generally characterized by a smooth release of the obstructed air. The voiced plosives do not entail noise, and in the large majority of the voiceless tokens, the VOT is close to 0 ms and no, or only a negligible

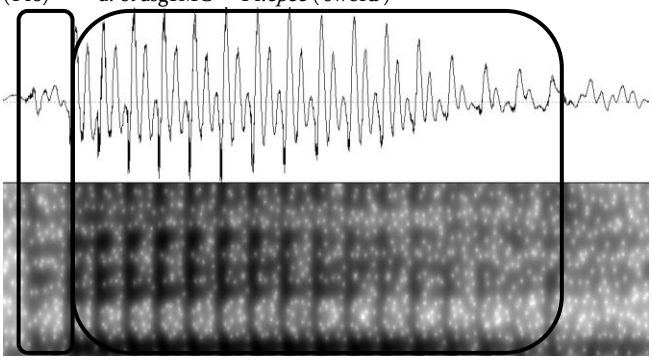
[163] As in the preceding chapter, the labelling of sequences was done on the basis of the actual recordings, in order to control for unexpected realizations or errors, *Loi de Position* and liaison phenomena for instance. Again, in case of liaison, only contexts where resyllabification actually took place have been considered.

[164] Only the VOT of the voiceless plosives was measured, as for voiced plosives the beginnings and endings could not always be detected. Recall from the previous chapter that, following Cho & Ladefoged (1999:215), VOT was defined as the interval between the onset of the plosive release and the start of the first complete glottal pulse in the waveform. The boundaries were positioned at the zero crossing.

amount of noise is detectable. Nevertheless, in a number of cases, interesting releases arise.

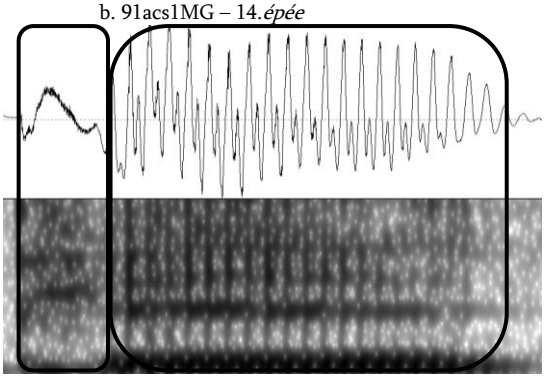
First of all, several tokens in the contexts [pe/pɛ, pø/pœ, po/pɔ, pa/pɑ] are characterized by a noisy interval preceding the onset of vocal fold vibration. In order to illustrate this pattern, the images below show both a neatly released [pe] sequence in (146a), and instances of the same token with more lengthy and noisy releases in (146b) and (146c).

(146) a. 69asg1MG – 14.*épée* ('sword')



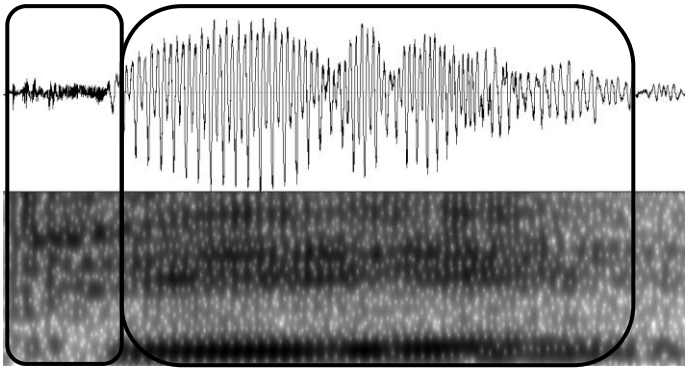
[p]: 14ms [e]: 147ms

b. 91acs1MG – 14.*épée*



[p^h]: 34ms [e]: 148ms

c. 75xlv1MG – 14.*épée*



[p^h]: 44ms [e]: 233ms

The waveforms and spectrograms in (146b) and (146c) show a portion of noise immediately following the end of the plosive closure, which is absent in (146a). The auditory quality of the noise is one of a puff of air. During these longer intervals, the formant structure of the following vowel, except for the F1, is discernable, and the following vowel shows a clear periodical pattern. As such, the plosives in (146b) and (146c) thus display the characteristics of some degree of aspiration, which is, as noted earlier, a common property of syllable-initial voiceless plosives of English or German for instance, but not of French.

The images in (146) randomly reflect a [pe] sequence, but our data reveal that the same may happen in the contexts [pø/pœ, po/pɔ, pa/pɑ] in the word list. The above examples also show that the phenomenon is subject to variation. The length of the aspiration interval in a specific Labial+Vowel sequence differs between speakers: most speakers produce no aspiration, whereas others realize a subtle aspirated cue and others even a more clearly pronounced aspirated element. At the same time, even in the realizations of a single speaker differences arise. Some speakers only occasionally produce an aspirated labial, whereas others aspirate (a specific Labial+Vowel sequence) more systematically. The total numbers of labial plosives produced with and without this kind of noise are listed in (147).

(147)	[pe]/[pɛ]	[pø]/[pœ]	[pa]/[pɑ]	[po]/[pɔ]
n total	586	83	503	166
Overall mean VOT (ms)	22.04 (SD:8.75)	20.78 (SD:6.92)	18.74 (SD:6.87)	27.67 (SD:11.49)
No noise (n)	478 (81.57%)	77 (92.77%)	480 (95.43%)	138 (83.13%)
Mean VOT (ms)	19.27 (SD:5.52)	19.98 (SD:5.79)	17.93 (SD:5.58)	24.22 (SD:6.63)
Glottis-generated noise (n)	108 (18.43%)	6 (7.23%)	23 (4.57%)	28 (16.87%)
Mean VOT (ms)	34.33 (SD:9.79)	30.97 (SD:11.78)	35.03 (SD:9.61)	44.66 (SD:14.96)

Even though several parameters of variation are potentially involved (to which we will return below), and even though the number of tokens is not equally distributed across the different contexts, the numbers do show that there is a considerable amount of variation when it comes to the length of the VOT in a specific vowel context. For English, Ladefoged (2005:137) notes that the VOT is about "50-60 ms for **k**, and slightly less for **t** and **p**". The mean VOTs of French thus are generally shorter than the average VOTs of English in comparable contexts, and as a consequence, if aspiration arises, it will be relatively weak in comparison with English aspirated realizations.[165]

In the [pi]/[pj] contexts something different happens. As a matter of fact, the releases in this context are far from noise-free, but contrary to the contexts just discussed, noise may arise which is more than "simple" aspiration. If noise is produced, this may be of the type illustrated in (146b/c), but a large majority of speakers produce a vowel or glide with some amount of more intense, highly turbulent airflow. In such cases, the sound wave and the spectral/spectrographic patterns are not those of the following vowel, and they are more fricative-like (cf. Delattre 1965,[166] Thomas 2011). Again, though, variation arises. The overall mean VOT values of [pi] (in *piquet*, *piquer* and cognates) and [pi]/[pj] (in *épier*) are provided in (148) and (149).

[165] For this reason, prescriptive learner's manuals of French, which are not descriptive accounts of actual language behaviour, should indeed continue to stress that native speakers of English and German for instance should avoid aspirating their plosives in French.

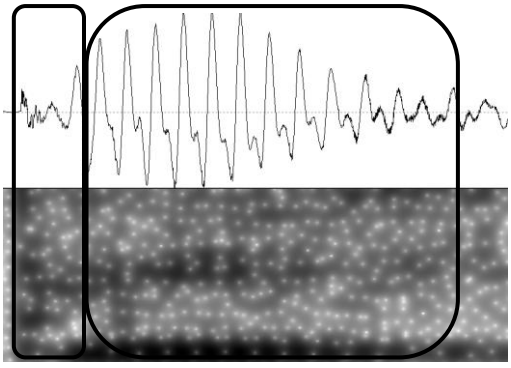
[166] "On spectrograms, affrication must not be confused with aspiration. The latter appears as noise in the second and third formants, the former as a separate slice of non-periodic sound, independent of the formants" (Delattre 1965:111).

(148) [pi] – *piquet, piqué, piquais, piquer* ('stake'/'to prick, past part.'/'to prick, 1/2sg., imp.'/'to prick, inf.')	
n total	333
Overall mean VOT (ms)	38.87
	(SD:24.29)

(149) [pj]/[pi] – *épier* ('to spy upon')	
n total	83
Overall mean VOT (ms)	104.36
	(SD:43.49)

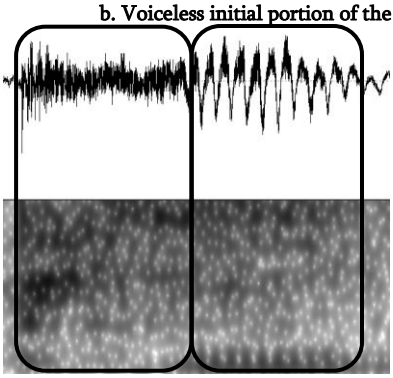
When considering the length of the mean VOT in (148) and (149), especially the mean value of the *épier* tokens is quite striking. In the case of the *piquet/piqué*-type tokens, several possible releases emerge, although there is a dominant pattern. In an extremely limited number of cases, the plosive-vowel transition does not involve noise. In the other cases, noise does arise, which may be aspirate-like as in (146), but in a large majority of instances, oral cavity turbulence is involved as well. The noisy releases that emerge in this context vary in length, and as a matter of fact, the noise may be such that it is not limited to the plosive-vowel transition, but that it extends to the following vowel. This then leads to a partially or fully devoiced vowel. When the vowel is fully devoiced, the plosive release and the following vowel both drown in a noisy pattern that shows no clear periodicity at all. The different types of release are illustrated in (150).

(150) **a. No noise, no devoicing** – 54bgh1MG – 13.*piquet*



[p]: 12ms [i]: 68ms

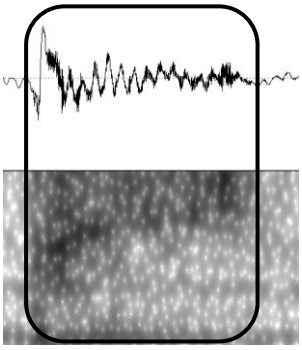
b. Voiceless initial portion of the vowel – 75xlv1MG – 82.*piquer*



[p̥i]: 59ms [i]: 58ms

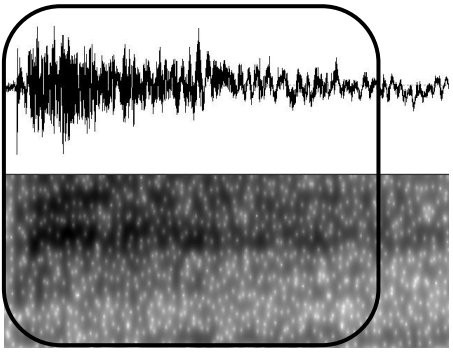
c. Fully devoiced

13ads1MG – 45.*piqué*



[p̥i]: 76ms

75clb1MG – 82.*piquer*



[p̥i]: 91ms

When considering the [pi] releases, there are clearly more instances entailing some amount of noise than noiseless releases. Table (151) lists for *piquet* ('stake'), the verb *piquer* ('to prick') and a number of its cognates, the actual effect of these noisy releases on the voicing of the following vowel.

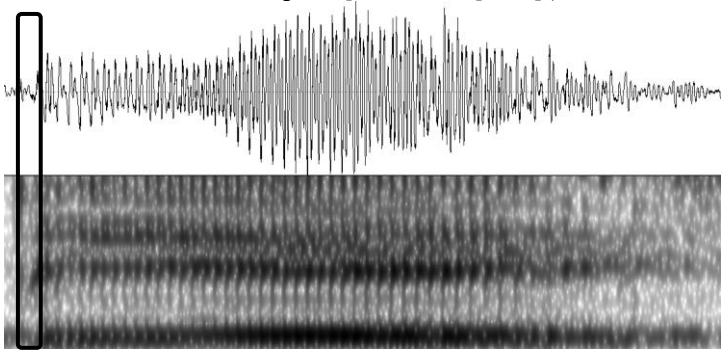
(151) [pi] – *piquet, piqué, piquais, piquer*	
n total	333
Overall mean VOT (ms)	38.87
	(SD:24.29)
Degree of devoicing:	
I. No devoicing (n)	11 (3.30%)
Mean VOT (ms)	15.29
	(SD:3.71)
II. Initial devoicing (n)	308 (92.49%)
Mean VOT (ms)	36.03
	(SD:14.94)
III. Full devoicing (n)	14 (4.20%)
Mean length [p̥i] (ms)	119.77
	(SD:45.62)

A large majority of the [i] tokens in the [pi] contexts are realized with an initial voiceless portion, and consequently, the VOT is substantially higher than in the cases where no devoicing arises. Full devoicing, where the vowel is entirely disguised by breathy or turbulent noise, shows lengthy noiseless intervals.

The [pi]/[pj] tokens in *épier* ('to spy upon') constitute the second type of Labial+high vowel context in the word list. This word may be realized either as trisyllabic with a vowel-glide-vowel sequence [e.pi.je], or as a bisyllabic sequence where the plosive is directly followed by the glide, giving [e.pje]. In the former realization, releases actually may arise where no substantial noise is generated. These smooth releases are clearly exceptions, as it occurs only once in the selected PFC surveys. The other 82 *épier* realizations ([epje] or [epije]) indeed show a portion of noise, which is shortest in the [epije] tokens and considerably longer in the instances of [epje]. Contrary to the *piquet/piqué/piquais/piquer* tokens, the noise in *épier* always involves some amount of channel turbulence.[167] If this turbulence is only weak, a sharp cue arises, which may lead to some devoicing of the vowel or glide. If, on the other hand, turbulence increases, due to a narrower passage created in the oral cavity, the glide may actually be partially or fully devoiced, and be turned into a fricative [ç]. The different patterns that emerge are illustrated in (152).

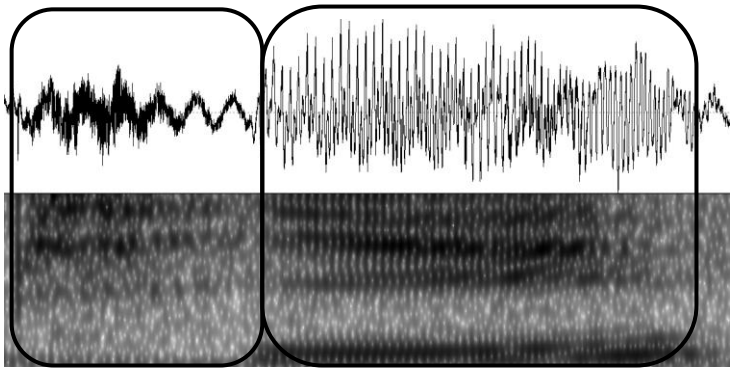
[167] This noise may still be breathy-like, and a combination of frication and aspiration may arise.

(152) **a. No noise/devoicing** – 54bpm1MG – 25.*épier* [epije]



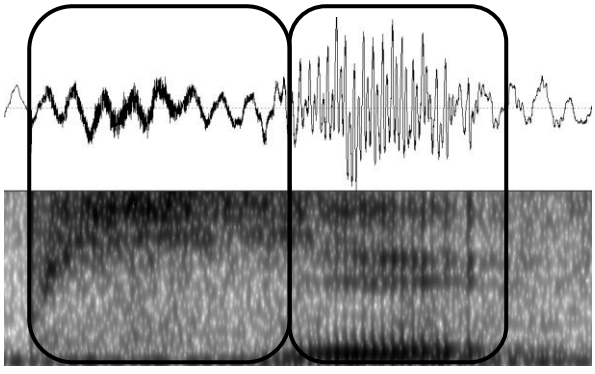
[p]: 20ms [ije]: 43ms

b. Channel turbulence, no frication – 75xmm1MG – 25.*épier*



[pj]: 133ms [je]: 229ms

c. Channel turbulence, frication of the glide – 13aag1MG – 25. *épier*



[pç]: 176ms [je]: 163ms

The pattern for the [pi]/[pj] tokens in *épier* is even more skewed than for the [pi] tokens in the *piqué/piquet* series (cf. (151)). As shown in table (153), only one instance of a fully voiced vocalic segment was found, whereas in 98.80% of the *épier* tokens, some devoicing was detected. As we have just described, several scenarios emerge, but these 82 instances share the fact that noise generated in the oral cavity comes into play. In all these cases where constriction-based noise is produced, important VOT lengths arise.

(153) [pj]/[pi] – *épier*	
n total	83
Overall mean VOT (ms)	104.36 (SD:43.49)
Noise source:	
I. No noise (n)	1 (1.20%)
Mean VOT (ms)	18.14
II. Glottis (n)	-
Mean VOT (ms)	
III. Oral cavity/glottis+oral cavity (n)	82 (98.80%)
Mean VOT (ms)	105.42 (SD:42.68)

The noise produced in the [pi] and [pj] contexts, and the differences in length of VOT described in this section seem to result from the shape of the vocal tract. During normal breathing, the vocal folds are apart, no glottal pulses are generated, and the air expelled from the lungs can freely escape through the speaker's mouth or nose. For voicing to occur, the vocal folds have to be sufficiently adduced when air passes through the larynx, and the transglottal pressure difference ($\Delta P_{glottal} = P_{subglottal} - P_{oral}$) has to be sufficiently high to enable the air expelled from the lungs to push the vocal folds apart, a repetitive process yielding the glottal pulses. As it is not straightforward to increase subglottal pressure, maximization of the pressure difference is generally achieved by decreasing oral air pressure (cf. Ohala 1997b).

In the case of voiceless plosives, the vocal folds are abducted and no glottal pulses are generated. A considerable amount of air thus passes unhindered through the larynx and reaches the oral cavity, where it is obstructed behind the closure. Because of the position of the obstruction, oral air pressure will increase most rapidly for uvulars and least rapidly for labials. If the plosive closure is released into a low vowel, this large amount of air is released through a relatively wide channel, and no noise will be generated in the oral cavity. Aspiration noise may arise, though, if the vocal folds are not (yet) sufficiently adduced when the plosive closure is released. Air passes through the glottis where, depending on

the size of the opening, breathy or whispered noise is generated. If, on the contrary, the plosive is followed by a high vowel, the obstructed air has to be released through a narrow channel,[168] where noise is generated. In the case of obstruents, there is a large amount of air behind the obstruction or constriction, and if the volume velocity is sufficiently high, a laminar release of the air is impossible. Instead, turbulent airflow[169] is generated. Depending on the tightness of the constriction, it may take some time for the transglottal pressure difference to reach a level where voicing is possible again. This may lead to substantial differences in VOT, and it may cause the vowel to take a partially or fully voiceless release.

8.4.1.2 Coronals

The PFC coronals turn out be fascinating in several respects as well. Even though not all possible Coronal+Vowel contexts are included in the word list, the contexts that are included display a number of characteristics that deserve to be examined in more detail. That is, in some cases the plosive is released very neatly, with only the burst as such and without any additional noise. In other cases, additional noise is noticeable, and as reflected by the spectral and spectrographic characteristics, this noise can be generated at the glottis and/or in the oral cavity. A summary of the different patterns is given in (154) and (155).

(154)	[di]	[de]/[dɛ]
n total	83	331
Noise source:		
I. No noise (n)	63 (75.90%)	331 (100%)
II. Glottis (n)	0	0
III. Oral cavity (n)	20 (24.10%)	0

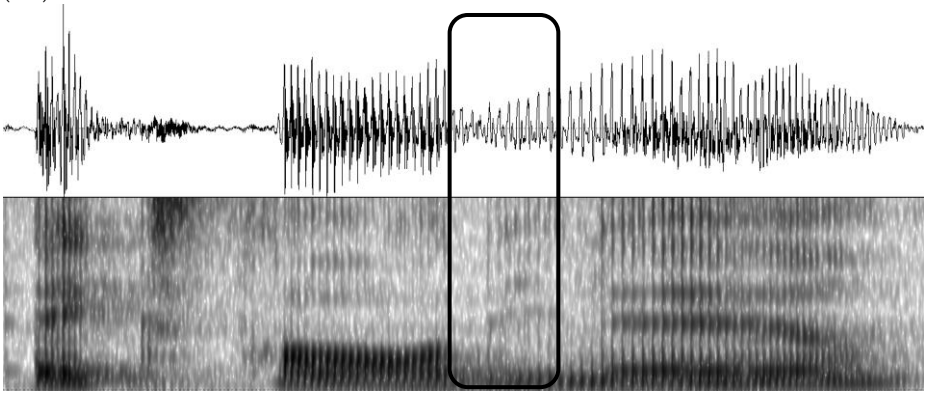
[168] Ohala (1997b:94), for instance, notes the following with respect to these high vowels: "by virtue of their high close construction, [they] impede the flow of air more and constitute 'almost' obstruents".

[169] The likelihood of turbulent airflow can be predicted by computing Reynold's number. If this number, which divides the product of the volume velocity and the diameter of the channel by a constant value (i.e. 0.14), exceeds a threshold (which is set at about 2000), turbulence is generated (cf. Catford 1977:39-42, Rietveld & van Heuven 2001:86). Catford (1977:37) makes a distinction between two types of turbulence: "channel turbulence" involves the turbulence generated by the flow of air through a narrow channel, "wake turbulence, on the other hand, concerns the turbulence caused by the air meeting an obstacle (such as the teeth) in the oral cavity.

(155)	[ti]	[te]	[ta]/[tɑ]
n total	83	417	168
Overall mean VOT (ms)	93.89 (SD:58.88)	41.85 (SD:13.77)	27.07 (SD:8.67)
Noise source:			
I. No noise (n)	0	43 (10.32%)	100 (59.52%)
Mean VOT (ms)		24.42 (SD:5.31)	22.54 (SD:5.46)
II. Glottis (n)	0	108 (25.90%)	48 (28.57%)
Mean VOT (ms)		38.14 (SD:8.56)	32.93 (SD:7.18)
III. Oral cavity/glottis+oral cavity (n)	83 (100%)	266 (63.79%)	20 (11.90%)
Mean VOT (ms)	93.89 (SD:58.88)	46.18 (SD:13.79)	35.67 (SD:10.27)

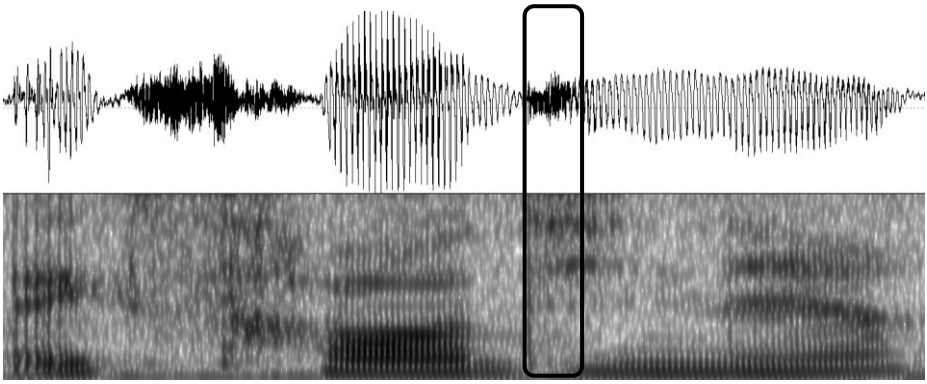
Like the voiced labials, the voiced coronals are generally released without triggering noise. Noisy realizations may occur, however, if the voiced coronal is followed by the high front vowel [i]. In such cases, noise arises which takes its origin in the oral cavity, and which gives the plosive release a strident character, turning it into a subtle [dz] or [dʒ]. Examples are provided in (156).

(156) **a. No noise** – 13aas1MG – 70.*extraordinaire*



[di]: 141ms

b. Assibilation – 69akb1MG – 23.*extraordinaire* ('extraordinary')



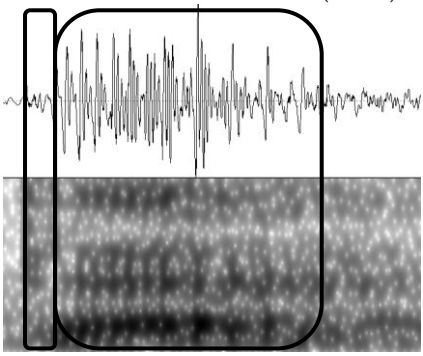
[dz]: 63ms

The voiceless coronals display more variation. The different tokens may either take a noise-free release, or noise may be generated at the glottis and/or in the oral cavity. Again, the patterns differ according to the quality of the following vowel. The [ta/tɑ] tokens, first of all, appear to exhibit most often a noiseless release. If noise does arise, it is mostly generated at the glottis. In a number of cases, however, the spectrogram and the waveform show that more is going on. That is, another noise source comes into play, i.e. the oral cavity. In such cases, the release of the plosive closure is so tense – a cue which is also perceptually very salient –, that a small amount of noise arises. Because the plosive is released into a low vowel, the portion of noise is relatively short and weak; it is purely restricted to the plosive occlusion as such, and no channel turbulence is generated. For all cases where noise arises, whether at the glottis or at the constriction in the oral cavity, the VOT increases with the amount of noise.

The same patterns can be observed for the [te/tɛ] contexts, where relatively more tokens appear to take a noisy release. A minor number still shows noiseless releases, but there is a fair share of tokens with a release entailing some amount of noise. This can again be an aspiration puff of air, but in the great majority of cases, it is at the constriction where noise arises. Like for [ta/tɑ], the tenseness of the plosive constriction may yield a quite noisy take-off, and as [e] and [ɛ] are front mid vowels, a channel is created which, depending on the tenseness of the articulation and the narrowness of the constriction, generates a certain amount of turbulence. Examples of the [ta/tɑ] and [te/tɛ] releases are provided in (157) and (158).

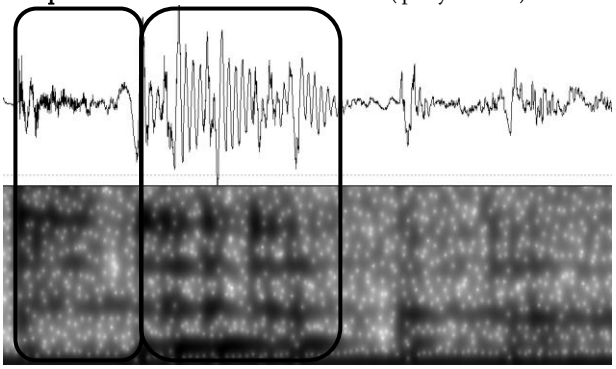
(157) [ta]/[tɑ]

a. No noise – 54bmc1MG – 8.*intact* ('intact')



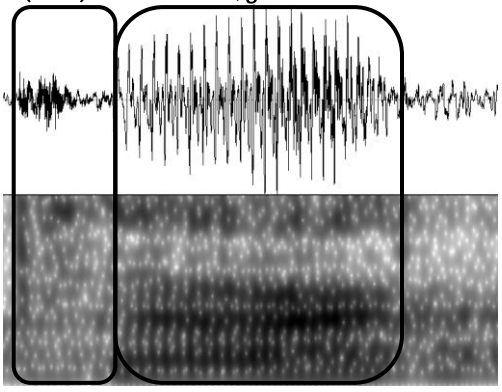
[t]: 13ms [a]: 97ms

b. Aspiration noise – 44ars1MG – 10.*fêtard* ('party animal')



[tʰ]: 32ms [a]: 53ms

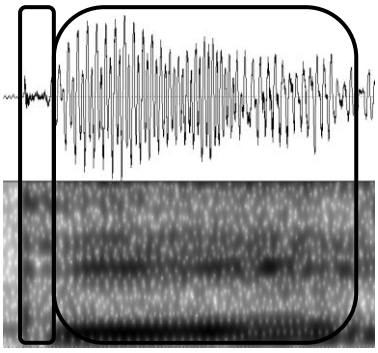
c. (Small) amount of noise, generated at constriction – 54bcg1MG – 8.*intact*



[t]: 36ms [a]: 104ms

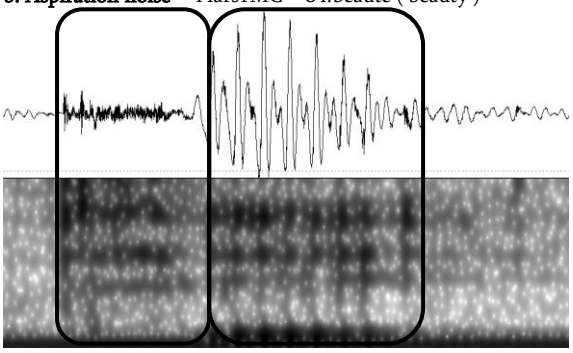
(158) [te]/[tɛ]

a. No noise – 54bmc1MG – 73.*botté* ('in boots')



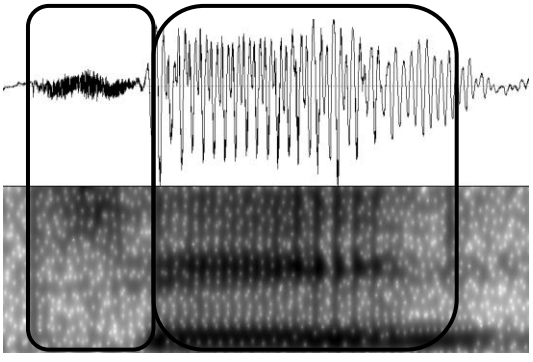
[t]: 17ms [e]: 145ms

b. Aspiration noise – 44ars1MG – 84.*beauté* ('beauty')



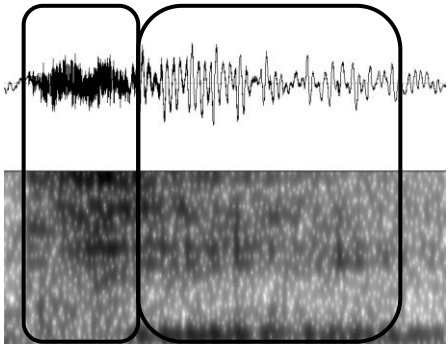
[t^h]: 48ms [e]: 66ms

c. (Small) amount of noise, generated at constriction – 75xad1MG – 84.*beauté*



[t]: 43ms [e]: 122ms

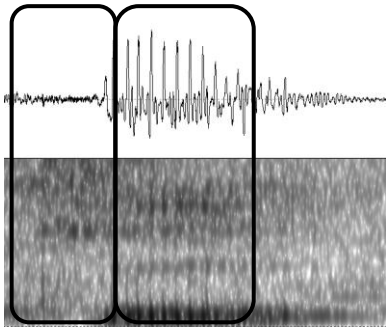
d. Constriction-based noise, close to assibilation 75xjo1MG – 84. *beauté*



[tˢ]: 58ms [e]: 155ms

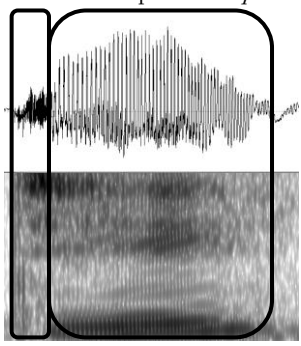
For the final coronal context in the word list, i.e. the 83 occurrences of *petit* ('small', 'little'), the pattern is most clear, but at the same time, also most intriguing. None of these specific tokens has a release that does not entail a substantial amount of noise, as reflected by the lengthy VOTs in this context. Instead, in all cases, oral cavity noise is involved. This oral cavity noise may be of the type just discussed, i.e. constriction noise/channel turbulence, giving a sharp cue. In the [ti] context, it may be that intensive that the voicing of the vowel is affected, causing it to become initially or fully devoiced. However, as the constriction gets more severe, the channel turbulence becomes such that a sibilant cue may emerge. Like we have seen for the [di] contexts, the result is that the plosive surfaces as [ts] or, with a more palatal character, as [tʃ]. When a sibilant element arises between the plosive and the vowel, the following vowel may still be affected in the sense that it loses the initial part of its voicing, or that it becomes devoiced throughout. The examples in (159) illustrate the different realizations of *petit*.

(159) **a. No assibilation, devoicing of the vowel**
54bfl1MG – 60.*petit*



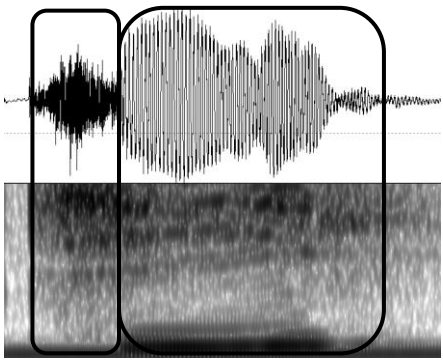
[tj̥]: 94ms [i]: 123ms

12atp1MG – 60.*petit*



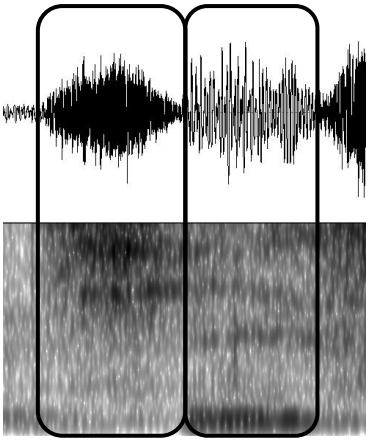
[tj̥]: 47ms [i]: 263ms

b. Assibilation
44asc1MG – 60.*petit*



[ts]/[tʃ]: 91ms [i]: 250ms

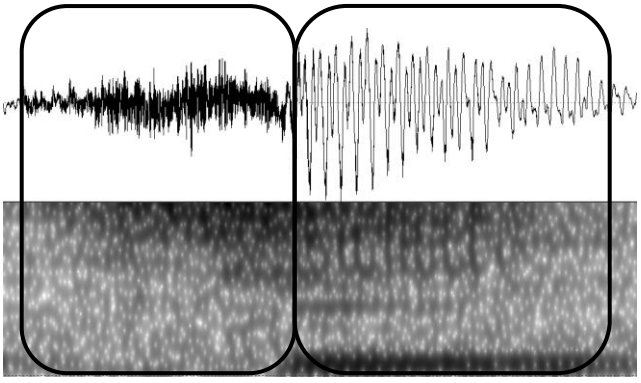
54bcg1MG – 60.*petit*



[tʃ]: 149ms [i]: 125ms

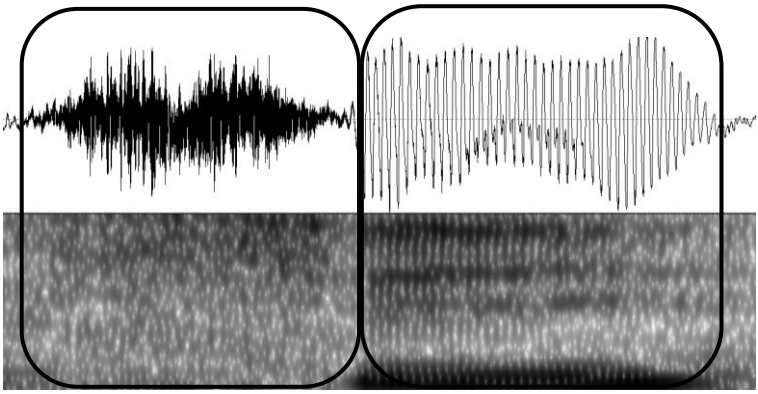
All the noisy cues we have seen up to now are interesting, as these phenomena have virtually been ignored in the literature, but the assibilated plosives are especially fascinating. As noted in chapter 6, the Canadian French varieties are commonly considered emblematic of plosive assibilation. In order to better situate the metropolitan French cases of assibilation with respect to Canadian French, let us compare the two varieties more closely. The images in (160) show a number of arbitrarily selected realizations of *petit* from the PFC corpus of Québec.

(160) a. cqacp2 (M) – *petit*



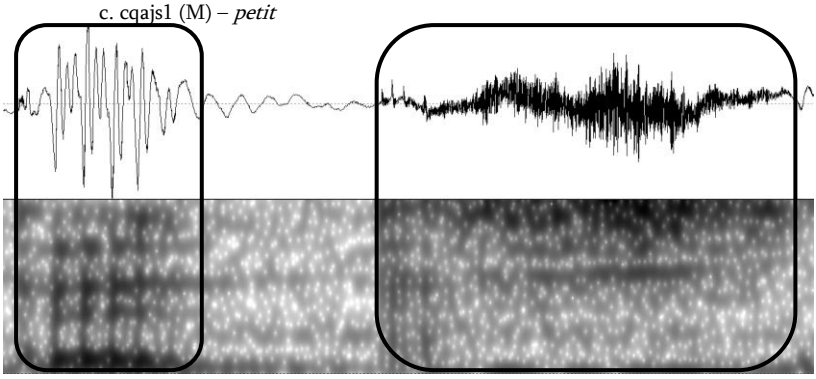
[ts]: 116ms [i]: 142ms

b. cqams1 (F) – *petit*



[ts]: 170ms [i]: 177ms

c. cqajs1 (M) – *petit*



[pə]: 60ms [tsʲ]: 131ms

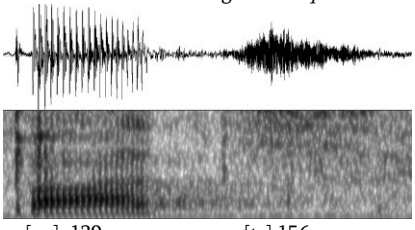
Realizations (160a) and (160b) show a lengthy interval of aperiodicity, followed by a clearly periodical vowel. In (160c), the plosive is assibilated as well, but apparently, the transglottal pressure difference does not reach a level where vocal fold vibration is possible, and the vowel takes a fully devoiced, turbulent realization. Even though there is individual variation when it comes to the exact length and intensity of the assibilation, the assibilated cues in Canadian French are clearly pronounced and realized in a systematic way in any [t/d] + high vowel context. The process can therefore be said to be grammaticalized, instead of being "only" a phonetically-triggered, low-level phenomenon.

In metropolitan French, on the other hand, this systematic application is absent. Even though table (155) shows that all instances of *petit* realized by the PFC speakers entail some oral cavity noise, and even though the length of the

assibilation may come close to the length of assibilation in Québec French, the phenomenon in the metropolitan French varieties is variable in nature. That is, in some cases, there is no genuine assibilation, only a certain amount of noise caused by the release of a tightly held obstruction as such. In yet other cases, real assibilation does arise, but it greatly differs in length (the Canadian assibilations may also differ in length, but contrary to speakers from France, the assibilated part is always clearly discernable, as if there were a kind of lower-bound, again demonstrating the categorical nature of the process in this variety). For the speakers in France, the process is entirely phonetically conditioned: depending on the exact shape of the vocal tract during the Coronal+[i] transition, assibilation may arise, and as the shape of the vocal tract is variable (the channel caused by the plosive-to-vowel transition may be more or less narrow for instance), the actual emergence of an assibilated plosive is variable as well.[170] Moreover, the default Canadian assibilated plosives are [dz] and [ts], whereas the European assibilated plosives may also be more palatal-like, i.e. [dʒ] or [tʃ], depending on the exact position of the articulators. The PFC data thus show that plosive assibilation in metropolitan varieties has not been phonologized. Assibilation of plosives may be related to the speech style of the speaker, though, in the sense that speakers whose speech is characterized by a very tense articulation are likely to produce more assibilated plosives, as the phonetic conditions are more often met.

The [ti] instances discussed in this section are all tokens of the frequently occurring adjective *petit*. It is therefore not unlikely that word frequency plays a role here, where for some speakers assibilation has become exceptionless in some way for such frequently occurring tokens. We will return to the possible effects of word frequency and inter- and intra-speaker variation below.

[170] An affricated release may also arise when the coronal plosive is in phrase-final position, a context which was as such not included in our analysis, but it is a phenomenon that nevertheless caught our attention when listening to the recordings. The tokens *patte* and *pâte* for instance, may be realized either as [pat]/[pɑt], but we also came across several realizations like [pa**ts**]/[pɑ**ts**]. In these cases, there seems to be a mistiming of articulatory gestures, giving the plosive a delayed, sibilant, release, as shown below for 69acg1MG-85.*patte:*



[pa]: 139ms [ts]:156ms

8.4.1.3 Velars

As far as the velar plosives are concerned, the word list only contains voiceless tokens, in three different vocalic contexts. Like the labial and coronal categories, the velar plosives exhibit interesting releases with, again, a considerable amount of variation between the different contexts. Table (161) lists the different patterns and the mean VOTs.

(161)	[kj]/[ki]	[ke]/[kɛ]	[ka]/[kɑ]
n total	84	333	1511
Overall Mean VOT (ms)	97.72 (SD:26.45)	52.93 (SD:16.36)	34.47 (SD:11.87)
Noise source:			
I. No noise (n)	-	-	147 (9.73%)
Mean VOT (ms)			21.57 (SD:5.52)
II. Glottis (n)	-	4 (1.20%)	7 (0.46%)
Mean VOT (ms)		48.44 (SD:13.65)	51.53 (SD:36.49)
III. Oral cavity/glottis+oral cavity (n)	84 (100%)	329 (98.80%)	1357 (89.81%)
Mean VOT (ms)	97.72 (SD:26.45)	52.98 (SD:16.40)	35.77 (SD:11.25)

Let us first of all consider the 84 *cinquième* ('fifth') tokens, either containing the sequence [kjɛ] or [ki.jɛ], depending on the exact realization chosen by the speaker. All velar plosives in these contexts are pronounced with some amount of noise, which is in fact not surprising from both a phonetic and typological point of view, but which is nevertheless remarkable seeing the classical characterization of French plosives. The noise that arises, which is reflected by the lengthy VOTs in table (161), takes its origin in the oral cavity, but yet, it may differ in nature between the different speakers, as also reflected by the standard deviation of the VOT. That is, the [ki] or [kj] sequence may give rise to a channel that may differ in width and length. In case the channel is still relatively wide, and/or relatively short, some noise will arise (also because of the general strength of articulation of French plosives), but this noise will be relatively short and only relatively weakly turbulent. If the constriction is more severe, the amount of turbulence will increase and the velar release will become more fricative-like. In the most extreme case, the velar will be turned into an affricate [kx]. This

phenomenon is very fascinating, as such velar affricates are not reported by studies on Canadian French affrication.[171]

In the case of [ke]/[kɛ] and [ka]/[kɑ] the picture is less neat, but yet again, the same mechanism seems at work. Like for [ki]/[kj], the release of these specific [ke]/[kɛ] tokens appears to be accompanied by a certain period of noise. In a small number of cases, this noise takes its origin at the glottis, whereas in the great majority of tokens, constriction-based noise comes into play (as well). Like for the [ki]/[kj] tokens, the exact quality of the noise depends on the configuration of the vocal tract. The more open the quality of the vowel, and the smaller the degree of coarticulation, the less channel turbulence will be generated. If, on the other hand, the speaker pronounces the [ke]/[kɛ] sequence in a very tense way, involving a considerable coarticulation, the more likely it is that a channel arises where turbulence is produced. Also in the [ke]/[kɛ] contexts, the channel may thus become so narrow that [k] takes a genuine affricated release.

Finally, for the [ka]/[kɑ] contexts, the most variation in the velar release is observed. About 20% of the tokens have a release without any substantial noise. A small number of instances show only glottis-generated noise, but in the great majority of cases, constriction-based noise shows up. The noise may be a rather brief effect of a very high tension of the release of the constriction of the [k] as such; if there is no narrow channel, no turbulence is created, and only a very short period of noise arises. In other cases, however, there seems more coarticulation between the velar and the *a*, especially when [a] is a (more) anterior vowel, as we have seen in the preceding chapter. In such cases, more noise arises, which may become quite fricative-like. Because of the tenseness of French articulation, which is clearly, and sometimes very clearly, manifested by several PFC speakers, a narrow passage may arise between the velar and the following *a*, which turns the velar into an affricate [kx].

Depending on the state of the glottis, the degree of narrowness and the length of the constriction, the release of the velar takes a specific colour: it may either be a smooth, noiseless release or a release with a certain portion of noise. If noise arises, it may differ in quality, intensity and length. Examples of the different attested [k] releases are given in (162)-(164).

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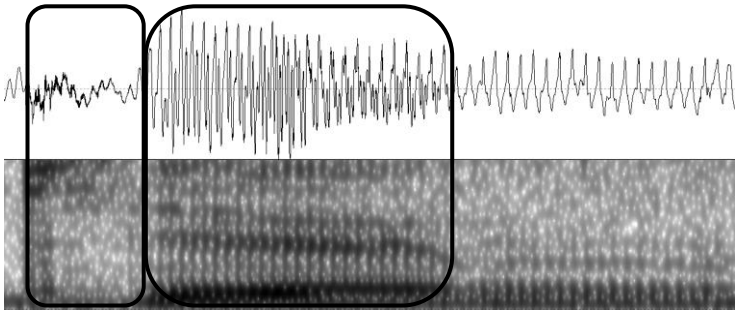
[171] Even though [kx] is not an allophone in the Canadian affrication process, from a phonetic point of view it would not be unexpected to find this sound in this context. That is, the surface covered by a velar followed by a front vowel is larger than the surface covered by a coronal in the same context. As a more extended closure needs to be removed in the case of velars, affrication is more likely to occur "by accident" for velar than for coronal plosives.

(162) [kj]/[ki]

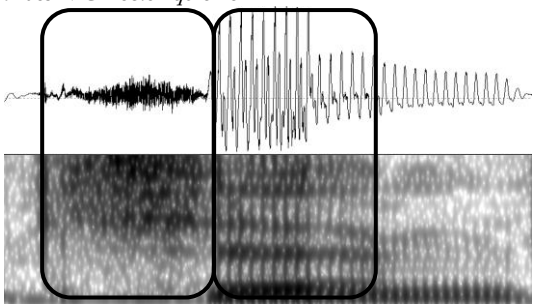
a. Constriction noise, no affrication – 13aid1MG – 68.*cinquième*



[k]: 59ms [jɛ]: 149ms [m]

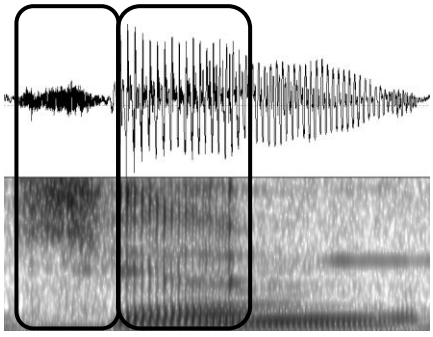
b. Affrication

91acs1MG – 68.*cinquième*



[kˣ]: 107ms [jɛ]: 101ms [m]

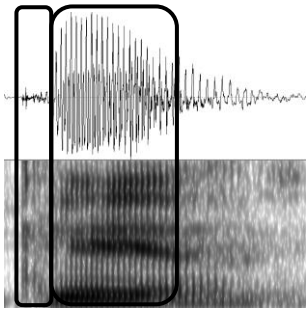
69aj11MG – 39.*cinquième*



[kˣ]: 128ms [jɛ]: 148ms [m]

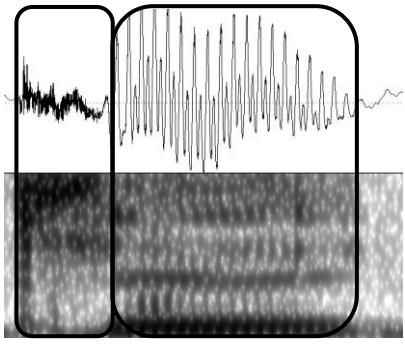
(163) [ke]/[kɛ]

a. Aspiration – 12ajp1MG – 82.*piquer* ('to prick')



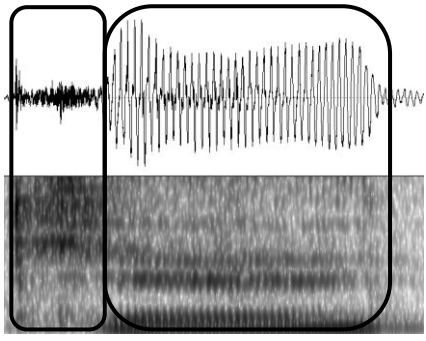
[kʰ]: 39ms [e]: 146ms [ʁ]

b. (Small) amount of noise, generated at constriction – 91acs1MG – 82.*piquer*



[k]: 47ms [e]: 115ms

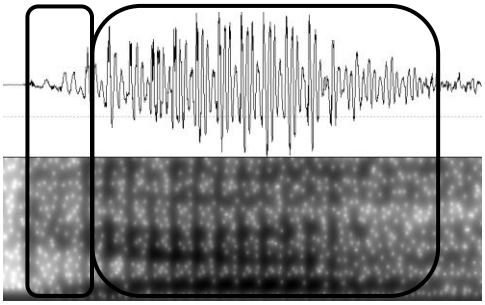
c. Affrication – 54bjc1MG – 13.*piquet* ('stake')



[kˣ]: 107ms [ɛ]: 312ms

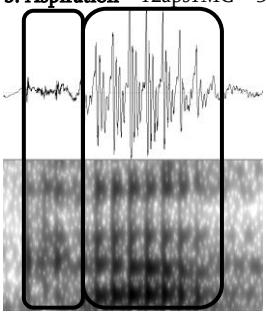
(164) [ka]/[kɑ]

a. No noise – 44aar1MG – *90* (digit)



[k]: 18ms [a]: 106ms

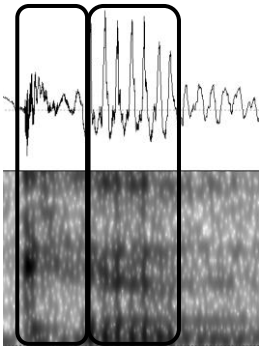
b. Aspiration – 12aps1MG – *54* (digit)



[k^h]: 41 ms [a]: 72ms

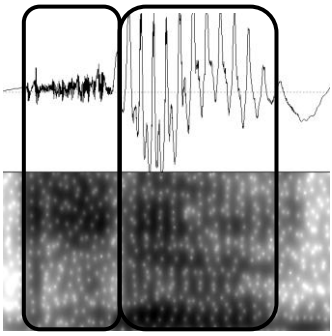
c. (Small) amount of noise, generated at constriction

91acs2MG – 78.*quatrième* ('fourth')



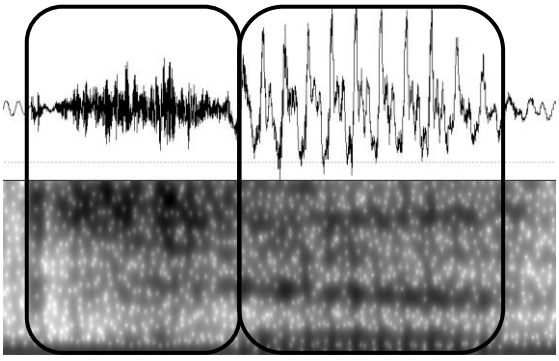
[k]: 39ms [a]: 57ms

91ael1MG – 78.*quatrième*



[k]: 31ms [a]: 50ms

d. Affrication – 44ars1MG – *44* (digit, [ka] in *quarante*)



[kx]: 68ms [a]: 95ms

8.4.2 Read text: Puteaux-Courbevoie

The word lists revealed a number of interesting aspects, but at the same time, because of their specific nature, the information provided by the word lists as such is too limited in a number of respects to get a reliable picture of the plosive releases in running speech. This section will therefore consider the plosive realizations in the read text, which contains plosives in genuine running speech and in a larger variety of contexts. As, due to practical limitations, it is not possible to carry out a detailed acoustic analysis of the read texts of all 84 participants, this section will be limited to the Puteaux-Courbevoie corpus, a variety closely related to Parisian French (cf. footnote 162).

8.4.2.1 Labials

The labial plosives occur in a total of five different vocalic contexts. The numbers of occurrence and the mean VOT values of the different contexts are provided in (165) and (166).

(165)	[bi]	[be]/[bɛ]	[ba]/[bɑ]	[bo]/[bɔ]
n total	5	25	10	40
Noise source:				
I. No noise (n)	5 (100%)	25 (100%)	10 (100%)	40 (100%)
II. Glottis (n)	0	0	0	0
III. Oral cavity (n)	0	0	0	0

(166)	[pj]/[pi]	[pe]/[pɛ]	[pa]/[pɑ]	[pu]	[po]/[pɔ]
n total	25	20	45	15	20
Overall mean VOT (ms)	80.60 (SD:36.28)	19.97 (SD:7.49)	16.40 (SD:5.35)	35.53 (SD:21.10)	31.25 (SD:11.13)
Noise source:					
I. No noise (n)	1 (4%)	19 (95%)	45 (100%)	9 (60%)	17 (85%)
Mean VOT (ms)	21.00	18.89 (SD:5.07)	16.40 (SD:5.35)	26.89 (SD:8.37)	28.00 (SD:8.05)
II. Glottis (n)	3 (12%)	1 (5%)	0	6 (40%)	3 (15%)
Mean VOT (ms)	53.67 (SD:38.55)	44.00		48.50 (SD:28.25)	49.67 (SD:7.64)
III. Oral cavity/glottis+oral cavity (n)	21 (84%)	0	0	0	0
Mean VOT (ms)	87.29 (SD:33.13)				

Like the voiced tokens in the word list, the voiced labials in the text never take a noisy release. In most of the voiceless contexts, the Puteaux-Courbevoie speakers generally release their plosives very neatly as well. Some aspirate-like releases arise in the back vowel contexts [u] and [o/ɔ], and occasionally in the case of the front vowels [e/ɛ] and [i]. But again, this latter context is more likely to trigger noise that is generated in the oral cavity. This noise may be some channel turbulence which may additionally lead to some degree of devoicing of the vowel, especially in the case of words like *stupide* ('stupid') and *olympiques* ('olympic'). If the coronal plosive is followed by a glide, as in *champion* ('champion'), *pied* ('foot') and *Pierre* ('proper name'), the channel may get narrower, and in such cases, the noisy releases involve some frication and devoicing of this glide (fully or partially), turning it into [ç] (as in (152b/c)).

8.4.2.2 Coronals

The read text contains a larger variety of vocalic contexts than the word list. As tables (167) and (168) show, quite clear-cut patterns emerge:

(167)	[di]	[de]/[dɛ]	[da]/[dɑ]	[dy]
n total	10	84	5	35
Noise source:				
I. No noise (n)	8 (80%)	84 (100%)	5 (100%)	29 (82.86%)
II. Glottis (n)	0	0	0	0
III. Oral cavity (n)	2 (20%)	0	0	6 (17.14%)

(168a.)	[ti]/[tj]	[te]/[tɛ]	[ta]/[tɑ]
n total	60	59	44
Overall mean VOT (ms)	74.28 (SD:23.59)	36.42 (SD:7.71)	25.68 (SD:6.87)
Noise source:			
I. No noise (n)	2 (3.33%)	19 (32.20%)	33 (75%)
Mean VOT (ms)	32.50 (SD:3.54)	31.58 (SD:6.83)	23.27 (SD:5.22)
II. Glottis (n)	0	24 (40.68%)	10 (22.73%)
Mean VOT (ms)		38.13 (SD:7.43)	32.90 (SD:6.59)
III. Oral cavity/glottis+oral cavity (n)	58 (96.67%)	16 (27.12%)	1 (2.27%)
Mean VOT (ms)	75.72 (SD:22.64)	39.63 (SD:6.61)	33.00

(168b.)	[ty]	[tø]/[tœ]	[tu]	[to]/[tɔ]
n total	19	10	39	10
Overall mean VOT (ms)	76.63 (SD:26.98)	36.00 (SD:12.46)	48.13 (SD:21.52)	33.20 (SD:5.96)
Noise source:				
I. No noise (n)	0	5 (50%)	2 (5.13%)	4 (40%)
Mean VOT (ms)		27.20 (SD:4.87)	48.50 (SD:14.85)	30.00 (SD:6.78)
II. Glottis (n)	6 (31.58%)	5 (50%)	32 (82.05%)	6 (60%)
Mean VOT (ms)	54.50 (SD:15.88)	44.80 (SD:11.50)	49.06 (SD:23.26)	35.33 (SD:4.76)
III. Oral cavity/glottis+oral cavity (n)	13 (68.42%)	0	5 (12.82%)	0
Mean VOT (ms)	86.85 (SD:25.08)		42.00 (SD:9.82)	

In line with the results of the word list, the voiced coronal tokens do not entail noise, except in the [di]/[dy] contexts, where stridency may show up, giving the plosive a sibilant release. Also in line with the results of the word list, noise arises most often with a voiceless coronal, the nature of the noise depending on the quality of the following vowel.

The [ti]/[tj], [te]/[tɛ], [ta]/[tɑ] contexts, which were also part of the word list, more or less show the same pattern as in table (155). That is, the [ta]/[tɑ] tokens are generally not accompanied by noise, and if it does arise, this is of the glottis-generated type rather than oral cavity noise. Oral cavity noise only incidentally arises, if the constriction is tight, and if the vowel has a "closer" articulation. For the [te]/[tɛ] tokens, then, a pattern arises where the different tokens are more equally distributed across the three categories in (168). About one third of the tokens does not take a noisy release, another one third shows some amount of aspiration noise, and the remaining one third is accompanied by noise that emerges in the oral cavity because of a tensely released occlusion, possibly accompanied by some weak turbulence. The [ti]/[tj] tokens again strikingly entail turbulent oral cavity noise, which may sound more or less sibilant-like depending on the exact narrowness of the channel.

The four remaining contexts, the front and back rounded vowels [ty], [tø]/[tœ], [tu], [to]/[tɔ], were not included in the word list. The mid vowels [tø]/[tœ], [to]/[tɔ] behave alike in the sense that the release of the preceding plosive may involve a certain amount of glottis noise, but if not, the plosive is released as such. In any case, they do not involve oral cavity-based noise. The high rounded vowels [ty] and [tu], then, display patterns which are not fully identical. That is, even though both vowels generally do entail some noise at their release, this noise is rather generated at the glottis for the back rounded vowel. The front rounded vowel may also be released with glottal noise, but in the majority of cases, it triggers oral cavity noise. In the case of [ty], a narrower channel is created, which may cause the sound to take a turbulent, at times even a sibilant-like, release. This is not necessarily the case for [tu], thus explaining the different distributions of the patterns.

8.4.2.3 Velars

The velar contexts found in the text are more diverse than the ones in the word list. For these different contexts, the mean VOT values and the type of release are listed in (169) and (170).

(169)	[ga]/[gɑ]	[gu]
n total	5	5
Noise source:		
I. No noise (n)	5 (100%)	5 (100%)
II. Glottis (n)	0	0
III. Oral cavity (n)	0	0

(170a.)	[ki]/[kj]	[ke]/[kɛ]	[ka]/[kɑ]
n total	45	25	25
Overall mean VOT (ms)	77.93 (SD:26.73)	36.64 (SD:10.49)	35.04 (SD:11.94)
Noise source:			
I. No noise (n)	0	8 (32.00%)	9 (36.00%)
Mean VOT (ms)		26.00 (SD:8.47)	22.78 (SD:5.76)
II. Glottis (n)	0	3 (12.00%)	3 (12.00%)
Mean VOT (ms)		37.67 (SD:2.52)	39.00 (SD:6.08)
III. Oral cavity/glottis+oral cavity (n)	45 (100%)	14 (56.00%)	13 (52.00%)
Mean VOT (ms)	77.93 (SD:26.73)	42.50 (SD:7.52)	42.62 (SD:8.84)

(170b.)	[ky]	[ku]	[ko]/[kɔ]
n total	5	15	55
Overall mean VOT (ms)	69.40 (SD:16.96)	46.67 (SD:17.45)	37.87 (SD:11.15)
Noise source:			
I. No noise (n)	0	3 (20%)	12 (21.82%)
Mean VOT (ms)		21.33 (SD:7.02)	27.33 (SD:4.66)
II. Glottis (n)	4 (80.00%)	11(73.33%)	43 (78.18%)
Mean VOT (ms)	65.75 (SD:17.17)	51.18 (SD:11.49)	40.81 (SD:10.66)
III. Oral cavity/glottis+oral cavity (n)	1 (20%)	1 (6.67%)	0
Mean VOT (ms)	84.04	46.67	

Like the voiced labials and the majority of voiced coronals, the pronunciation of a voiced velar does not give rise to noisy cues. For the voiceless velars, on the other hand, quite some noisy releases arise. The first series of voiceless velars in (170a), [ki]/[kj], [ke]/[kɛ], [ka]/[kɑ], shows a distribution that closely resembles the corresponding vocalic contexts in (161). It is not an exception for [ke]/[kɛ] or [ka]/[kɑ] to take a noise-free release, but it is not an exception for them either to be accompanied by some amount of noise. This may be noise which is uniquely

generated at the glottis, but most frequently, the effects of oral cavity configurations are detectable. This may be the effect of a tightly released velar occlusion, but if the following vowel is produced in a more tense way as well, channel turbulence may emerge. Recall from the preceding chapter that *a* may be realized as a front vowel, and if there is a large amount of coarticulation, an important narrow channel may arise. In such cases, the velar may even take an affricated release [kx].

Seeing our observations for the word list tokens, it comes as no surprise that the releases of [ki] and [kj] are without exception realized with a certain amount of noise by the Puteaux-Courbevoie residents, though it remains an intriguing phenomenon for European French. In these cases, oral cavity noise is always involved, and we find releases as divergent as tight offshoots to affricated velars with a substantial portion of frication. Again, the exact quality and length of the noise are brought about by the specific shape of the vocal tract.

The behaviour of the velars in the three remaining contexts, i.e. before the rounded vowels [y], [u] and [o]/[ɔ], cannot be compared directly to the word list, as these contexts were not included in that task. Still, a number of observations can be made, which rather fit the patterns we have seen up to now for other Plosive+Vowel contexts. That is, like the coronals followed by a mid back vowel [o]/[ɔ], a velar in this context is often accompanied by some glottis-generated noise. Noiseless releases do also arise, but oral cavity noise is generally not found. For the high front and back vowels [y] and [u], oral cavity noise may be produced, but it is the purely glottis-based noise that appears to be the most frequent in these contexts.

8.4.3 Summary

The read text patterns do not crucially deviate from the patterns derived from the word lists, and both tasks show that the release of a plosive is variable. Next to aspiration and blowing noise as a variation on the 'standard' instantaneous release, French plosives can also be accompanied by real frication, which transforms them into surface affricates [ts] and [kx] for instance. The aspirated cues are generally considerably more subtle than in English or German, and the affrication phases are highly variable in length and intensity, but both aspects turn out to be salient (though neglected) characteristics of metropolitan French.

The results described in the preceding section only concern the texts realized by one specific group of speakers, and more data are required to confirm or refine the derived patterns. Still, as their realizations closely correspond to the general patterns derived from the word lists, it is unlikely that the texts read by

the speakers of the other surveys radically differ from the Puteaux-Courbevoie corpus, or from the word lists in general.[172]

In fact, all variation seems directly attributable to (gradual) variations in the shape of the vocal tract, brought about by a specific context (i.e. type of plosive and quality of the following vowel) and by a specific speaker. As no absolute settings are involved, for every type of Plosive+Vowel sequence there is a range of possible articulations (more or less front, back, closed or open, more or less coarticulation) which causes the plosive release to take a specific colour.

8.5 The sociophonetics[173] of French plosives

The release of French plosives is characterized by variation; between speakers, but also in the realizations of a single speaker variation arises. As demonstrated in the preceding section, phonetic factors play an important role in the likelihood for a noisy release to show up. In this section, we will consider the segmental factors in more detail, and determine which of these play a significant determining role. Moreover, we will consider which sociolinguistic factors are involved.

8.5.1 Segmental factors[174]

As we have seen above, the length of the VOT and the frequency of a more noisy release differ from one context to another, both as far as the type of plosive and the following vowel are concerned. In order to better compare the different contexts, tables (171) and (172) give an overview of the mean VOT values (of the voiceless tokens) discussed earlier.

[172] Even though the (relative) frequencies of the different patterns may of course slightly differ because a different kind of task is involved.

[173] Sociophonetics is the interface between sociolinguistics and phonetics, which has, from about the middle of the 1990s, gradually become an autonomous subdomain of sociolinguistics. For a more detailed description of the history and foundations of sociophonetics, the reader is referred to Foulkes & Docherty (2006) and Thomas (2011).

[174] We will limit the discussion of the linguistic factors to the segmental aspects, i.e. the quality of the plosive and the following vowel. Without any doubt, other linguistic aspects such as syllable structure, word length and phrasal position are worth investigating, but in our case, the number of observations per subcontext would be too skewed to be able to say anything meaningful.

(171) Word list – Mean VOTs

	[i/j]	[e/ɛ]	[ø/œ]	[a/ɑ]	[o/ɔ]
Labials	*n* = 416 $\bar{X}$ = 51.93 SD = 39.15	*n* = 586 $\bar{X}$ = 22.04 SD = 8.75	*n* = 83 $\bar{X}$ = 20.78 SD = 6.91	*n* = 503 $\bar{X}$ = 18.74 SD = 6.87	*n* = 166 $\bar{X}$ = 27.67 SD = 11.49
Coronals	*n* = 83 $\bar{X}$ = 93.89 SD = 58.88	*n* = 417 $\bar{X}$ = 41.85 SD = 13.77	-	*n* = 168 $\bar{X}$ = 27.07 SD = 8.67	-
Velars	*n* = 84 $\bar{X}$ = 97.72 SD = 26.45	*n* = 333 $\bar{X}$ = 52.93 SD = 16.36	-	*n* = 1511 $\bar{X}$ = 34.47 SD = 11.87	-

(172) Read text – Mean VOTs

a.	[i/j]	[y]	[e/ɛ]	[ø/œ]
Labials	*n* = 25 $\bar{X}$ = 80.60 SD = 36.28	-	*n* = 20 $\bar{X}$ = 19.97 SD = 7.49	-
Coronals	*n* = 60 $\bar{X}$ = 74.28 SD = 23.59	*n* = 19 $\bar{X}$ = 76.63 SD = 26.98	*n* = 59 $\bar{X}$ = 36.42 SD = 7.71	*n* = 10 $\bar{X}$ = 36.00 SD = 12.46
Velars	*n* = 45 $\bar{X}$ = 77.93 SD = 26.73	*n* = 5 $\bar{X}$ = 69.40 SD = 16.96	*n* = 25 $\bar{X}$ = 36.64 SD = 10.49	-

b.	[a/ɑ]	[u]	[o/ɔ]
Labials	*n* = 45 $\bar{X}$ = 16.40 SD = 5.35	*n* = 15 $\bar{X}$ = 35.53 SD = 21.10	*n* = 20 $\bar{X}$ = 31.25 SD = 11.13
Coronals	*n* = 44 $\bar{X}$ = 25.68 SD = 6.87	*n* = 39 $\bar{X}$ = 48.13 SD = 21.52	*n* = 10 $\bar{X}$ = 33.20 SD = 5.96
Velars	*n* = 25 $\bar{X}$ = 35.04 SD = 11.94	*n* = 15 $\bar{X}$ = 46.67 SD = 17.45	*n* = 55 $\bar{X}$ = 37.87 SD = 11.15

When we look at the values of the vocalic contexts which the different plosives have in common, it appears that VOT is generally longest for velars and shortest

for labials,[175] with the only exception that in the [i/j] contexts of the read text the values are quite close to one another.

The high front vowels display the highest VOT values across the different plosive contexts, both in the word list and the read text. The VOT values of the other vocalic contexts are closer to one another. Still, all patterns show a smaller or larger amount of variation. In order to assess the role of vowel quality with respect to the length of the VOT, repeated measures ANOVAs were carried out in SPSS, for each of the three (voiceless) plosive contexts individually. Moreover, the tokens of the word list and read text were treated separately. The (mean) length of the VOT was specified as dependent variable, the vowel quality was defined as within-subject factor, and gender, generation and regional background (in the case of the word list) were included as between-subject variables.

For the word list tokens, the vowel quality proves to be significant for all the plosive contexts.[176] Tables (173)-(175) give an overview of the different vowels that significantly differ from one another in the three plosive contexts, the significant differences are indicated by *.

(173) Labials

	[i/j]	[e/ɛ]	[ø/œ]	[a/ɑ]	[o/ɔ]
[i/j]		*	*	*	*
[e/ɛ]	*			*	*
[ø/œ]	*				*
[a/ɑ]	*	*			*
[o/ɔ]	*	*	*	*	

(174) Coronals

	[i/j]	[e/ɛ]	[a/ɑ]
[i/j]		*	*
[e/ɛ]	*		*
[a/ɑ]	*	*	

[175] Which basically corresponds to the typological patterns described in Cho & Ladefoged (1999).

[176] The respective F values obtained for the different contexts are the following: Labials $F_{4,144} = 71.82$ ($p = 0.00$), Coronals $F_{35,72} = 94.79$ ($p = 0.00$), Velars $F_{36,74} = 180.52$ ($p = 0.00$).

(175) Velars

	[i/j]	[e/ɛ]	[a/ɑ]
[i/j]		*	*
[e/ɛ]	*		*
[a/ɑ]	*	*	

In the case of the coronals and the velars, all three vowel contexts significantly differ from one another: the realized VOT difference is substantially largest for the [i/j] tokens, smallest for the low vowel [a/ɑ], and [e/ɛ] occupies the mid range, which is not homogeneous with both the high and low vowels. In the case of the five labial contexts, both front [i/j] and back [o/ɔ] show VOT lengths which significantly diverge from all the other vocalic contexts, with [i/j] displaying the absolute largest differences, and [o/ɔ] differences which are somewhat smaller, yet substantially larger (i.e. aspirated cue) than in the remaining contexts [e/ɛ], [ø/œ], [a/ɑ]. These three categories then also show a number of meaningful differences: [e/ɛ] crucially deviates from the high front and mid back vowel, and at the same time it has a significantly longer VOT than the [a/ɑ] contexts. The [ø/œ] VOTs are homogeneous with both the VOTs of [e/ɛ] and [a/ɑ], this latter context being characterized by the absolute smallest VOT differences in comparison with the three other vocalic contexts.

The read text tokens yield similar results as far as the quality of the vowel is concerned: for the labials, the coronals as well as the velars, the quality of the following vowel has a determining influence on the length of the VOT.[177] Tables (176)-(178) visualize, for each of the different contexts, the significant and non-significant differences (again, significant differences are indicated by *).

(176) Labials

	[i/j]	[e/ɛ]	[a/ɑ]	[u]	[o/ɔ]
[i/j]		*	*	*	*
[e/ɛ]	*				*
[a/ɑ]	*			*	*
[u]	*		*		
[o/ɔ]	*	*	*		

[177] Labials: $F_{4,4} = 38.82$ ($p = 0.002$), Coronals: $F_{6,6} = 45.36$ ($p = 0.00$), Velars $F_{5,5} = 34.97$ ($p = 0.001$).

(177) Coronals

	[i/j]	[e/ɛ]	[y]	[ø/œ]	[a/ɑ]	[u]	[o/ɔ]
[i/j]		*		*	*	*	*
[e/ɛ]	*		*		*	*	
[y]		*		*	*	*	*
[ø/œ]	*		*				
[a/ɑ]	*	*	*			*	
[u]	*	*	*		*		*
[o/ɔ]	*		*			*	

(178) Velars

	[i/j]	[e/ɛ]	[y]	[a/ɑ]	[u]	[o/ɔ]
[i/j]		*		*	*	*
[e/ɛ]	*					
[y]						
[a/ɑ]	*					
[u]	*					
[o/ɔ]	*					

In the case of a voiceless labial, the VOT is significantly longest when followed by a high front unrounded vowel or glide. When followed by its back rounded counterpart, this effect is clearly less strong, and the VOT is only clearly longer in comparison with low [a/ɑ]. The mid front and back vowels, [e/ɛ] and [o/ɔ], however, do not form a homogeneous subset: they differ significantly from one another, with [o/ɔ] displaying longer VOTs. This latter vowel also has significantly longer VOTs than the [a/ɑ] context, whereas this difference is not revealed between [e/ɛ] and [a/ɑ] (and *a* thus appears to resemble more closely the mid front vowel than the mid back vowel, which is in line with the findings presented in chapter 7). In sum, the high vowels show the strongest effect.

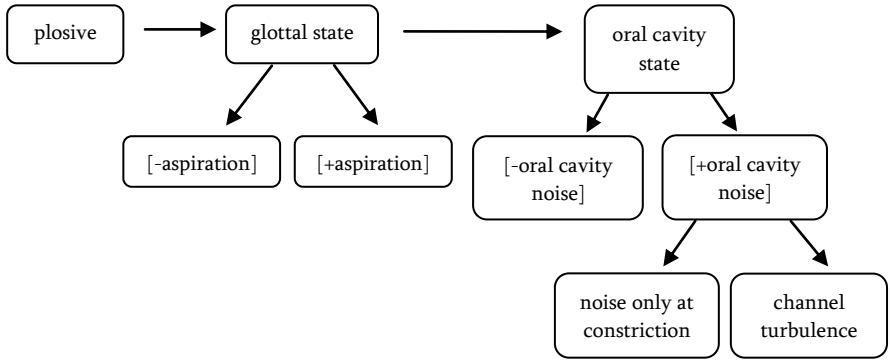
This tendency clearly returns in the scores obtained for the coronals. [i/j] and [y] show significantly longer VOTs than the other Coronal+Vowel contexts. The high back vowel [u], then, falls in the mid-range. On the one hand, it significantly differs from [i/j] and [y], on the other hand, it also crucially deviates from the other mid and low vowels (except [ø/œ]). The mid vowels, then, do not show important differences between one another, but they do differ, however, in the degree in which they deviate from the other high and low vowels.

For the velar plosives, finally, quite a neat pattern arises. The high front unrounded vowel shows again a clearly longer VOT, which differs from all other vowels except from its front rounded counterpart. No significant effects among the other vowels were revealed.

Summing up the results discussed up to now, the significant effects reflect the differences in length of noise that arise in the different Plosive+Vowel contexts. This noise is generally longest in a high vowel context. The mid and low vowels can entail some noise, but they display more variation between each other in the nature and length of the noise that emerges. The best guess for an answer to a potential million dollar question "In which environment do we generally find the longest VOTs in modern French?", would then be: "if a voiceless velar is followed by a high front unrounded vowel (or its glide equivalent)".

Let us next combine the different phonetic aspects discussed above and combine them in such a way as to get a schematic overview of the different plosive releases that may arise in French:

(179)



If a plosive is released without any noticeable noise, the states of both the glottis and oral cavity are such that no noise can arise. If, however, the glottis is somewhat opened because oral air pressure did not yet sufficiently decrease for the vocal folds to get adducted, an aspiration puff of air may surface. A second source of noise is located in the oral cavity. If the oral cavity constriction is very tight, a salient cue may be produced. If there is more than only a tightly held obstruction, and if a more or less narrow channel is put in place, channel turbulence is generated, which may, in the most extreme case, cause the plosive

to surface as an affricate. Noise may arise from the glottis or oral cavity only, but both noise sources may be combined as well: the glottis is open, and the constriction in the oral cavity provides an additional noise source.

As a matter of fact, the releases of French plosives as described here perfectly fit the source-filter model of speech production (cf., for instance, Kent & Read 1992). The sound that is actually pronounced is the result of the specific source(s)[178] that is (or are) activated, and which is further coloured by the specific shape of the vocal tract, which acts as a filter. The pharyngeal, oral and nasal cavities can, in a very simplified way, be considered tubes, each favouring specific frequencies. The exact shape of the tube varies constantly with the position of the articulatory organs. As a result, some frequencies are transmitted whereas others are dampened. Furthermore, the shape of the vocal tract is not exactly identical for all speakers, and even a single speaker will not manage to put his speech organs in the exact same shape every time he or she has to pronounce a specific sound or combination of sounds; as a natural result, variation in plosive releases will arise.

Let us next consider whether we can relate general differences in the shape of the vocal tract to particular sociolinguistic factors, and move on to the between-subject factors included in the analyses.

8.5.2 Sociophonetic factors

Like in the preceding chapter, the sociolinguistic variables included in the analysis are the age, gender and regional background of the speakers. Strikingly, these factors do not turn out to have an important overall influence on the length of the VOT.

For the plosives in the word list, none of the between-subject factors yield a significant result in the case of the labials and the velars. In the case of the coronals, 'regional background' does not appear to play a role either, but significant effects are obtained for the factors 'gender' and 'generation'.[179] The VOT realized by the females in this context is significantly longer than the length of the VOT realized by the male speakers,[180] and the youngest generation produces significantly longer VOTs than the oldest generation, whereas the

[178] Vocal fold vibration, glottis noise, constriction/channel noise, and 'obstacles' in the oral cavity such as the teeth.

[179] Gender: $F_{1,36} = 4.95$, $p = 0.033$, Generation: $F_{2,36} = 4.21$, $p = 0.023$.

[180] Male: $\bar{X} = 41.03$ms (SD:21.88), Female: $\bar{X} = 47.56$ms (SD:36.34).

group of speakers aged between 31 and 54 does not differ significantly from the other two generations.[181]

For the read texts, only the variables 'gender' and 'generation' could be taken into account, as only the realizations of the Puteaux-Courbevoie residents were considered. In none of the three plosive contexts do these two variables turn out to be significant, and only the quality of the vowel appears to be decisive.

Taking into account all the results, it has to be concluded that no consistent overall effects are obtained as far as the sociolinguistic factors are concerned. It seems that the differences in the VOTs revealed by the PFC data (and hence the variations in the nature of the plosive release) are not related to broad social stratification; they rather seem to be the result of *individual*, more or less random, differences between speakers. With 'vowel quality' as a clear determining factor, these individual differences relate to the shape which the vocal tract takes in a specific Plosive+Vowel context. This shape shows of course resemblances across different speakers, but yet at the same time, differences arise as not all speakers configure their vocal tract in the exact same way: the tongue may be more or less back, the mouth may be more or less open and speakers may speak with more or less articulatory energy. As a matter of fact, it may even be a *general* characteristic of certain speakers to have a more anterior articulation, or to keep their mouth relatively closed when talking. As such, differences between speakers arise, but as a speaker cannot reproduce the exact same shape every time he or she has to pronounce a particular instance, differences in the realizations of a single speaker arise as well.

Although no broad social stratification appears to be involved, some social identity aspects may still come into play. That is, the individual differences may be fully random or due to chance for the speakers who only incidentally produce a noisy release, but for others consistent patterns arise, in the sense that salient releases show up in a systematic way in their speech. For these latter speakers, the way the plosive is released may be considered a characteristic of their specific idiolect, a habit that belongs to the speech of a specific speaker.[182] It is even not unlikely that such characteristics hold for a small or tightly-knit group of friends

[181] Generation I: $\bar{X}$ = 49.45ms (SD:40.23), Generation II: $\bar{X}$ = 46.51 (SD:23.15), Generation III: $\bar{X}$ = 39.21ms (SD:23.47).

[182] Specific consistent usage of the human voice can often fulfil a social function or act as a discourse marker. For examples and for a more detailed account of such functioning of voice, cf. Esling (1978), Henton & Bladon (1988), Pittam (1994), Thomas (2011).

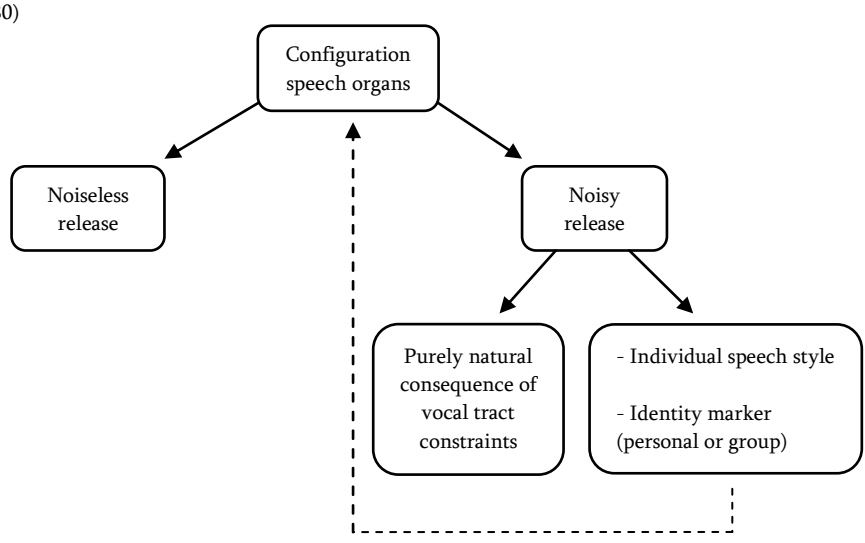
or relatives to which the speaker belongs, and function as a kind of identity marker.

Without any doubt, future studies will show the extent to which such social identity factors play a role, and whether salient plosive releases may come to characterize social identity at a more general level, in the sense that it extends from individuals or small cliques to larger social strata. The future will also tell whether or not we are dealing with an incipient sound change here. That is, assibilation of the coronal in *petit* yielded two significant effects, for 'age' and 'gender' respectively; showing that the youngest generation and the women tend to assibilate the plosive most often in this context. As such, our results are in line with the observation made by Malécot (1977:13, cf. section 6.2). Especially younger, professional women have often proved to be the leaders in linguistic change (cf. Labov 2001:279-293), and if the phenomenon systematically spreads from this frequently occurring token to other lexical items and ultimately attains all members (and generations) of the speech community, metropolitan French might be heading towards a situation of categorical plosive affrication, such as in Canadian French.

8.5.3 Summary and discussion

The schematic visualization in (179) captures the different types of release that may arise depending on the specific settings of the glottis and the oral cavity. The model in (180) describes the process in yet a different way, by also taking into account the inter- and intra-speaker differences:

(180)



(180) summarizes the different aspects described in the preceding sections. Depending on the exact configuration of the vocal tract, a plosive may either get a neat, noise-free release, or a more salient realization, involving a certain amount of noise. For such a noisy release to arise, a specific configuration of the glottis and/or the oral cavity is required. This configuration can be simply the effect of a specific setting that arises in a particular context, but for other speakers, an additional dimension may be involved as their noisy-released plosives can rather be seen as belonging to their personal speech style, or may even become a genuine identity marker. In such a case, the specific configuration giving rise to a salient release is brought about by default or on purpose, and in a systematic way (indicated by the dotted arrow).

Up to now, the different types of plosive releases in French have been described and discussed. We have also seen several times that the vowel may be affected, but without paying any proper attention to vowel devoicing as such. Like plosive assibilation, vowel devoicing is a phenomenon which is not as well-studied as liaison and schwa deletion for instance. In order to better understand and situate it, let us, before concluding this chapter, dedicate a section to this phenomenon.

8.6 A few words on vowel devoicing

Vowel devoicing is a common characteristic of languages like Japanese or Korean, but it has also been reported for several varieties of French. As far as metropolitan French is concerned, Tranel (1987:21) notes that "[o]rdinarily, vowels are [...] voiced, but it is possible for them as well (particularly [i, y, u]) to be voiceless when they occur between two voiceless consonants". Fónagy (1989, 2006) observes that in utterance-final position not only the high vowels [i, y, u], but also the mid front vowels [e, ø] tend to be devoiced. In final position, the final part of the vowel may be realized with palatal or velar fricative noise, whereas its initial part is fully voiced. Fónagy suggests that this phrase-final devoicing serves to mark the end of an utterance. Examples of both devoicing patterns are given in (181).

(181) a.

quitter	[kɻ̟ite]	'to leave'
occupation	[ɔkɣ̟pasjɔ̃]	'occupation'
découper	[dekʊ̟pe]	'to cut out'

(Tranel 1987:21)

b.	merci	[mɛʁsiç]	'thank you'
	je t'ai vu	[ʒətevyç]	'I have seen you'
	j'ai tout raconté	[ʒetuʁakõteç]	'I have told everything'
	tout	[tux]	'every, everything'

(Fónagy 2006:46)

Several experimental studies on vowel devoicing have been carried out. Although the exact outcomes differ in detail, both Fagyal & Moisset (1999) and Smith (2003), focusing on factors such as sentence type and nature of the pitch contour, conclude that vowel-final devoicing (181b) is a strategy to mark finality. Martin (2004) examined the vocalic renditions of 56 native French-speaking participants from Belgium, Canada, France and Switzerland. The stimuli were designed in such a way that the vowels [i], [y] et [u] were preceded and followed by a voiceless plosive. His results largely correspond to the observations made by other studies, and at the same time his data show that in this inter-plosive context, vowel-final devoicing does not occur. Martin detected two types of vowel devoicing. The first one is full devoicing, where the vowel is turned into noise (either with or without some acoustic traces of the vowel); the second one is partial devoicing, where periodicity is absent in the *initial* portion of the vowel.

As a matter of fact, the examination of the PFC plosive releases also shows that vowel devoicing is a salient characteristic of contemporary French spoken in France. If devoicing applies, the vowel may take different appearances. A summary of the patterns derived from the data (i.e. vowels in post-plosive position) is given in (182).

(182) Different distributions of vowel devoicing:

I. Vowel starts voiced, ends devoiced, e.g. [iç]/[ix][183]

II. Voiced phase is preceded by a devoiced interval, e.g. [i̥i]

III. Vowel is devoiced throughout, e.g. [i̥]

Even though a thorough quantitative analysis still needs to be done, also including the vowels that are not preceded by a plosive but by other types of consonants, the data that were analyzed for the purpose of this chapter, already

[183] In line with the description given by Fónagy (2006), it turns out that the noise arising at the end of the vowel can be of palatal [ç] or velar [x] nature, as indicated by the differences in the distribution of energy in the spectra. Their distribution appears to be subject to free variation, as [ç] and [x] may show up in similar contexts and are not in complementary distribution. Still, both instances are very interesting, as neither of these sounds is part of the segment inventory of standard French.

clearly show that vowel devoicing is highly variable and subject to both inter- and intra-speaker variation. Moreover, the data also strongly suggest that pattern I on the one hand, and patterns II and III on the other, are manifestations of different phenomena.

That is, it seems that for patterns II and III, phonetic factors play the most important role. If a high or mid-high vowel gets devoiced, the transglottal air pressure apparently does not reach a level where vocal fold vibration is possible. This is likely if a non-low vowel is preceded by a voiceless plosive, and even more likely if the vowel is also followed by a voiceless obstruent. In the case of full or initial devoicing of the vowel, the noise is not restricted to the release of the plosive. The airflow may be so strong that the initial portion of the vowel or even the entire vowel is disguised by the noise. This effect is strongest for high vowels, where oral air pressure decreases only very slowly as the air has to pass through a high vocalic constriction. Still, also non-high vowels can be subject to some degree of devoicing. Plosives followed by a high or mid-high vowel can be released with highly turbulent noise, whereas devoiced low and mid-low vowels rather take a breathy-like release. For this whispering or aspiration, the glottis is set in a specific shape: the vocal folds are drawn together but there still is a small opening, where noise is generated if air passes through.[184]

Pattern I, on the contrary, differs from the other two patterns in several important respects. First of all, unlike patterns II and III, vowel-final devoicing is clearly not induced by a preceding voiceless plosive, as also vowels in phrase-final position preceded by other types of segments can be finally devoiced. Some examples are given in (183).

(183) - *37. re**lier*** – [ʁəljɛx]
'to bind (again)'
75ccm1 – word list

- *[…] il n'y avait que quarante pour cent des gens qui l'a**vaient***. – [lavɛç]
'only 40% of the people got it'
75clb1 – unguided conversation

[184] This partial opening of the glottis could be brought about by the fact that the transglottal pressure difference nearly reaches the level where the vocal folds get adducted again, thus resulting in a partial closure only. Alternatively, it might be an anticipation of the vocal folds on the following vowel: the vocal folds are drawn apart during voiceless segments, but have to be drawn together for voicing. If this process of adduction is not completed, a small opening is created, vocal fold vibration is absent and noise arises. In the oral cavity, the air does not meet a serious obstacle and it is released through a relatively wide opening, with the puff of air generated in the larynx. If the noise is strong enough, this may yield a partially or fully disguised vowel.

- *La mairie du huitième est assez jo**lie**.* – [ʒɔliç]
'The town hall of the eighth [district] is rather nice'
75ccr2 – unguided conversation

Second, it is striking that type-I devoicing never takes place word- or phrase-medially, but only in (intonation) phrase-final position. This does not hold for the initial and full devoicings, which occur both word-internally and word-finally. In existing literature, it has therefore been claimed that vowel-final devoicing serves as a finality marker. The PFC data do not contradict this idea; it explains for instance why these devoicings are quite often found in the word list. Speakers may regard each separate item of the enumeration as an ending (instead of the final entry only), and apply devoicing to mark it as such. The read text, on the other hand, involves running speech and, from a finality point of view, it is therefore less likely to find a vowel with a devoiced tail at the end of individual words or phrases. However, the PFC data suggest that the scope of vowel-final devoicing is not restricted to purely signalling a finality. A quick (and again non-exhaustive) search in the unguided conversations shows that this type of devoicing may also be used to add emphasis, or to highlight a particular message. Consider for instance the words in bold in the following fragment of speaker 75clb1:

(184) Là j'ai vu mon fils c'est bien simple, il a les cours se sont terminés. Un, c'était quand, un **mardi** [maʁdiç]. Il passait la philosophie le **jeudi** [ʒødiç]. Il avait rien commencé à réviser le **mardi** [maʁdiç]. Et il a alors il a des facilités. <E : Hum hum.> C'est vrai mais il avait rien commencé à faire le **mardi** [maʁdiç]. C'est/ je le coinçais comme la télévision est là et l'ordinateur est au premier étage et qu'on est dans une maison lui est au deuxième dès que je l'entendais descendre je lui disais « qu'est-ce que tu fais ? ».[185]

The speaker and the interviewer (E) are discussing the level of the final exams in high school, which according to 75clb1 is decreasing substantially. In order to illustrate her opinion, she compares her own preparation for finals at the time with her son's preparation. In this extract, which can nearly be seen as a monologue, she expresses her indignation on the little time her son took to

[185] I have seen my son, it's easy, he has, classes were finished. On a, when was it again, on a **Tuesday**. His philosophy exam was on **Thursday**. He hadn't started studying at all on **Tuesday**. And well he learns with ease. <E: Hum hum> It's true but he hadn't started studying at all on **Tuesday**. It is/I wedged him in because the television is there and the computer is on the first floor and because we live in a house, he is on the second [floor] as soon as I heard him coming down I asked him "what are you doing?".

prepare for his exams. This indignation is of course expressed by the content of the words and the syntactic and intonational structure of the phrases, but it is strengthened by pronouncing each day of the week that she mentions with a finally devoiced vowel, in this way drawing the attention of the speaker towards these items.[186]

The vowel-final devoicings may thus be said to have a paralinguistic meaning.[187] They are functionally motivated, and may be used to signal an ending, or – as followed from the PFC recordings – to highlight an utterance. It is especially worth recalling in this respect that French is a language with a fixed prominent position (i.e. the final syllable of the phrase), which offers only limited possibilities in terms of intonational phonology. Speakers might compensate for this lack by resorting to the segmental level. As already noted above, the initial and full devoicings are not restricted to a specific phrasal position. Moreover, no functional motivation can be established, and these instances of devoicing seem purely phonetically-based.

With this excursus on vowel devoicing, we arrive at the end of this chapter, which has addressed a considerable number of aspects related to the release of French plosives. In order to properly conclude the chapter, the main findings will be summarized in the following section.

8.7 Discussion and conclusion

This chapter has zoomed in on the release of the French plosives in prevocalic position. Basic descriptions, mainly based on introspective judgements, generally characterized French plosives as neatly released sounds, consisting of an obstruction followed by a smooth release. The results obtained on the basis of the corpus data have put this traditional characterization in a different perspective. The data nicely illustrate that in contemporary French the release of a noncontinuant obstruent is subject to variation. This variation resides first of all

[186] The absence of vowel-final devoicing of the other phrase-final vowels in this fragment (*terminés*, *facilités*), is not due to the fact that these are mid-high instead of high vowels, as other fragments of the recordings of this speaker do contain mid-high tokens ending in a fricative constriction.

[187] In this respect, it is worth mentioning a similar phenomenon in English where vowels are realized with creaky voice in utterance-final position. This phenomenon has been analyzed as contextually-determined, where the creaky voice is used for a variety of demarcative purposes. It is seen as socially marked, and often considered an affected pronunciation. For more details on this phenomenon, the reader is referred to Esling (1978), Henton & Bladon (1988) and Zetterholm (1998).

in purely phonetic aspects. The nature of the plosive and the quality of the following vowel cause the articulators to take a specific configuration and, depending on the setting of the vocal folds and the tightness of the constriction, a more or less noisy release is produced. These more general effects of articulation may be further strengthened by the tense articulation which is characteristic of French, and which may both lengthen and narrow the constriction in the oral cavity even more. As it is virtually impossible for a speaker to configure the speech organs in the exact same way in all instances of a particular context, and as the exact shape of the vocal tract differs from one speaker to another, variation arises. At the same time, however, some speakers seem to produce a noisy plosive release more systematically than others. It could therefore be said that such an articulation characterizes the speech of a speaker, in such a way that it may become a stylistic characteristic as well.

The study of French plosive releases has also shown that plosive assibilation, a phenomenon that has always been associated with Canadian varieties, but virtually never with metropolitan French, is a salient characteristic of these latter varieties as well, both for coronals and velars. Unlike Canadian French, however, affrication in the metropolitan varieties is purely based on vocal tract constraints and it has not been systematized in any way. While assibilation of [t] or [d] is categorical in Canadian varieties, we are facing a high degree of variability in France: it characterizes an individual speaker with a tight and tense speech style, rather than an entire speech community.

All aspects addressed in this chapter and the preceding one, concern phonetic variation that does not play a role at the phonological level. Whether the [t] in *petit* is realized with or without frication noise does not entail confusion between words. As a matter of fact, most speakers of French will not even notice that some of their compatriots pronounce a plosive with a noisy release under specific circumstances, and even the speakers who realize these noisy plosives will not be aware of this themselves, as is also nicely reflected by the following observations made by respectively Léon & Léon (1976) and Fónagy (2006):

> "S'il existe des *variantes*, elles ne sont généralement pas perçues par les sujets parlants, car elles sont souvent peu importantes […]."[188]
>
> (Léon & Léon 1976:31)

[188] If *variants* exist, they are generally not heard by the speakers, because they are often not very important.

> "Si on faisait observer à un Français ne parlant que sa langue maternelle qu'il prononce dans des mots comme *tirer*, *voiture* ou *quatuor*, une consonne qui est bien loin du *t* standard, une sorte de *t* 'mouillé' [t'] ou une occlusive palatale [c], il ne comprendrait pas de quoi on parle à cause de la perception phonologique, catégorielle. Nous sommes « sourds » à ces variations qui n'apportent pas de changement de signification."[189]
>
> (Fónagy 2006:26)

The PFC data allowed us to study the French plosives from a sociophonetic perspective, which would have been less straightforward with the data obtained by lab-based experiments. Yet at the same time, our investigation leaves several issues undetermined, precisely because of the specific nature of the data. The acoustic analysis was restricted to a limited number of aspects; we have no information about the exact tongue movements involved, and we are still ignorant about the effects of word frequency for instance. Therefore, the present study should be considered a first glance at the quality of French plosive releases, which may be complemented by other investigations, studying the phenomenon from different perspectives. It may also be an interesting direction for future research to test the perceptual and attitudinal side of the variation in plosive releases. What are people's judgements on speech that contains more noisy releases: does it bother the listener in some kind of way, is it given a value judgement (e.g. mincing, posh or non-standard speech) or are hearers completely insensitive and indifferent to it?

This chapter was the final part of the corpus investigation. The corpus study has shown that a considerable amount of the variation observed can be attributed directly to phonetic factors, and the synchronic data have provided more insight into the problematic change in the historical phonology of French. In the following chapter, all findings will be combined, in order to provide an answer to the research questions.

[189] If we were to point out to a Frenchman only speaking his mother tongue that in words like *tirer*, ('to pull'), *voiture* ('car') or *quator* ('quartet') he pronounces a consonant which is quite different from standard *t*, a kind of 'weakened' [t'] or a palatal plosive [c], he would not understand what we were talking about because perception is phonological, categorical. We are "deaf" to variations that do not entail a change in meaning.

.....

9

.....

Conclusion:
The phonetics and phonology of affricates

9.1 Introduction

As has been argued in the first two chapters of this study, the remaining uncertainty about the phonological representation of affricates is due to the ill-balanced, incomplete and contradictory image of the patterning and structuring of these sounds in the world's languages. This thesis aimed at contributing to a solution of this problem by approaching the question from two different angles. The typological investigation represented the first part. Its purpose was on the one hand to complete, update and check the cross-linguistic patterns. On the other hand, by paying special attention to affrication processes in the historical phonology of French, which is an exception in showing palatalization/affrication before the low vowel *a*, an additional dimension was added to the typological investigation. The second major part of this study involved a corpus analysis of allophonic palatalization and affrication in several varieties of French spoken in France, and shed light on the linguistic and sociolinguistic factors involved.

This final chapter will combine the complementary findings presented in the preceding chapters in order to formulate the answers to the research questions. For clarity's sake, the research questions as they were formulated in chapter 1, are repeated in (185).

(185) **What is the phonetic and phonological status of affricates?**

I. Does a universal phonological class of affricates exist?

- If so, how are affricates specified at the underlying level? Is this underlying representation a universal one?

- If not, which description is required in order to predict exactly the contrasts and natural segment classes that are attested, to the exclusion of the ones that are not?

II. **What are the characteristics of allophonic velar palatalization and plosive affrication in modern metropolitan French?**
   - To what extent are both processes active in France?
   - What are the linguistic and sociolinguistic factors involved in both phenomena?

Section 9.2 will consider question I, and question II on French will be discussed in 9.3. In section 9.4, the different elements will be combined, in order to answer the main question of this thesis, i.e. what is the phonetic and phonological relevance of affricates? Finally, in section 9.5, this concluding chapter will also consider in more detail some implications for phonetics and phonology and highlight a number of issues for future research.

9.2 A phonological class of affricates?

The primary issue to settle when looking for an answer to the question how affricates should be described phonologically, is whether the concept "affricate" is of phonological relevance in the first place. As we have seen several times, the existence of a phonological category of affricates has come under attack in the most recent analyses. Clements (1999) and, even more explicitly, LaCharité (1993) and Kehrein (2002) argue against affricates as a pre-established natural segment class and claim that these sounds should primarily be seen as stops (i.e. [-continuant]). Affricated plosives can be distinguished from their non-affricated counterparts by means of independently motivated features (e.g. place features, or [±strident], [±lateral]) which do not reflect "affricateness" as such.

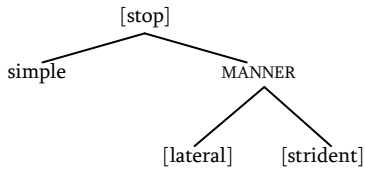
As a matter of fact, our investigation of the segment inventories of UPSID 1992 (chapters 3 and 4) did not provide counterevidence to this claim. The affricates in the different inventories can be distinguished from plain plosives and/or fricatives without relying on configurations which are exclusively designed for affricates (i.e. complex or contour segment, strident stop). Instead, place or manner of release contrasts ([strident], [lateral]) are involved.

As the synchronic examination of segment inventories did not tell anything about the phonological behaviour of affricates as such, the typological part also investigated the processes involving affricates in the historical phonology of French (chapter 5). Affricates emerged in a considerable variety of

contexts. Their emergence seems essentially phonetically triggered, and it is not unlikely that perceptual confusion comes into play, which makes that speakers massively come to perceive specific sound sequences as affricates, ultimately followed by an adaptation of the phonological representations. The way French treated affricates in reduction processes shows that these sounds do not necessarily pattern with their non-affricated equivalents in spirantization processes. Yet, a dual structure with two values for the feature [±continuant] is not required to account for this (potentially) deviant behaviour, and it even leads to incorrect predictions in the case of the strengthened labial and palatal glides. A radical plosive view can do the job as well, but then, contrary to the assumptions made by Kehrein (2002), it has to be stipulated that stops without a Manner specification like [strident] may reduce to the exclusion of Manner-specified stops.

In sum, departing from the taxonomy provided in Kehrein (2002), cf. (32) above, the sounds that have traditionally been considered phonological affricates can be classified as follows:

(186) **Affricates and non-affricated stops at the phonological level:**



Natural classes:

I.	All stops
II.	All simple stops
III.	All Manner-specified stops
IV.	[lateral] stops
V.	[strident] stops

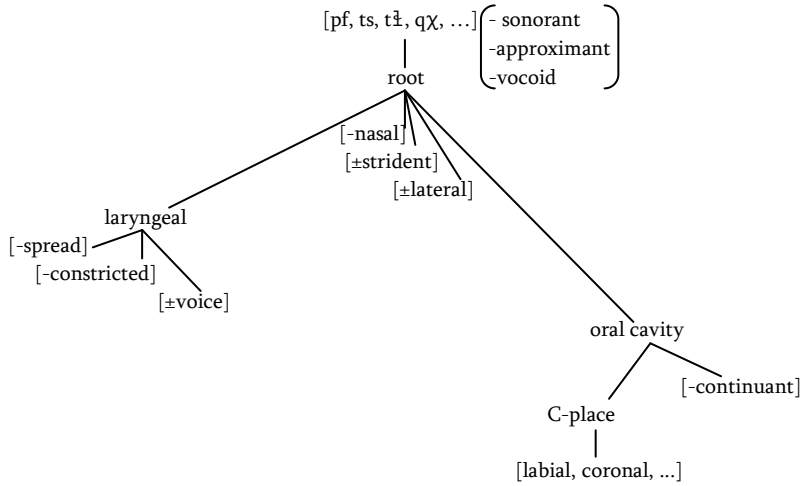
According to (186), affricates and plain stops constitute a natural class. The two do not always behave in the same way: simple stops[190] may behave differently from the Manner-specified stops (or the other way round), and the two

[190] In Kehrein's taxonomy, the branch of "simple stops" includes both the non-affricated plosives, as well as the non-sibilant/non-lateral affricates [pf], [tθ], [cç], [kx] and [qχ]. Alternatively, as we have seen in the typological part, (some of) these affricates may be hosted by the category of strident stops as well, depending on the way the feature [strident] is defined. Additional evidence is required in order to settle this issue: for instance from languages with both sibilant and non-sibilant affricates that reduce all these sounds to fricatives at the same time, to the exclusion of the non-affricated stops.

categories of Manner-specified stops may each act on their own, and/or pattern with the lateral or strident fricatives.

"Affricates" may be found among the strident and lateral stops, and possibly among the simple stops, depending on the exact lay-out of the category of [strident] stops. The basic geometry of an affricate would then look as in (187), cf. section 4.4.3. This approach is less powerful and more restrictive than an SPE delayed-release-analysis or a contour or complex stop description, while it allows both affricates and non-affricated plosives to behave differently from one another in specific circumstances.

(187)



The answer to the first research question "Does a universal phonological class of affricates exist?" thus appears to be "no": there is no need to stipulate the existence of some general feature combination which serves to refer to affricates to the exclusion of non-affricated plosives or fricatives. Affricates and plain plosives can be seen as a natural class, and the contrasts and patterning of affricates may be explained in terms of place or manner features (depending on the language in question), without relying on contour or complex segments. In principle, affricates are thus banned from phonology as such; even though in languages with only strident affricates, the entire class of affricates can be described as strident stops, which looks, in some way, as if there were a phonological category of affricates.

9.3 Palatalization and affrication in modern metropolitan French

French is not only interesting from a diachronic point of view; also the synchronic, allophonic, behaviour of plosives is a valuable source of evidence in the discussion on the phonetics and phonology of affricates.

The common process of velar palatalization, where velars are pulled towards the palatal region and may ultimately become coronal affricates, has taken place in the history of French and is synchronically active again. This tendency towards fronting is frequently noted in all kinds of descriptions of the modern French sounds, but, to the best of our knowledge, it has never been studied from a wider sociolinguistic perspective. As the PFC data have nicely illustrated, velar fronting is indeed a phenomenon which occurs throughout the different areas of France, and in a very general (yet unsurprising) way, it could be said that the likelihood of fronting depends on the place of articulation of the following vowel: the more anterior the vowel, the more likely it is to find a fronted velar. Definitely interesting in this respect is the behaviour of the vowel *a*: depending on its degree of centrality or anteriority, the velar is fronted, and this fronting has proven to be substantial in a considerable number of cases. This synchronic evidence may help to better understand the atypical diachronic change. Yet, the likelihood of velar fronting depends on the frontness of the following vowel, and as the word "likelihood" indicates, the process is gradual and subject to variation, both in the speech of an individual speaker and between speakers. Factors that play a role in this variation are the degree of coarticulation, the speech rate, but also the age and gender of the speaker(s) involved.

Next to the degree of velar fronting, the quality of the release of the different plosives in contemporary French was analyzed. These releases, which are in fact a neglected feature of French phonology, turned out to be very fascinating as a large variety of possible releases emerged. By also approaching this phenomenon from a sociophonetic perspective, the results nicely illustrated the spread of the phenomenon throughout the French territory, while they at the same time clearly demonstrated the linguistic and sociolinguistic variation involved. The actual nature of the release is variable, both between speakers and in the renditions of individual speakers, and this variation can be ascribed primarily to variations in the configurations of the vocal tract. For some speakers the emergence of a more noisy released is completely determined by chance, as the vocal tract in a specific context happens to be set in such a shape that an incidental noisy cue arises. For others, with a more tense articulation, and/or with an articulation which is mainly concentrated in the anterior region of the

oral cavity, these noisy cues arise (more) systematically, and in that sense, it can be considered a characteristic of their personal speech style. Another intriguing particularity of the way plosives are realized in present-day European French is that affricated plosives may arise, which is generally considered a specificity of the Canadian varieties of French or of marginal varieties spoken in the Parisian suburbs (*banlieues*). Yet, the crucial difference between plosive affrication in the two varieties is that in France it is not systematized in any way but purely phonetically conditioned: coronals and velars turn into affricates [ts] or [kx] for instance when the configurations are such that frication noise arises. In Canadian French, on the other hand, coronals invariably take an affricated realization when followed by a high front vowel.

In sum, with respect to research question II, "What are the characteristics of allophonic velar palatalization and plosive affrication in modern metropolitan French?", it could be said that both phenomena are primarily phonetically conditioned. However, even though both phenomena can be found in all regions of France, there is a certain amount of variation involved, which is on the one hand a direct result of the phonetic factors underlying the process, yet on the other hand, social aspects come into play as well. It could very well be the case that we are facing sound change(s), which will eventually spread throughout the speech community with the youngest generations.

9.4 The phonetics, phonology and sociolinguistics of affricates

Affricates can only be properly understood if a clear distinction is made between the aspects that belong to phonetics, to phonology or to the phonetics-phonology interface.

The phonetic characteristics first of all straightforwardly account for the elementary distribution of affricates in segment inventories; affricates are not as frequent as plain plosives or fricatives because of their articulatory complexity (i.e. binary articulation), voiced affricates are even less frequent because vocal fold vibration is complicated by conflicting oral air pressure requirements for the plosive and fricative parts, and as affricates share phonetic characteristics with both plosives and fricatives, affricates may attract modifiers which also occur on the other obstruents, but at the same time, because of its composition, an affricate may also pattern differently from these other types of obstruents when it comes to the hosting of modifiers. In short, because of their phonetic characteristics, it is expected that affricates sometimes show the same patterns as

plosives, sometimes as fricatives, and that yet other times, because their dual articulation also makes affricates clearly distinct from the other obstruents, their patterns deviate from both plosives and fricatives. Trying to explain the lay-out of affricate series in segment inventories by means of a specific phonological representation, or using this lay-out as an argument in favour of a specific representation, as has been done by several analyses described in chapter 2, is not adequate as it leaves numerous patterns unexplained. It rather depends on the contrasts and phonological processes in the language how affricates should be described phonologically. As far as the segmental contrasts in UPSID 1992 are concerned, it appeared that affricates can clearly be kept apart from both plosives and fricatives by means of the feature [-continuant] and an additional place or manner feature, without relying on such a powerful configuration as a contour or complex segment. The patterning of affricates in the historical phonology of French can be adequately described without these complex representations as well. Moreover, these facts also nicely illustrated the basic phonetic mechanisms involved, as the emergence of affricate appeared to be articulatory and/or perceptually motivated. If such a perceptual confusion arises and indeed leads to sound change, the process is not correctly captured by some autosegmental spreading operation of features, but there is a more direct and natural motivation: in a specific environment a sound or sound sequences come(s) to resemble an affricate (for articulatory or aerodynamic reasons), which results in confusion between two phonological representations, and the previously existing representation comes to be replaced by the representation of the affricate.

Still, as we have also seen, phonetics explains the basics underlying the patterns of affricates, but phonology nevertheless plays an important role which should not be neglected. It is because of their underlying representation that affricates come to pattern in a specific way in phonological processes. Moreover, the actual appearance of numerous inventories shows that phonological aspects play a role as well, as the effects of a principle like feature economy are often clearly detectable. It was argued that this feature economy interacts with the opposite principle of maximal dispersion of contrasts: the UPSID 1992 inventories strongly suggest that there is a default situation with a tendency towards economy of distinctive features, which is, so to speak, supervised by a mechanism which assures that *sufficient* dispersion between the phonemes is guaranteed. Ultimately, at the end of the phonological derivation, the affricate, which is underlyingly represented as some kind of stop, is turned into a linear sequence [-continuant, +continuant] in the phonetic implementation.

Finally, the study of synchronic French has allowed us to witness in real-time how (allophonic) affricates may emerge in a language. It has shown, first of all, which phonetic factors are involved in velar fronting, and in which way articulatory aspects condition the nature of a plosive release. At the same time, the synchronic French data have also shown how sociolinguistic factors may be involved in these potential sound changes, and moreover, it has been argued that in the speech of speakers where affricated plosives arise quite systematically, noisy releases may become some kind of stylistic or identity feature.

9.5 Conclusion and perspectives

This study contributes to a solution of the problem of the phonological representation of affricates in several respects. First of all, a contrastive and more or less thematically organized overview of existing analyses has been provided in order to be able to pinpoint exactly to the relevant controversies and lacunas. A second result of this study then is that by means of UPSID 1992 and the French historical data, the poor existing typological picture has been updated and completed, and the existing arguments and analyses have been critically evaluated. A third contribution to the debate is the corpus study of synchronic French, which has provided a sociophonetic approach to velar fronting and the quality of plosive releases in modern metropolitan French. In this way, a new dimension has been added to the existing data, which were mostly intuitive and/or impressionistic in nature, and moreover, surprising aspects have been revealed.

When looking for an answer to such a complex question as the phonological status of affricates, it is quite obvious that we also run into a number of issues that have to be left undetermined because additional evidence is required. Such issues concern the exact definition of the feature [strident], and the way the non-sibilant affricates should be described exactly. We will leave these questions open for future research, and it goes without saying that also the view defended here is open for falsification.

Let us finish by pointing out some additional interesting topics for follow-up studies, which especially concern the French developments described in chapters 7 and 8. It may be worthwhile to replicate the analysis of the place of articulation of velars and the release quality of all plosives in 10, 20 and/or 30 years of time, in order to determine whether we are indeed dealing with incipient sound changes, or whether they rather are evanescent phenomena that

do not get rooted in the speech community. Is metropolitan French heading towards a system with palatal stops or systematic plosive affrication as in Canadian French; or will velars just remain slightly fronted and will the noisy plosive releases have disappeared altogether? And what about other European variants of French, like the Belgian or Swiss varieties? Moreover, as far as the current state of the metropolitan variety is concerned, it would definitely be interesting to study conversational data and to test people's awareness of the existence of such phonetic cues and to retrieve people's attitudes towards the quality of the different French plosives.

Affricates have created friction between phonetics and phonology for a long time: how does the phonetic binarity of the affricate relate to its underlying structure? To what extent is there a mismatch and how can it be justified? By clearly separating the aspects that should be explained by phonetics from those that should be explained by phonology, we hope to have shown that there is in fact no reason why this friction should exist. The acoustic friction of affricates does not make them complicated sounds, but rather highly fascinating ones.

APPENDICES

Appendix A

The following overview lists the languages in UPSID with one or more affricates. The languages are classified by language family (following UPSID's categorization), and for each language the number of affricates as well as the total number of consonantal segments is indicated (clicks and glottal stops included). The language names are the ones used as primary names in UPSID 1992, and their spelling has been checked against the Ethnologue (Lewis 2009). In case of deviations, the orthography used in this latter source is given in the overview below. With respect to the phonetic transcription in the rightmost column, the original SAMPA transcription used in UPSID 1992 has been replaced, for convenience's sake, by an IPA notation.

Afro-Asiatic

Sub-family	Language	Number of consonants	Number of affricates	Affricates
Chadic	1. Angas	32	2	tʃ dʒ
	2. Hausa	31	2	tʃ dʒ
	3. Kera	24	2	tʃ dʒ
	4. Kotoko	27	2	pf' t͡θ'
	5. Lame	30	3	ts dz ⁿdz
	6. Margi	30	4	ts tʃ dz dʒ
	7. Tera	42	3	cç ɟʝ ⁿɟʝ
Cushitic	8. Awiya	28	4	ts tʃ dz dʒ
	9. Beja	21	1	dʒ
	10. Dahalo	54	11	ts tɬ tʃ dz dɮ dʒ ts' tɬ' tʃ' ⁿdz ⁿdʒ
	11. Iraqw	33	2	ts' tɬ'
	12. Somali	22	1	tʃ

Omotic	13. Dizi	24	4	tʃ dʒ ts' tʃ'
	14. Hamer	25	1	ts
	15. Kefa	22	3	tʃ dʒ tʃ'
	16. Kullo	24	4	ts tʃ dʒ ts'
Semitic	17. Amharic	30	3	tʃ dʒ tʃ'
	18. Arabic	27	1	dʒ
	19. Neo-Aramaic	24	2	tʃ dʒ
	20. Tigré	26	4	tʃ dʒ ts' tʃ'

Australian

Sub-family	Language	Number of consonants	Number of affricates	Affricates
Pama-Nyungan	21. Bandjalang	12	1	dʒ

Austro-Asiatic

Sub-family	Language	Number of consonants	Number of affricates	Affricates
Bahnaric	22. Brao	22	2	cç ^{n}tʃ
	23. Sedang	41	2	tʃ ^{n}dʒ
Katuic	24. Bruu	20	1	tɸ
Khasi	25. Khasi	21	1	dʒ
Munda	26. Kharia	31	4	tʃ dʒ tʃ^{h} dʒ^{h}
	27. Mundari	32	4	tʃ dʒ tʃ^{h} dʒ^{h}
Nicobarese	28. Nicobarese	16	1	tʃ

Palaungic	29. Parauk	29	4	tʃ dʒ tʃʰ dʒʰ

Austro-Tai

Sub-family	Language	Number of consonants	Number of affricates	Affricates
Atayalic	30. Atayal	19	1	ts
East Malayo-Polynesian	31. Adzera	18	2	dz tsʰ
	32. Iai	36	2	tʃ dʒ
	33. Pohnpeian	14	1	t̪s̪
Lati-Gelao	34. Gelao	31	6	ts tɕ tsʰ tɕʰ ⁿts ⁿtɕ
Li-Kam-Tai	35. Lai	44	2	tɕ tɕʰ
	36. Lakkia	33	2	ts tsʰ
	37. Lue	22	2	tʃ tʃʰ
	38. Lungchow	21	2	tʃ tʃʰ
	39. Poai	19	2	tʃ tʃʰ
	40. Sui	47	4	ts tʃ tsʰ tʃʰ
	41. Thai	21	2	t̪s̪ t̪s̪ʰ
Paiwanic	42. Paiwan	22	1	t̪s̪
Tsouic	43. Rukai	23	1	ts
	44. Tsou	15	1	t̪s̪
West Malayo-Polynesian	45. Batak	16	1	dʒ
	46. Chamorro	20	2	ts dz
	47. Iban	19	2	tʃ dʒ
	48. Ivatan	19	2	tʃ dʒ
	49. Javanese	21	2	ts t̪s̪ʰ
	50. Malagasy	21	2	t̪s̪ d̪z̪
	51. Sa'ban	19	2	tʃ dʒ
	52. Sama	26	4	tʃ dʒ ⁿtʃ ⁿdʒ
	53. Tagalog	18	1	tʃ

Caucasian

Sub-family	Language	Number of consonants	Number of affricates	Affricates
	54. Archi	74	24	qχ tsʰ tɬʰ tʃʰ qχʷ tsʷʰ tɬʷʰ tʃʷʰ qχˤ qχʷˤ ts’ tɬ’ tʃ’ qχ’ ts’ː tʃ’ː qχ’ː tsʷ’ tɬʷ’ tʃʷ’ qχʷ’ qχˤ’ qχˤ’ː qχʷˤ’
	55. Avar	44	14	tsː tɬː tʃː kxː qχː tsʰ tʃʰ ts’ tʃ’ ts’ː tɬ’ː tʃ’ː kx’ː qχ’ː
	56. Bats	35	6	d͡z dʒ t͡sʰ tʃʰ t͡s’ tʃ’
	57. Georgian	28	6	ts tʃ tsʰ tʃʰ ts’ tʃ’
	58. Kabardian	48	5	t͡s qχ d͡z qχʷ t͡s’
	59. Lak	60	12	tsː tʃː tsʰ tʃʰ tsʷː tʃʷː tsʷʰ tʃʷʰ ts’ tʃ’ tsʷ’ tʃʷ’
Northwest Caucasian	60. Rutul	59	10	dz dʒ tsʰ tʃʰ dʒʷ tsʷʰ ts’ tʃ’ tsʷ’ tʃʷ’

Chukchi-Kamchatkan

Sub-family	Language	Number of consonants	Number of affricates	Affricates
	61. Chukchi	15	1	ts
	62. Itelmen	27	2	tʃ ts’
	63. Koryak	16	1	tʃ

Dravidian

Sub-family	Language	Number of consonants	Number of affricates	Affricates
	64. Brahui	24	2	tʃ dʒ
	65. Kota	23	2	dʒ tʃʰ
	66. Koya	19	2	tʃ dʒ
	67. Telugu	32	3	ts tɕ dz
South Dravidian	68. Tulu	24	2	tʃ dʒ

Eskimo-Aleut

Sub-family	Language	Number of consonants	Number of affricates	Affricates
Aleut	69. Aleut	24	1	ts
Eskimo	70. Inuit	19	1	ts

Indo-European

Sub-family	Language	Number of consonants	Number of affricates	Affricates
Albanian	71. Albanian	28	6	ts tʃ cç dz dʒ ɟʝ
Armenian	72. Armenian	30	6	t̪s̪ tʃ t̪s̪ʰ tʃʰ t̪s̪’ tʃ’
Baltic	73. Lithuanian	36	5	ts tʃ dz dʒ tsʲ
Celtic	74. Irish	45	2	tʃ dʒ

West Germanic	75. German	22	2	pf	ts
Greek	76. Greek	21	2	ts	dz
Indic	77. Bengali	29	4	tʃ tʃʰ	dʒ dʒʰ
	78. Hindi-Urdu	40	4	tʃ tʃʰ	dʒ dʒʰ
	79. Kashmiri	27	6	ts dz tsʰ 	 tʃʲ dʒʲ tʃʲʰ
	80. Konkani	19	2	tɕ	dʑ
	81. Nepali	27	4	ts tsʰ	dz dzʰ
	82. Sinhalese	22	2	cç	ɟʝ
Iranian	83. Farsi	24	2	tʃ	dʒ
	84. Kurdish	30	2	tʃ	dʒ
	85. Ormuri	25	4	ts dz	tʃ dʒ
	86. Pashto	31	4	t͡s d͡z	tʃ dʒ
Romance	87. Romanian	22	3	t͡s	tʃ dʒ
	88. Spanish	20	1	tʃ	
Slavic	89. Bulgarian	35	4	t͡s t͡sʲ	tʃ dʒ
	90. Russian	33	2	ts	tʃ

Khoisan

Sub-family	Language	Number of consonants	Number of affricates	Affricates		
Central Khoisan	91. Nama	32	2	t͡sʰ	kxʰ	
Hadza	92. Hadza	57	13	ts dz tsʰ ts’ ⁿdz	tɬ tɬʰ tɬ’ 	tʃ dʒ tʃʰ tʃ’ ⁿdʒ

North Khoisan	93. !Xu	98	14	ts tʃ tsʰ tʃʰ dzʰ dʒʰ tsˠ tʃˠ dzˠ dʒˠ ts’ tʃ’ dz’ dʒ’
Sandawe	94. Sandawe	47	7	ts tɬ dz dɮ tsʰ ts’ tɬ’

Na-Dene

Sub-family	Language	Number of consonants	Number of affricates	Affricates
Athabaskan	95. Ahtna	30	6	dz dɮ tsʰ tɬʰ ts’ tɬ’
	96. Chipewyan	38	14	t̪θ̪ ts tɬ tʃ t̪θ̪ʰ tsʰ tɬʰ tʃʰ kxʰ kxʷʰ t̪θ̪’ ts’ tɬ’ tʃ’
	97. Hupa	28	7	ts tʃ tsʰ tʃʷʰ ts’ tɬ’ tʃ’
	98. Navajo	31	9	ts tɬ tʃ dɮ tsʰ tʃʰ ts’ tɬ’ tʃ’
Eyak	99. Eyak	32	9	dz dɮ dʒ tsʰ tɬʰ tʃʰ ts’ tɬ’ tʃ’
Haida	100. Haida	46	6	tɬ tʃ dɮ tʃʰ tɬ’ tʃ’
Tlingit	101. Tlingit	43	9	ts tɬ tʃ dz dɮ dʒ ts’ tɬ’ tʃ’

Niger-Kordofanian

Sub-family	Language	Number of consonants	Number of affricates	Affricates
Adamawa	102. Lua	23	3	tʃ dʒ ⁿdʒ
Bantoid	103. Aghem	25	5	ts tʃ bv dz dʒ
	104. Beembe	16	4	pf ts pfʰ tsʰ
	105. Ewondo	26	3	ts dz ⁿdz
	106. Fe'Fe'	17	2	tʃ dʒ
	107. Mambila	19	3	tʃ bv dʒ
	108. Noni	19	2	tʃ dʒ
	109. Teke	21	4	pf tʃ bv dʒ
	110. Zulu	32	3	dʒ tʃ' kɬ'[191]
Cross River	111. Kohumono	28	2	tʃ dʒ
Dogon	112. Dogon	16	1	dʒ
Jukunoid	113. Kpan	24	2	ts dz
Kordofanian	114. Moro	22	2	tʃ dʒ
Kwa	115. Akan	21	4	cç ɟʝ cçʷ ɟʝʷ
	116. Éwé	26	2	t̪s̪ d̪z̪
	117. Ga	29	4	dʒ tʃʷ dʒʷ tʃʰ
	118. Igbo	43	3	dʒ tʃʰ dʒʰ
	119. Yoruba	18	1	dʒ
Kru	120. Klao	11	2	cç ɟʝ
Mande	121. Bambara	21	2	tʃ dʒ
Plateau	122. Amo	25	3	ts tʃ dʒ
	123. Tarok	26	2	tʃ dʒ
Togo Remnant	124. Lelemi	22	2	ts dz

[191] In Maddieson (1984) and the UPSID 1992 web-interface this sound is described as a "velar lateral ejective affricate".

Ubangi (Eastern)	125. Mba-ne	24	3	tʃ dʒ ⁿdʒ
Voltaic	126. Dagbani	23	2	tʃ dʒ
West Atlantic	127. Wolof	26	1	qχ

Nilo-Saharan

Sub-family	Language	Number of consonants	Number of affricates	Affricates
Berta	128. Berta	24	1	dʒ
Central Sudanic	129. Lugbara	26	2	ts dz
	130. Yulu	35	1	d̪z̪
East-Sudanic	131. Ik	31	6	ts tʃ dz dʒ ts' tɬ'
	132. Luo	23	4	t̪θ̪ tʃ d̪ð̪ dʒ
	133. Maasai	19	1	tʃ
	134. Nera	17	1	dʒ
	135. Nubian	16	2	tʃ dʒ
Fur	136. Fur	19	1	dʒ
Kunama	137. Kunama	19	2	tʃ dʒ
Saharan	138. Kanuri	23	2	tʃ dʒ

North American

Sub-family	Language	Number of consonants	Number of affricates	Affricates
Almosan	139. Bella Coola	28	3	ts ts' tɬ'
	140. Kwak'wala	42	6	dz dɮ tsʰ tɬʰ ts' tɬ'
	141. Lushootseed	33	7	ts tʃ dz dʒ ts' tɬ' tʃ'
	142. Ojibwa	16	2	tʃ ʰtʃ
	143. Quileute	33	6	ts tɬ tʃ ts' tɬ' tʃ'
	144. Shuswap	37	3	tʃ t̪ʃ t̪ɬ̪

(Almosan)	145.	Tseshaht	37	6	ts ts’	tɬ tɬ’	tʃ tʃ’
	146.	Upper Chehalis	30	5	ts ts’	 tɬ’	tʃ tʃ’
	147.	Wiyot	24	4	ts tsʰ	tʃ tʃʰ	
Hokan	148.	Achumawi	17	1	dʒ		
	149.	Diegueño	25	1	tʃ		
	150.	Karok	15	1	tʃ		
	151.	Pomo	27	2	ts	ts’	
	152.	Shasta	17	2	tʃ	tʃ’	
	153.	Tol	22	3	ts	tsʰ	t̪s̪
	154.	Tonkawa	15	1	ts		
	155.	Yana	22	3	 tʃʰ tʃ’	dʒ	
Keresiouan	156.	Acoma	39	9	d̪z̪ t̪s̪ʰ t̪s̪’	dʒ tʃʰ tʃ’	dʐ ʈʂʰ ʈʂ’
	157.	Caddo	20	4	ts ts’	tʃ tʃ’	
	158.	Cherokee	11	1	dz		
	159.	Dakota	28	3	tʃ	tʃʰ	tʃ’
	160.	Seneca	11	1	dz		
	161.	Wichita	21	4	ts ts’	tsː	 ʈʂʰ
	162.	Yuchi	38	8	ts dz tsʰ ts’	tʃ dʒ tʃʰ tʃ’	
Kiowa-Tanoan	163.	Kiowa	22	2	ts	ts’	
	164.	Picuris	26	1	tʃ		
Oto-Manguean	165.	Amuzgo	25	2	ts	tʃ	
	166.	Highland Chinantec	26	2	ts	dz	
	167.	Mazahua	45	6	ts tsʰ ts’	tʃ tʃʰ tʃ’	
	168.	Mazatec	25	6	ts ⁿdz	tʃ ⁿdʒ	ʈʂ ⁿdʐ
	169.	Mixtec	15	1	tʃ		
	170.	Tlapanec	20	3	ts	tʃ dʒ	

Penutian	171. Alabama	14	1	tʃ
	172. Huasteco	21	4	ts tʃ ts' tʃ'
	173. Huave	23	1	ts
	174. Jacaltec	27	6	tsʰ tʃʰ ʈʂʰ ts' tʃ' ʈʂ'
	175. K'ekchi	21	4	ts tʃ ts' tʃ'
	176. Mixe	14	1	tɹ
	177. Nez Perce	25	1	qχ
	178. Sierra Miwok	15	1	tʃ
	179. Totonac	15	2	ts tʃ
	180. Tsimshian	38	3	ts dz ts'
	181. Tunica	17	1	tʃʰ
	182. Tzeltal	22	4	t̪s̪ ts (alv) t̪s̪' ts'(alv)
	183. Wappo	30	4	ts tʃ ts' tʃ'
	184. Wintu	30	6	tɬ tʃ dʒ ts' tɬ' tʃ'
	185. Yucatec	20	4	ts tʃ ts' tʃ'
	186. Zoque	16	1	ts
	187. Zuni	20	4	tsʰ tʃʰ ts' tʃ'
Uto-Aztecan	188. Kawaiisu	25	2	ts tʃ
	189. o	21	1	tʃ
	190. Nahuatl	16	3	ts tɬ tʃ
	191. Papago	19	2	tʃ dʒ
	192. Yaqui	17	1	tʃ

Papuan

Sub-family	**Language**	**Number of consonants**	**Number of affricates**	**Affricates**
Andamanese	193. Andamanese	16	2	tʃ dʒ
Geelvink Bay	194. Yawa	14	1	dʒ
Sepik-Ramu	195. Alamblak	18	2	tʃ dʒ

(Sepik Ramu)	196. Kwoma	24	2	tʃ ⁿdʒ
Trans-New Guinea	197. Angaatiha	12	1	tʃ
	198. Asmat	11	1	tʃ
	199. Suena	13	1	dz
	200. Wahgi	17	2	t̪s̪ ⁿd̪z̪
	201. Yareba	13	1	dz
West Papuan	202. West Makian	17	2	tʃ dʒ

Sino-Tibetan

Sub-family	**Language**	**Number of consonants**	**Number of affricates**	**Affricates**
Himalayic	203. Newari	24	4	dz ts dzʰ tsʰ
	204. Tamang	19	4	t̪s̪ tɹ t̪s̪ʰ tɹʰ
Hmong-Mien	205. Hmong	46	12	t̪s̪ tʃ ʈʂ t̪s̪ʰ tʃʰ ʈʂʰ ⁿt̪s̪ ⁿtʃ ⁿʈʂ ⁿt̪s̪ʰ ⁿtʃʰ ⁿʈʂʰ
	206. Mien	33	3	ts dz tsʰ
Kachin	207. Jingpho	25	5	ts tʃ dz dʒ tʃʰ
Karenic	208. Phlong	25	2	tʃ tʃʰ
Kuki-Naga	209. Ao	14	1	cç
	210. Tiddim Chin	21	1	ts
Lolo-Burmese	211. Burmese	33	3	tʃ dʒ tʃʰ
	212. Lahu	26	3	tʃ dʒ tʃʰ
	213. Naxi	38	12	t̪s̪ tɕ ʈʂ d̪z̪ dʑ ɖʐ t̪s̪ʰ tɕʰ ʈʂʰ ⁿd̪z̪ ⁿdʑ ⁿɖʐ
Sinitic	214. Bai	18	2	ts tsʰ
	215. Changzhou	25	3	ts tsʰ t̪ɕʰ
	216. Fuzhou	14	2	ts tsʰ
	217. Hakka	16	2	ts tsʰ

(Sinitic)	218. Mandarin	25	6	ts ts^h	ʈʂ $ʈʂ^h$	cç $cç^h$
	219. Tai Shan	20	2	tʃ	$tʃ^h$	
	220. Xiamen	19	4	ts dz ts^h	dʒ	

South American

Sub-family	Language	Number of consonants	Number of affricates	Affricates		
Andean	221. Araucanian	20	2	tʃ	ʈɻ	
	222. Jaqaru	36	9	ts ts^h ts’	tʃ $tʃ^h$ tʃ’	ʈʂ $ʈʂ^h$ ʈʂ’
	223. Jebero	19	1	cç		
	224. Qawasqar	16	2	tʃ	tʃ’	
	225. Quechua	31	3	tʃ	$tʃ^h$	tʃ’
	226. Tehuelche	28	6	t͡s t͡s’	tɕ tɕ’	tʃ tʃ’
Chibchan	227. Bribri	18	2	ts	tʃ	
	228. Cuna	16	1	tʃ		
	229. Shiriana	13	1	tʃ		
	230. Tarascan	33	4	ts ts^h	tʃ $tʃ^h$	
Equatorial	231. Ach	11	2	tʃ	dʒ	
	232. Camsá	22	3	ts	tʃ	ʈʂ
	233. Cayuvava	17	2	tʃ	dʒ	
	234. Cofán	30	3	tʃ $tʃ^h$	dʒ	
	235. Guaraní	24	1	tʃ		
	236. Jivaro	15	2	ts	tʃ	
	237. Saliba	22	2	tʃ	dʒ	
	238. Sirionó	16	2	tʃ ^{n}dʒ		
	239. Trumai	18	1	ts		
Macro-Arawakan	240. Amuesha	23	4	ts^h	$tʃ^h$ $tʃ^{jh}$	$ʈʂ^h$
	241. Campa	14	2	ts	tʃ	
	242. Guahibo	17	1	ts		
	243. Guajiro	14	1	tʃ		
	244. Island Carib	16	1	tʃ		
	245. Moxo	21	2	ts	tʃ	

(Macro-Arawakan)	246. Resígaro	30	6	ts tʃ dz dʒ tsʰ tʃʰ
	247. Wapishana	17	1	tʃʰ
	248. Yucuna	16	1	tʃ
Macro-Carib	249. Andoke	11	2	tʃ dʒ
	250. Hixkaryána	18	1	tʃ
	251. Japreria	12	1	tʃ
	252. Muinane	22	2	tʃ dʒ
	253. Ocaina	25	3	ts tʃ dz
	254. Panare	12	2	ts tʃ
	255. Yagua	11	2	ts tʃ
Macro-Ge	256. Apinayé	13	1	tʃ
	257. Borôro	13	2	tʃ dʒ
	258. Iate	18	4	ts cç ʒ ʝ tsʰ
	259. Maxakalí	10	2	tʃ ⁿdʒ
Macro-Panoan	260. Abipon	15	1	tʃ
	261. Amahuaca	14	1	tʃ
	262. Ashuslay	22	4	ts tʃ t̪s̪ t̪ʃ
	263. Tacana	18	2	tʃ ʈʂ
Macro-Tucanoan	264. Cacua	12	1	tʃ
	265. Cubeo	11	1	tʃ
	266. Huari	22	4	ts tʃ dz dʒ
	267. Movima	18	1	tʃ
	268. Siona	18	1	tʃ
	269. Ticuna	18	2	tʃ dʒ
Paezan	270. Cayapa	23	2	ts tʃ
	271. Epena Pedee	17	1	tʃ
	272. Guambiano	18	3	ts tʃ ʈʂ
	273. Itonama	19	2	tʃ tʃʼ
	274. Páez	29	2	ts tʃ

Ural-Altaic

Sub-family	Language	Number of consonants	Number of affricates	Affricates
Ainu	275. Ainu	11	1	tʃ
Finno-Ugric, Finnic	276. Komi	26	4	tʃ cç dʒ ɟʝ
	277. Mari	25	2	ts tʃ
	278. Saami	39	6	ts tʃ dz dʒ tsʲ dzʲ
Finno-Ugric, Ugric	279. Hungarian	26	6	t͡s tʃ cç d͡z dʒ ɟʝ
	280. Khanty	19	1	ʈʂ
Korean	281. Korean	21	3	tʃ tʃʰ t̠ʃ
Mongolian	282. Dagur	22	4	tʃ ʈʂ dʒ ɖʐ
	283. Khalkha	20	4	dz dʒ tsʰ tʃʰ
	284. Moghol	24	2	tʃ dʒ
	285. Monguor	23	3	dz dʒ tʃʰ
Samoyed	286. Nenets	27	2	ts tsʲ
	287. Nganasan	20	1	kx
	288. Selkup	18	1	ʈʂ
Tungus	289. Even	17	2	tʃ dʒ
	290. Manchu	18	2	tʃ dʒ
	291. Nanai	18	2	tʃ dʒ
Turkic	292. Azerbaijani	24	2	tʃ dʒ
	293. Bashkir	27	2	ts tʃ
	294. Chuvash	21	2	ts tʃ
	295. Kirghiz	22	2	ts tʃ
	296. Turkish	25	2	tʃ dʒ
	297. Tuva	20	4	t͡s tʃ d͡z dʒ
	298. Uzbek	23	2	tʃ dʒ
	299. Yakut	22	2	tʃ dʒ
Yukaghir	300. Yukaghir	20	1	tʃ

Others/Ungrouped

Language	Number of consonants	Number of affricates	Affricates		
301. Basque	23	3	ts	tʃ	ʈʂ
302. Burushaski	38	8	ts	tʃ	ʈʂ
				dʒ	ɖʐ
			tsʰ	tʃʰ	ʈʂʰ

Appendix B

The following text and list were read aloud by the PFC participants.

Text

Le Premier Ministre ira-t-il à Beaulieu ?
Le village de Beaulieu est en grand émoi. Le Premier Ministre a en effet décidé de faire étape dans cette commune au cours de sa tournée de la région en fin d'année. Jusqu'ici les seuls titres de gloire de Beaulieu étaient son vin blanc sec, ses chemises en soie, un champion local de course à pied (Louis Garret), quatrième aux jeux olympiques de Berlin en 1936, et plus récemment, son usine de pâtes italiennes. Qu'est-ce qui a donc valu à Beaulieu ce grand honneur ? Le hasard, tout bêtement, car le Premier Ministre, lassé des circuits habituels qui tournaient toujours autour des mêmes villes, veut découvrir ce qu'il appelle "la campagne profonde". Le maire de Beaulieu - Marc Blanc - est en revanche très inquiet. La cote du Premier Ministre ne cesse de baisser depuis les élections. Comment, en plus, éviter les manifestations qui ont eu tendance à se multiplier lors des visites officielles ? La côte escarpée du Mont Saint-Pierre qui mène au village connaît des barrages chaque fois que les opposants de tous les bords manifestent leur colère. D'un autre côté, à chaque voyage du Premier Ministre, le gouvernement prend contact avec la préfecture la plus proche et s'assure que tout est fait pour le protéger. Or, un gros détachement de police, comme on en a vu à Jonquière, et des vérifications d'identité risquent de provoquer une explosion. Un jeune membre de l'opposition aurait déclaré : "Dans le coin, on est jaloux de notre liberté. S'il faut montrer patte blanche pour circuler, nous ne répondons pas de la réaction des gens du pays. Nous avons le soutien du village entier." De plus, quelques articles parus dans La Dépêche du Centre, L'Express, Ouest Liberté et Le Nouvel Observateur indiqueraient que des activistes des communes voisines préparent une journée chaude au Premier Ministre. Quelques fanatiques auraient même entamé un jeûne prolongé dans l'église de Saint Martinville.
Le sympathique maire de Beaulieu ne sait plus à quel saint se vouer. Il a le sentiment de se trouver dans une impasse stupide. Il s'est, en désespoir de cause,

décidé à écrire au Premier Ministre pour vérifier si son village était vraiment une étape nécessaire dans la tournée prévue. Beaulieu préfère être inconnue et tranquille plutôt que de se trouver au centre d'une bataille politique dont, par la télévision, seraient témoins des millions d'électeurs.

Word list

1.	roc	48.	bouleverser
2.	rat	49.	million
3.	jeune	50.	explosion
4.	mal	51.	influence
5.	ras	52.	mâle
6.	fou à lier	53.	ex-mari
7.	des jeunets	54.	pomme
8.	intact	55.	étrier
9.	nous prendrions	56.	chemise
10.	fêtard	57.	brin
11.	nièce	58.	lierre
12.	pâte	59.	blanc
13.	piquet	60.	petit
14.	épée	61.	jeûne
15.	compagnie	62.	rhinocéros
16.	fête	63.	miette
17.	islamique	64.	slip
18.	agneau	65.	compagne
19.	pêcheur	66.	peuple
20.	médecin	67.	rauque
21.	paume	68.	cinquième
22.	infect	69.	nier
23.	dégeler	70.	extraordinaire
24.	bêtement	71.	meurtre
25.	épier	72.	vous prendriez
26.	millionnaire	73.	botté
27.	brun	74.	patte
28.	scier	75.	étriller
29.	fêter	76.	faites
30.	mouette	77.	feutre

31. déjeuner
32. ex-femme
33. liège
34. baignoire
35. pécheur
36. socialisme
37. relier
38. aspect
39. niais
40. épais
41. des genêts
42. blond
43. creux
44. reliure
45. piqué
46. malle
47. gnôle
78. quatrième
79. muette
80. piquais
81. trouer
82. piquer
83. creuse
84. beauté
85. patte
86. pâte
87. épais
88. épée
89. jeune
90. jeûne
91. beauté
92. botté
93. brun
94. brin

Appendix C

The following tables list the participants in the PFC corpora. The identification number of the speaker should be read as follows:

69aer1

69	number of the *département*
a	distinguishes between multiple surveys recorded in the same department (b, c, ...)
er	initials of the speaker
1	distinguishes between speakers with identical initials (2, 3, ...)

Aveyronnais à Paris (12 participants)[192]

	Speaker's ID	Age[193]	Gender	Profession
1.	75xab1	24	M	controller
2.	75xad1	75	F	seamstress, retired
3.	75xba1	65	M	sales representative, retired
4.	75xcm1	23	F	engineer
5.	75xdl1	79	F	housewife
6.	75xep1	22	F	student
7.	75xjo1	23	F	student
8.	75xlv	51	F	office employee, disabled
9.	75xmb1	41	M	restaurant employee
10.	75xmm1	21	F	student
11.	75xpd1	23	M	student
12.	75xrg1	77	M	baker/office employee, retired

[192] For the Aveyronnais à Paris corpus, 18 speakers were recorded, but for 6 of them no data are available.

[193] Age at the time of recording.

Brunoy (10 participants)

	Speaker's ID	Age	Gender	Profession
13.	91aal1	27	F	teacher
14.	91aal2	73	M	company director, retired
15.	91acs1	22	M	mechanic
16.	91acs2	49	F	public servant
17.	91adb1	54	M	researcher
18.	91aed1	60	F	teacher
19.	91ael1	73	F	bank employee, retired
20.	91ajc1	63	M	executive, retired
21.	91amb1	62	M	mechanic, retired
22.	91asl1	64	F	accountant, retired

Lyon (8 participants)[194]

	Speaker's ID	Age	Gender	Profession
23.	69aag1	51	M	teacher
24.	69acg1	25	F	student
25.	69ajd1	46	F	secretary, unemployed
26.	69ajl1	52	M	head human resources
27.	69akb1	29	F	educator
28.	69all1	74	M	instructor, retired
29.	69asg1	25	M	conscientious objector
30.	69asp1	31	M	house painter/carpenter

Marseille centre ville (10 participants)

	Speaker's ID	Age	Gender	Profession
31.	13aac1	76	F	teacher, retired
32.	13aag1	48	F	speech therapist
33.	13aas1	73	M	technical manager, retired

[194] Two recordings (i.e. 69aep1, 69aer1) were discarded, either because the recording was incomplete or because the recording suffered from substantial background noise. A third recording, i.e. 69amg1, was not included either, because the participant was laughing and tryied to imitate particular accents.

34.	13adg1	49	M	paediatrician
35.	13ads1	74	F	public servant, retired
36.	13aid1	45	F	financial adviser
37.	13alg1	20	F	student
38.	13amb1	18	F	student
39.	13aog1	23	M	student
40.	13apd1	54	M	executive at a bank

Nantes (10 participants)[195]

	Speaker's ID	Age	Gender	Profession
41.	44aar1	82	M	gardener, retired
42.	44aar2	43	F	executive
43.	44ajn1	57	M	veterinarian
44.	44ajs1	79	M	executive, retired
45.	44amr1	81	F	housewife/secretary, retired
46.	44ams1	22	F	student
47.	44ams2	55	F	teacher, retired
48.	44ars1	23	M	student
49.	44asc1	80	F	pharmacist
50.	44asr1	29	F	student

Ogéviller (10 participants)[196]

	Speaker's ID	Age	Gender	Profession
51.	54bcg1	29	F	housewife
52.	54bfl1	31	M	worker
53.	54bgc1	79	F	farmer, retired
54.	54bgh1	72	F	housewife

[195] Eleven speakers were recorded, but only ten recordings are actually available.

[196] For the Ogéviller corpus, 12 speakers were recorded, but we took into account only 10 them. For speaker 54bdc1, no data were available, and the other speaker, 54bmd1 (age: 10), was still acquiring the French writing system, which therefore hampered her reading. As stated on the PFC website, the data of this latter speaker should therefore be treated with great caution. In order to avoid any troubling influence of this speaker on the results, we decided not to take into consideration her data at all.

55.	54bjc1	51	M	executive
56.	54bjl1	54	F	assistant accountant
57.	54bkl1	23	F	technician
58.	54bmc1	58	F	clerical staff, unemployed
59.	54bpm1	81	M	basket maker, retired
60.	54brm1	93	M	professional soldier, retired

Paris centre (12 participants)[197]

	Speaker's ID	Age	Gender	Profession
61.	75cab1	69	F	unknown
62.	75cac1	41	M	unknown
63.	75ccb2	25	M	unknown
64.	75ccm1	33	M	unknown
65.	75ccr1	34	F	unknown
66.	75ccr2	56	F	unknown
67.	75cgn1	86	M	chemical laboratory manager, retired
68.	75clb1	47	F	unknown
69.	75clc1	23	M	unknown
70.	75clh1	64	M	unknown
71.	75csb1	25	F	unknown
72.	75cvl1	25	F	unknown

[197] 14 Parisian speakers participated, but the recordings of two of them were not available. Moreover, for most of the subjects in the Paris Centre corpus, their age at the time of recording was not listed in the PFC meta-data. Given that the Parisian survey was conducted in 2004, we estimated the age of the speakers involved on the basis of their year of birth, assuming that the recordings took place after their birthday.

Puteaux-Courbevoie (5 participants)[198]

	Speaker's ID	Age	Gender	Profession
73.	92aaf1	55	M	consultant
74.	92aaf2	55	F	teacher, unemployed
75.	92aaf3	27	F	architect
76.	92acd1	25	M	teacher
77.	92app1	25	F	teacher

Rodez (7 participants)[199]

	Speaker's ID	Age	Gender	Profession
78.	12acr1	26	F	warehousewoman/stock keeper
79.	12afl1	28	M	warehouseman/salesman
80.	12aja1	64	F	trader, retired
81.	12ajp1	74	M	cabinet maker, retired
82.	12als1	28	F	saleswoman
83.	12aps1	26	M	assistant educator
84.	12atp1	69	F	medical receptionist, retired

[198] The sixth speaker recorded in this survey was discarded because the recordings were clipped.

[199] Speakers 12ags1 and 12ams1 were discarded because their recordings were not, or only partially available.

Appendix D

Vowel Space

The following overview lists the average F2 values of the front [i] and back [u] tokens (measured at 50% of the vowel) in the word list (see section 7.5.2). On the basis of these upper and lower bounds of the horizontal dimension of the vowel space, a F2 mid value was derived, which approximates the mid of the vowel space of every individual speaker. In order to better illustrate the patterns described in section 7.5.1, the F2 in *patte* and *pâte* (both in random and minimal context) are positioned with respect to these front, back and central reference points.[200]

Total	Front	Central	Back
patte (R):	1	65	17
pâte (R):	1	52	30
patte (M):	0	70	14
pâte (M):	0	45	39

Aveyronnais à Paris

75xab1			**75xad1**		
[i]: 1954	Mid: 1560	[u]: 1165	[i]: 2414	Mid: 1689	[u]: 963
patte (R): 1363	Central		patte (R): 1685	Central	
pâte (R): 1456	Central		pâte (R): 1597	Central	
patte (M): 1444	Central		patte (M): 1517	Central	
pâte (M): 1419	Central		pâte (M): 1539	Central	

[200] These reference points are purely arithmetic values: experimental evidence is required to determine how these values relate to the non-linear perceptual domain.

75xba1			**75xcm1**		
[i]: 2019	Mid: 1394	[u]: 769	[i]: 2288	Mid: 1642	[u]: 996
patte (R): 1356	Central		patte (R): 1411	Central	
pâte (R): 1402	Central		pâte (R): 1371	Central	
patte (M): 1377	Central		patte (M): 1787	Central	
pâte (M): 1314	Central		pâte (M): 1640	Central	

75xdl1			**75xep1**		
[i]: 2417	Mid: 1710	[u]: 1002	[i]: 2335	Mid: 1735	[u]: 1134
patte (R): 1232	Back		patte (R): 1351	Back	
pâte (R): 1328	Back		pâte (R): 1439	Central	
patte (M): 1212	Back		patte (M): 1407	Back	
pâte (M): 1198	Back		pâte (M): 1366	Back	

75xjo1			**75xlv1**		
[i]: 2199	Mid: 1609	[u]: 1018	[i]: 2443	Mid: 1713	[u]: 983
patte (R): 1456	Central		patte (R):1 563	Central	
pâte (R): 1450	Central		pâte (R): 1540	Central	
patte (M): 1236	Back		patte (M): 1630	Central	
pâte (M): 1293	Back		pâte (M): 1593	Central	

75xmb1			**75xmm1**		
[i]: 1832	Mid: 1450	[u]: 1067	[i]: 2409	Mid: 1666	[u]: 923
patte (R): 1291	Central		patte (R): 1564	Central	
pâte (R): 1375	Central		pâte (R): 1600	Central	
patte (M): 1343	Central		patte (M): 1733	Central	
pâte (M): 1294	Central		pâte (M): 1710	Central	

75xpd1			**75xrg1**		
[i]: 2057	Mid: 1433	[u]: 808	[i]: 2431	Mid: 1623	[u]: 814
patte (R): 1366	Central		patte (R): 1277	Central	
pâte (R): 1380	Central		pâte (R): 1295	Central	
patte (M): 1452	Central		patte (M): 1287	Central	
pâte (M): 1336	Central		pâte (M): 1198	Back	

Brunoy

91aal1			**91aal2**		
[i]: 2589	Mid: 1712	[u]: 835	[i]: 2398	Mid: 1668	[u]: 938
patte (R): 1837	Central		patte (R): 1245	Back	
pâte (R): 1829	Central		pâte (R): 1135	Back	
patte (M): 1725	Central		patte (M): 682	Back	
pâte (M): 1898	Central		pâte (M): 854	Back	

91acs1			**91acs2**		
[i]: 1914	Mid: 1590	[u]: 1265	[i]: 2495	Mid: 1699	[u]: 903
patte (R): 1309	Back		patte (R): 1676	Central	
pâte (R): 1293	Back		pâte (R): 1598	Central	
patte (M): 1330	Back		patte (M): 1490	Central	
pâte (M): 1358	Back		pâte (M): 1298	Back	

91adb1			**91aed1**		
[i]: 2385	Mid: 1686	[u]: 987	[i]: 2524	Mid: 1836	[u]: 1147
patte (R): 1102	Back		patte (R): 1617	Central	
pâte (R): 1160	Back		pâte (R): 1424	Back	
patte (M): 1138	Back		patte (M): 1708	Central	
pâte (M): 1389	Central		pâte (M): 1254	Back	

91ael1			**91ajc1**		
[i]: 2572	Mid: 1771	[u]: 969	[i]: 2320	Mid: 1482	[u]: 643
patte (R): 1928	Central		patte (R): 1367	Central	
pâte (R): 1558	Central		pâte (R): 1460	Central	
patte (M): 1722	Central		patte (M): 1169	Central	
pâte (M): 1628	Central		pâte (M): 1200	Central	

91amb1			**91asl1**		
[i]: 2095	Mid: 1404	[u]: 713	[i]: 2202	Mid: 1570	[u]: 938
patte (R): 1069	Central		patte (R): 1631	Central	
pâte (R): 1044	Back		pâte (R): 1175	Back	
patte (M): 1449	Central		patte (M): 1646	Central	
pâte (M): 832	Back		pâte (M): 1362	Central	

Lyon

69aag1			**69acg1**		
[i]: 2145	Mid: 1479	[u]: 812	[i]: 2309	Mid: 1672	[u]: 1034
patte (R): 1437	Central		patte (R): 1412	Central	
pâte (R): 1289	Central		pâte (R): 1189	Back	
patte (M): 1424	Central		patte (M): 1149	Back	
pâte (M): 1307	Central		pâte (M): 1294	Back	

69ajd1			**69ajl1**		
[i]: 2370	Mid: 1689	[u]: 1008	[i]: 2017	Mid: 1447	[u]: 876
patte (R): -			patte (R): 1513	Central	
pâte (R): -			pâte (R): 1263	Central	
patte (M): 1600	Central		patte (M): 1225	Central	
pâte (M): 1242	Back		pâte (M): 1151	Back	

69akb1			**69all1**		
[i]: 2310	Mid: 1717	[u]: 1124	[i]: 2021	Mid: 1489	[u]: 957
patte (R): 1848	Central		patte (R): 1546	Central	
pâte (R): 1632	Central		pâte (R): 1500	Central	
patte (M): 1734	Central		patte (M): 1547	Central	
pâte (M): 1600	Central		pâte (M): 1333	Central	

69asg1			**69asp1**		
[i]: 2006	Mid: 1443	[u]: 879	[i]: 1919	Mid: 1479	[u]: 1038
patte (R): 1477	Central		patte (R): 1962	Front	
pâte (R): 1498	Central		pâte (R): 1861	Front	
patte (M): 1494	Central		patte (M): 1686	Central	
pâte (M): 1344	Central		pâte (M): 1674	Central	

Marseille centre ville

13aac1			**13aag1**		
[i]: 2491	Mid: 1734	[u]: 977	[i]: 2574	Mid: 1801	[u]: 1028
patte (R): 1365	Central		patte (R): 1376	Back	
pâte (R): 1468	Central		pâte (R): 1333	Back	
patte (M): 1388	Central		patte (M): 1468	Central	
pâte (M): 1238	Back		pâte (M): 1469	Central	

13aas1			**13adg1**		
[i]: 2324	Mid: 1638	[u]: 951	[i]: 2053	Mid: 1480	[u]: 906
patte (R): 1310	Central		patte (R): 1271	Central	
pâte (R): 1229	Back		pâte (R): 1317	Central	
patte (M): 1201	Back		patte (M): 1378	Central	
pâte (M): 1082	Back		pâte (M): 1004	Back	

13ads1			**13aid1**		
[i]: 2466	Mid: 1741	[u]: 1015	[i]: 2335	Mid: 1617	[u]: 899
patte (R): 1855	Central		patte (R): 1491	Central	
pâte (R): 1725	Central		pâte (R): 1486	Central	
patte (M): 1579	Central		patte (M): 1528	Central	
pâte (M): 1460	Central		pâte (M): 1546	Central	

13alg1			**13amb1**		
[i]: 2359	Mid: 1629	[u]: 898	[i]: 2254	Mid: 1653	[u]: 1051
patte (R): 1599	Central		patte (R): 1529	Central	
pâte (R): 1597	Central		pâte (R): 1510	Central	
patte (M): 1583	Central		patte (M): 1474	Central	
pâte (M): 1596	Central		pâte (M): 1488	Central	

13aog1			**13apd1**		
[i]: 1908	Mid: 1400	[u]: 891	[i]: 2109	Mid: 1499	[u]: 889
patte (R): 1419	Central		patte (R): 1281	Central	
pâte (R): 1464	Central		pâte (R): 1240	Central	
patte (M): 1491	Central		patte (M): 1256	Central	
pâte (M): 1446	Central		pâte (M): 1266	Central	

Nantes

44aar1			**44aar2**		
[i]: 2324	Mid: 1597	[u]: 870	[i]: 2511	Mid: 1713	[u]: 915
patte (R): 1450	Central		patte (R): 1520	Central	
pâte (R): 1101	Back		pâte (R): 1357	Central	
patte (M): 1465	Central		patte (M): 1490	Central	
pâte (M): 1086	Back		pâte (M): 1209	Back	

44ajn1			**44ajs1**		
[i]: 2465	Mid: 1705	[u]: 945	[i]: 2257	Mid: 1497	[u]: 736
patte (R): 1359	Central		patte (R): 1273	Central	
pâte (R): 1131	Back		pâte (R): 966	Back	
patte (M): 1498	Central		patte (M): 1423	Central	
pâte (M): 1127	Back		pâte (M): 839	Back	

44amr1			**44ams1**		
[i]: 2553	Mid: 1798	[u]: 1042	[i]: 2509	Mid: 1753	[u]: 997
patte (R): 1554	Central		patte (R): 1333	Back	
pâte (R): 1204	Back		pâte (R): 1179	Back	
patte (M): 1429	Central		patte (M): 1609	Central	
pâte (M): 1144	Back		pâte (M): 1552	Central	

44ams2			**44ars1**		
[i]: 2596	Mid: 1722	[u]: 847	[i]: 2261	Mid: 1579	[u]: 897
patte (R): 1755	Central		patte (R): 1579	Central	
pâte (R): 1646	Central		pâte (R): 1581	Central	
patte (M): 1571	Central		patte (M): 1539	Central	
pâte (M): 1308	Central		pâte (M): 1594	Central	

44asc1			**44asr1**		
[i]: 2537	Mid: 1626	[u]: 714	[i]: 2558	Mid: 1775	[u]: 992
patte (R): 1658	Central		patte (R): 2071	Central	
pâte (R): 1415	Central		pâte (R): 1997	Central	
patte (M): 1518	Central		patte (M): 1771	Central	
pâte (M): 1251	Central		pâte (M): 1957	Central	

Ogéviller

54bcg1			**54bfl1**		
[i]: 2340	Mid: 1717	[u]: 1094	[i]: 2034	Mid: 1446	[u]: 857
patte (R): 1575	Central		patte (R): 1057	Back	
pâte (R): 1439	Central		pâte (R): 1209	Central	
patte (M): 1659	Central		patte (M): 1025	Back	
pâte (M): 1550	Central		pâte (M): 994	Back	

54bgc1			**54bgh1**		
[i]: 2437	Mid: 1656	[u]: 875	[i]: 2530	Mid: 1754	[u]: 978
patte (R): 1267	Central		patte (R): 1582	Central	
pâte (R): 1257	Back		pâte (R): 1376	Central	
patte (M): 1363	Central		patte (M): 1593	Central	
pâte (M): 1228	Back		pâte (M): 1389	Central	

54bjc1			**54bjl1**		
[i]: 1806	Mid: 1225	[u]: 644	[i]: 2239	Mid: 1519	[u]: 798
patte (R): 1277	Central		patte (R): 1233	Central	
pâte (R): 1218	Central		pâte (R): 1330	Central	
patte (M): 1433	Central		patte (M): 1278	Central	
pâte (M): 1220	Central		pâte (M): 1186	Central	

54bkl1			**54bmc1**		
[i]: 2255	Mid: 1618	[u]: 981	[i]: 2319	Mid: 1575	[u]: 830
patte (R): 1426	Central		patte (R): 1813	Central	
pâte (R): 1075	Back		pâte (R): 1391	Central	
patte (M): 1696	Central		patte (M): 1241	Central	
pâte (M): 1234	Back		pâte (M): 943	Back	

54bpm1			**54brm1**		
[i]: 2344	Mid: 1578	[u]: 811	[i]: 2157	Mid: 1530	[u]: 903
patte (R): 1426	Central		patte (R): 1273	Central	
pâte (R): 1170	Back		pâte (R): 1120	Back	
patte (M): 1586	Central		patte (M): 1256	Central	
pâte (M): 1096	Back		pâte (M): 1029	Back	

Paris centre

75cab1			**75cac1**		
[i]: 2140	Mid: 1591	[u]: 1042	[i]: 2436	Mid: 1834	[u]: 1232
patte (R): 1424	Central		patte (R): 1284	Back	
pâte (R): 1400	Central		pâte (R): 1289	Back	
patte (M): 1174	Back		patte (M): 1268	Back	
pâte (M): 928	Back		pâte (M): 1272	Back	

75ccb2			**75ccm1**		
[i]: 2135	Mid: 1704	[u]: 1273	[i]: 2030	Mid: 1506	[u]: 982
patte (R): 1482	Back		patte (R): 1359	Central	
pâte (R): 1588	Central		pâte (R): 1167	Back	
patte (M): 1574	Central		patte (M): 1289	Central	
pâte (M): 1548	Central		pâte (M): 1239	Back	

75ccr1			**75ccr2**		
[i]: 2734	Mid: 1805	[u]: 875	[i]: 2688	Mid: 1979	[u]: 1269
patte (R): 1517	Central		patte (R): 1515	Back	
pâte (R): 1479	Central		pâte (R): 1400	Back	
patte (M): 1565	Central		patte (M): 1625	Central	
pâte (M): 1328	Back		pâte (M): 1496	Back	

75cgn1			**75c1b1**		
[i]: 2157	Mid: 1538	[u]: 919	[i]: 2377	Mid: 1816	[u]: 1255
patte (R): 1583	Central		patte (R): 1179	Back	
pâte (R): 1254	Central		pâte (R): 1123	Back	
patte (M): 1703	Central		patte (M): 1398	Back	
pâte (M): 1238	Central		pâte (M): 1185	Back	

75c1c1			**75c1h1**		
[i]: 2075	Mid: 1483	[u]: 891	[i]: 2012	Mid: 1633	[u]: 1254
patte (R): 1369	Central		patte (R): 1338	Back	
pâte (R): 1389	Central		pâte (R): 1236	Back	
patte (M): 1456	Central		patte (M): 1449	Central	
pâte (M): 1169	Back		pâte (M): 1178	Back	

75csb1			**75cvl1**		
[i]: 2441	Mid: 1873	[u]: 1304	[i]: 2397	Mid: 1837	[u]: 1277
patte (R): 1416	Back		patte (R): 1711	Central	
pâte (R): 1185	Back		pâte (R): 1643	Central	
patte (M): 1504	Back		patte (M): 1750	Central	
pâte (M): 1453	Back		pâte (M): 1713	Central	

Puteaux-Courbevoie

92aaf1			**92aaf2**		
[i]: 2035	Mid: 1613	[u]: 1190	[i]: 2567	Mid: 1715	[u]: 862
patte (R): 1450	Central		patte (R): 1664	Central	
pâte (R): 1343	Back		pâte (R): 1285	Back	
patte (M): 1455	Central		patte (M): 1612	Central	
pâte (M): 1002	Back		pâte (M): 1411	Central	

92aaf3			**92acd1**		
[i]: 2412	Mid: 1736	[u]: 1060	[i]: 1943	Mid: 1462	[u]: 980
patte (R): 1543	Central		patte (R): 1552	Central	
pâte (R): 1617	Central		pâte (R): 1298	Central	
patte (M): 1652	Central		patte (M): 1227	Central	
pâte (M): 1287	Back		pâte (M): 1180	Back	

92app1		
[i]: 2470	Mid: 1847	[u]: 1223
patte (R): 1571	Central	
pâte (R): 1613	Central	
patte (M): 1765	Central	
pâte (M): 1631	Central	

Rodez

12acr1			**12afl1**		
[i]: 2432	Mid: 1655	[u]: 877	[i]: 2228	Mid: 1525	[u]: 822
patte (R): 943	Back		patte (R): 1021	Back	
pâte (R): 1065	Back		pâte (R): 1037	Back	
patte (M): 1362	Central		patte (M): 1065	Back	
pâte (M): 1273	Central		pâte (M): 1104	Back	

12aja1			**12ajp1**		
[i]: 2342	Mid: 1587	[u]: 831	[i]: 2192	Mid: 1507	[u]: 821
patte (R): 1443	Central		patte (R): 1163	Back	
pâte (R): 1459	Central		pâte (R): 1162	Back	
patte (M): 1493	Central		patte (M): 1230	Central	
pâte (M): 1392	Central		pâte (M): 1181	Central	

12als1			**12aps1**		
[i]: 2388	Mid: 1580	[u]: 772	[i]: 2051	Mid: 1410	[u]: 768
patte (R): 1207	Central		patte (R): 1362	Central	
pâte (R): 1592	Central		pâte (R): 1220	Central	
patte (M): 1320	Central		patte (M): 1303	Central	
pâte (M): 1307	Central		pâte (M): 1316	Central	

12atp1		
[i]: 2519	Mid: 1660	[u]: 801
patte (R): 1513	Central	
pâte (R): 1547	Central	
patte (M): 1564	Central	
pâte (M): 1476	Central	

Appendix Ɛ

This appendix gives an overview of the tokens containing the Plosive + Vowel contexts (in the word list and text) examined in chapters 7 and 8.

Word list (MG)

Labials

Voiceless		**Voiced**	
[i]/[j]	piquet épier piqué piquais piquer	[i]/[j]	-
[y]	-	[y]	-
[e/ɛ]	épée (2x) pêcheur pécheur aspect épais (2x)	[e/ɛ]	bêtement baignoire
[ø/œ]	peuple	[ø/œ]	-
[a/ɑ]	pâte (2x) compagnie compagne patte (2x)	[a/ɑ]	-
[u]	-	[u]	bouleverser
[o/ɔ]	paume pomme	[o/ɔ]	botté (2x) beauté (2x)

Coronals

Voiceless		**Voiced**	
[i/j]	petit	[i/j]	extraordinaire
[y]	-	[y]	-
[e/ɛ]	fêter botté (2x) beauté (2x)	[e/ɛ]	des (2x) dégeler déjeuner
[ø/œ]	-	[ø/œ]	-
[a/ɑ]	intact fetârd	[a/ɑ]	-
[u]	-	[u]	-
[o/ɔ]	-	[o/ɔ]	-

Velars

Voiceless		**Voiced**	
[i/j]	cinquième	[i/j]	-
[y]	-	[y]	-
[e/ɛ]	piquet piqué piquais piquer	[e/ɛ]	-
[ø/œ]	-	[ø/œ]	-
[a/ɑ]	quatrième +17 digits	[a/ɑ]	-
[u]	-	[u]	-
[o/ɔ]	-	[o/ɔ]	-

Text (TG)

Labials

Voiceless		**Voiced**	
[i/j]	champion pied olympiques Pierre stupide	[i/j]	habituels
[y]	-	[y]	-

[e/ɛ]	appelle escarpée pays Dépêche	[e/ɛ]	Berlin bêtement liberté (2x) baisser
[ø/œ]	-	[ø/œ]	-
[a/ɑ]	pâtes campagne patte pas parus préparent sympathique impasse par	[a/ɑ]	barrages bataille
[u]	pour (3x)	[u]	-
[o/ɔ]	opposants police opposition politique	[o/ɔ]	Beaulieu (7x) bords

Coronals

Voiceless		**Voiced**	
[i]	ira-t-il titres multiplier d'identité soutien entier articles activistes fanatiques sympathique sentiment politique	[i]	d'identité indiqueraient

[y]	habituels préfecture stupide *Liaison/enchaînement:* qui ont_eu préparent_une vraiment_une	[y]	du (7x)
[e/ɛ]	étaient éviter côté protéger identité liberté (2x) était télévision témoins *Liaison/enchaînement:* grand_émoi côte_escarpée tout_est fait	[e/ɛ]	décidé (2x) des (8x) détachement déclaré désespoir d'électeurs dépêche *Liaison/enchaînement:* grand_emoi
[ø/œ]	Observateur électeurs	[ø/œ]	-
[a/ɑ]	étape (2x) Italiennes manifestations contact détachement entamé bataille *Liaison/enchaînement:* contact_avec	[a/ɑ]	d'année

[u]	tournée (2x) tout (2x) tournaient toujours autour tous	[u]	-
[o/ɔ]	plutôt *Liaison/enchaînement:* grand_honneur	[o/ɔ]	 *Liaison/enchaînement:* grand_honneur

Velars

Voiceless		**Voiced**	
[i]	jusqu'ici qu'est-ce qui a qui (3x) ce qu'il inquiet Jonquière tranquille	[i]	-
[y]	circuler	[y]	-
[e/ɛ]	qu'est-ce qui a provoquer quelques (2x) quel *Liaison/enchaînement:* Blanc_est	[e/ɛ]	-
[ø/œ]	-	[ø/œ]	-
[a/ɑ]	local quatrième car escarpée vérifications	[a/ɑ]	Garret

[u]	cours course découvrir	[u]	gouvernement
[o/ɔ]	commune cote comment côte connaît colère côté comme communes cause inconnue	[o/ɔ]	-

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Summary

What is an affricate?

Consonants are commonly subdivided into several categories, depending on their degree of oral occlusion. Consonants belonging to the category of "sonorants" are characterized by a constriction in the oral cavity that is sufficiently wide to allow the airstream to pass through without yielding friction. In this category, we find the nasals ([m, n]), the liquids ([l, r]) and the glides ([j, w]). The category of "obstruents", which are characterized by a substantial closure or constriction in the oral cavity, groups the plosives, the fricatives and the affricates.

Affricates are combinations of plosives and fricatives. We find them for instance at the beginning of the English word ***ch****ip* or the German word ***Pf****erd*. The articulation of an affricate starts, like the articulation of a normal plosive like [p] or [t], with a full closure in the oral cavity. This causes an increase of air pressure in the oral cavity. In the case of non-affricated plosives, this full closure is abruptly released, causing a brief explosion. In the case of an affricate, however, the full closure is not entirely removed, but changes into a narrow constriction (as we find in the case of fricatives like [f] or [s]), which causes friction when the obstructed air is released.

The problem

The articulatory characteristics of affricates can be described in a very straightforward way, but their phonological representation has always been, and still is, highly debated. How do these sounds behave in the world's languages, and what does their mental image look like in the brain of a speaker? Are they plosives with a special characteristic that distinguishes them from plain plosives? Or are they properly balanced plosive-fricative combinations? Or are they of no phonological relevance at all, and is there no need to assume a principled difference between affricated and non-affricated stops?

Chapter 2 presents a chronological overview of the different formal analyses that have been put forward in the history of phonological theory since the 1950's, when the first coherent sets of distinctive features were introduced. The overview shows that the absence of agreement on the phonological representation of affricates is mainly due to the fact that the existing studies are

mostly language-specific. Moreover, the small number of cross-linguistic studies arrived at conflicting conclusions. An answer to the question what an affricate looks like phonologically speaking can therefore only be given by testing the existing claims against a representative sample of the world's languages.

Affricates in the world's languages

Chapters 3 and 4 examine the patterns of affricates in the languages included in UPSID 1992, a genetically-based database of 451 languages. When we consider the position of affricates in direct relation to the position of plosives and fricatives, respectively, interesting aspects emerge. Affricates may show patterns that correspond to those of plosives, yet other times they resemble the fricative patterns more closely, but crucially, they may also show patterns that crucially deviate from both plosives and fricatives.

In the debate on the phonological representation of affricates, several typological characteristics have been used in favour of, or against, a specific formalization. The fact that affricates often occur at the same place(s) of articulation as fricatives, for instance, has been used in favour of a view of affricates as balanced plosive-fricative combinations. The UPSID sample, however, shows that the typology-based claims should be attenuated. That is, the typological patterns can only be fully understood by clearly separating phonetics from phonology. Because affricates are combinations of plosives and fricatives phonetically speaking, it is expected that they will show patterns that (partially) resemble the patterns of normal plosives and (partially) those of fricatives, but precisely because of their binary character – which clearly differentiates them from the other obstruents –, it is expected that the patterns of affricates may also substantially deviate from those of plain plosives and fricatives. Producing a voiced affricate for instance is even more difficult than producing a voiced plosive or fricative, which corresponds to the typological patterns where voiced affricates occur substantially less frequently than the other two types of obstruents.

It is only when affricates become phonologized (i.e. become distinctive) in a language, that phonological aspects come into play (like symmetry in a sound inventory for instance). It ultimately depends on the language in question what affricates look like exactly, but the UPSID patterns show that affricates do not ask for a specific, universal representation. If we adopt the most radical view on affricates, i.e. that they are as such meaningless phonologically speaking and can essentially be reduced to plosives, all UPSID patterns can be captured. Affricates

behave differently from, or pattern with, the other obstruents on the basis of independently motivated features like place or manner of articulation, not because they bear a phonological label "affricate".

Affricates in the history of French

Chapters 3 and 4 study the position of affricates in synchronic sound inventories, and as such, they do not tell us anything about the behaviour of these sounds in phonological processes: do they behave like normal plosives, like fricatives, or do they (sometimes) behave like a separate group? Because of practical limitations, it is not possible to investigate the process-related side of affricates in the 302 UPSID languages in which these sounds occur, and therefore the phonological behaviour of affricates in the historical phonology of French is studied. This language plays an important role in the debate, as affricates emerge, among others, in a typologically uncommon context: before the low vowel *a*.

Chapter 5 describes the development and loss of affricates in the history of French. The affricates that emerge seem to have primarily a phonetic basis: specific sounds come to resemble affricates (acoustically and perceptually) in a specific context (for instance, a velar plosive [k] followed by a high front vowel [i] which comes to be perceived as [tʃi]). If a sound change is indeed brought about, the representation of the original sequence becomes adapted.

Like the static typological investigation, historical French neither asks for a representation of affricates as well-balanced plosive-fricative combinations, and it appears that such a representation even leads to predictions that are not borne out. If it is assumed that affricates are basically plosives, and that in French they may, in specific cases, behave differently from the non-affricates because of a manner-feature [strident] (reflecting the sibilant release), the behaviour of affricates in this language can be adequately described.

Plosive bursts in modern French: place and manner

The French language is not only interesting because of its historical phonology. Also modern French can tell us a lot about the ways affricates may emerge in a language. Chapters 6, 7 and 8 present an analysis of a corpus of spoken French, recorded in different regions in France. Modern French has six plosives, produced at three different places of articulation (bilabial, dental, velar), each with a symmetrical voicing contrast.

French plosives are known for their tendency towards fronting when followed by a front vowel. Although this is a commonly noted property of contemporary French, its precise characteristics remain unclear, mainly because the existing descriptions are not backed up by representative data. Chapter 7 presents an analysis of the place of articulation of velar plosives in nine subcorpora of the PFC database. The place of articulation of velar plosives indeed turns out to be strongly dependent on the following vowel. The more anterior the vowel, the more the velar is moved forward. This also holds for the low vowel *a*, which quite often takes a rather anterior realization; it could be the case that the parallel, mysterious, historical shift was also triggered in this way. Next to the quality of the following vowel as such, there are also sociolinguistic factors that play a role in the degree of fronting: the female speakers and the oldest generation are generally more stable, and they less easily produce an anteriorisation of the velar.

Except for the fact that velar plosives tend to produce a shift in place of articulation depending on the quality of the following vowel, the French plosives are generally characterized as neat, but tightly articulated sounds. Yet, also with respect to this observation, representative data are lacking. Chapter 8 focuses on the quality of the release burst of the French plosives. These release bursts turn out to be highly variable, and a considerable amount of variation can be found between speakers as well as in the realizations of a single speaker. As a matter of fact, a French plosive is often indeed realized very neatly, without entailing an additional portion of noise, yet in other cases, interesting releases arise. These latter cases involve for instance plosives with a very tense off-shoot in the oral cavity, but also instances of aspiration or affrication. Especially the latter two realizations are very fascinating because they are typically not considered characteristics of standard French. The place of articulation of the plosive, combined with the articulatory strength and the tightness of the constriction in the oral cavity, may colour the release of the plosive in a specific way. Because it is impossible for a speaker to put his speech organs in the exact same position every time he comes to pronounce a specific sequence, variation arises. Moreover, for some speakers, the articulatory muscles are generally more tensely configured than for others: such speakers produce noisy cues more often, in a more systematic way, and it can therefore be seen as a characteristic of their personal way of speaking, or idiolect.

Conclusion: Phonetics vs. phonology

When combining the evidence obtained in the different chapters, it can be concluded that there is in fact no need for a separate phonological class of affricates. Our findings are thus in line with the most radical view on these sounds, which was introduced mainly by Darlène LaCharité, Nick Clements and Wolfgang Kehrein. We have argued that affricates can only be properly understood if a clear distinction is made between the aspects that belong to phonetics, to phonology or to the phonetics-phonology interface. The phonetic plosive-fricative combination within a single sound causes particular typological patterns to emerge, which partially correspond to the plosive patterns, partially to the fricative patterns, but which also partially deviate from the other obstruents. A specific phonological representation cannot account for all these patterns. And it does not need to: it is the phonological representation that ultimately explains why affricates behave like they do with respect to phonological processes. In turn, the investigation of diachronic and synchronic French clearly shows which mechanisms may be involved in the creation of an affricate. When the affricates become phonemes in a language, they are assigned a specific representation, that ultimately depends on the contrastive parameters exploited by the language in question. Phonologically speaking, affricates are plosives, and they may behave differently from "normal" plosives because of manner or place characteristics; affricates do not essentially differ from other obstruents because they are "affricates".

Affricates have caused friction between phonetics and phonology for a long time, we hope that this thesis has shown that this friction has in fact no reason for existence.

Samenvatting
(Summary in Dutch)

Wat is een affricaat?

Medeklinkers kunnen in verschillende subgroepen worden ingedeeld naar gelang de mate van afsluiting van de mondholte die met hun realisatie gepaard gaat. Aan de ene kant zijn er de *sonoranten* waarbij de lucht vrijelijk uit de mond kan ontsnappen zonder dat er frictie wordt geproduceerd. Tot deze groep behoren de nasalen ([m, n]), de liquida ([l, r]) en de half-medeklinkers ([j, w]). Aan de andere kant zijn er de *obstruenten*, waarbij er een substantiële afsluiting van de mondholte optreedt; tot deze groep behoren de plosieven (plofklanken), de fricatieven (wrijfklanken) en de affricaten.

Affricaten zijn combinaties van plosieven en fricatieven. We vinden ze bijvoorbeeld aan het begin van het Engelse woord ***ch****ip* of het Duitse woord ***Pf****erd*. De articulatie van een affricaat begint, net als die van een normale plosief zoals [t] of [p], door ergens in de mondholte een volledige afsluiting te creëren. De luchtdruk in de mondholte neemt hierdoor toe. Een plosief (of plofklank) dankt zijn naam dan ook aan de explosie die zich voordoet wanneer de afsluiting in de mondholte abrupt wegvalt. In het geval van een affricaat valt de blokkade echter niet zomaar weg: de volledige afsluiting wordt omgezet in een smalle vernauwing (zoals we die ook vinden bij de productie van een fricatief zoals [s] of [f]), waardoor er frictie ontstaat wanneer de lucht uit de mondholte ontsnapt.

Wat is het probleem?

Fonetisch gezien, dat wil zeggen wat hun concrete realisatie betreft, zijn de kenmerken van affricaten volledig duidelijk. Hun fonologische kant, met andere woorden de manier waarop talen met deze klanken omgaan en de abstracte representatie die sprekers van deze complexe klanken in hun hoofd hebben, is echter een kwestie waar fonologen zich al decennia lang over buigen. Gedragen affricaten zich als plofklanken met een speciale eigenschap waardoor ze zich onderscheiden van normale plosieven? Of zijn affricaten eerder gebalanceerde combinaties van een plosief en een fricatief? Of is een affricaat in wezen niets anders dan een normale plofklank zoals [t] of [p], en heeft het concept “affricaat” fonologisch gezien geen enkele betekenis?

In hoofdstuk 2 wordt een chronologisch overzicht gegeven van de verschillende formele beschrijvingen die zijn voorgesteld in de geschiedenis van de fonologische theorie, sinds de jaren '50 van de 20ste eeuw, toen de eerste coherente sets distinctieve kenmerken werden geïntroduceerd. Op basis van dit overzicht kan geconcludeerd worden dat de onduidelijkheid omtrent de fonologische representatie van affricaten vooral veroorzaakt wordt door het feit dat veel studies zich baseren op slechts één taal, en er weinig contrastief onderzoek is gedaan. Daarnaast leiden de weinige bestaande cross-linguïstische studies tot tegenstrijdige conclusies. Een antwoord op de vraag hoe een affricaat er fonologisch uitziet kan dan ook alleen gegeven worden door de bestaande inzichten te toetsen tegen een sample van talen dat voldoende groot is, en dat zodanig geselecteerd is dat het een betrouwbare afspiegeling vormt van de talen van de wereld.

Affricaten in de talen van de wereld

Hoofdstuk 3 en 4 bestuderen de patronen van affricaten in de talen van UPSID 1992, een database van 451 talen, gecontroleerd met betrekking tot genetische verwantschap. Wanneer de positie van affricaten in de verschillende talen wordt bekeken in directe relatie tot plosieven en fricatieven, komen interessante aspecten aan het licht. Dat wil zeggen, soms blijken affricaten sterke overeenkomsten te vertonen met plosieven, soms met fricatieven, maar er zijn ook talrijke gevallen te vinden waar affricaten een ander patroon laten zien dan zowel plosieven als fricatieven.

In het debat omtrent de fonologische representatie van affricaten zijn generalisaties gebaseerd op typologische patronen gebruikt als argumenten voor of tegen een bepaalde modelisering. Het feit dat affricaten vaak voorkomen op dezelfde plaats van articulatie als de fricatieven in een bepaalde taal, is bijvoorbeeld gebruikt als een argument om een affricaat te beschrijven als een evenwichtige plosief-fricatief combinatie. Echter, de patronen in UPSID laten zien dat dergelijke claims genuanceerd dienen te worden. Het is niet de fonologische representatie die de typologische patronen bepaalt, maar het zijn eerder de fonetische aspecten die in eerste instantie een rol spelen. Dat wil zeggen, omdat affricaten fonetisch gezien combinaties zijn van een plosief gevolgd door een fricatief, valt het te verwachten dat deze klanken patronen vertonen die (deels) overeenkomen met die van plosieven, (deels) met die van fricatieven, maar dat ze tegelijkertijd ook, vanwege hun interne complexiteit waarin ze zich onderscheiden van de andere obstruenten, andere patronen

kunnen laten zien dan zowel plosieven als fricatieven. Het realiseren van een affricaat met stembandtrilling is bijvoorbeeld nog moeilijker dan het produceren van een stemhebbende plosief of fricatief, hetgeen overeenkomt met de typologische patronen waar stemhebbende affricaten aanzienlijk minder frequent zijn dan de andere twee typen obstruenten.

Pas wanneer affricaten of bepaalde patronen fonemisch (betekenisonderscheidend) worden in een bepaalde taal, gaan fonologische aspecten een rol spelen (bijvoorbeeld symmetrie binnen de klankinventaris). Het hangt uiteindelijk van de taal af hoe affricaten er fonologisch precies uitzien, maar uit de UPSID patronen blijkt dat er niet één specifieke, universele, representatie nodig is voor de affricaat als zodanig. Als we uitgaan van de meest radicale opvatting over affricaten, namelijk dat ze fonologisch geen enkele relevantie hebben, en dat ze in principe kunnen worden beschreven als een plosief, blijken alle patronen beschreven te kunnen worden. Affricaten gedragen zich verschillend van, of overeenkomstig met, de andere obstruenten op basis van onafhankelijke features zoals plaats of manier van articulatie, niet omdat ze een stempel "affricaat" hebben.

Affricaten in de geschiedenis van het Frans

Hoofdstukken 3 en 4 kijken naar de plek die affricaten innemen binnen de klankinventarissen van talen, en vertellen als zodanig dus niets over het gedrag van deze klanken in fonologische processen: doen ze mee met de normale plosieven, de fricatieven, of gedragen ze zich (soms) als een aparte groep? Omdat het vanwege praktische redenen niet mogelijk is om de procesmatige kant van de affricaten te bekijken in de 302 UPSID talen waarin deze klanken voorkomen, is ervoor gekozen om hun gedrag te bestuderen aan de hand van de historische fonologie van het Frans. Deze taal speelt een belangrijke rol in het debat, omdat affricaten onder meer ontstaan in een typologisch gezien uitzonderlijke context: voor de lage klinker *a*. Hoofdstuk 5 beschrijft de verschillende processen waaruit tijdens de ontwikkeling van het Latijn naar het Oud Frans een affricaat is voortgekomen, en de manier waarop deze klanken uiteindelijk ook weer uit de taal verdwenen.

De affricaten die ontstaan in de geschiedenis van het Frans lijken voornamelijk een fonetische basis te hebben: bepaalde klanken of klankcombinaties gaan akoestisch en perceptueel op een affricaat lijken (bijvoorbeeld een velaire plosief [k] gevolgd door een hoge voorvocaal [i], die gehoord gaan worden als [tʃi]). Als er inderdaad een klankverandering

plaatsvindt, verandert de representatie van de oorspronkelijke klank in die van een affricaat. Ook hier blijkt dat de representatie van een affricaat als een combinatie van een gelijkwaardig [plosief] en [fricatief] deel niet nodig is, en zelfs verkeerde voorspellingen doet. Als wordt aangenomen dat affricaten in beginsel plosieven zijn, en dat ze zich in het Frans op basis van een manier-kenmerk zoals [strident] (verwijzend naar het sisklank deel van de affricaat) in sommige gevallen kunnen onderscheiden van niet-affricaat plosieven, kan hun gedrag in deze taal probleemloos worden beschreven.

De explosie van plosieven in het modern Frans: plaats en manier

Het Frans is niet alleen interessant vanuit historisch perspectief. Ook als we kijken naar het modern Frans krijgen we meer inzicht in de manier waarop affricaten in een taal kunnen ontstaan. In de hoofdstukken 6, 7 en 8 wordt een analyse gepresenteerd van een corpus gesproken Frans, opgenomen in verschillende regio's in Frankrijk. Het modern Frans heeft zes plosieven, die voorkomen op drie verschillende plaatsen van articulatie (bilabiaal, dentaal en velair), met elk een stemloze en een stemhebbende variant.

Van de Franse velaire plosieven is bekend dat ze de neiging hebben om naar voren in de mond te schuiven als ze worden gevolgd door een voorvokaal. Hoewel dit een vaak opgemerkt gegeven is, is er nooit echt onderzocht wat die verschuiving nu precies inhoudt. In hoofdstuk 7 wordt daarom een analyse gepresenteerd van de plaats van articulatie van de velaire plosieven in negen subcorpora van de PFC database. De plaats van articulatie van een velaire plosief blijkt inderdaad sterk afhankelijk te zijn van de volgende klinker. Hoe verder naar voren de plaats van articulatie van de klinker is, hoe meer de velair naar voren schuift. Dit geldt ook voor de lage klinker *a*, die erg voorin de mond wordt uitgesproken door een aantal sprekers; het zou dus kunnen dat de parallelle, enigszins mysterieuze, gebeurtenis in de geschiedenis van het Frans ook op een dergelijke manier op gang kwam. Naast de kwaliteit van de volgende klinker als zodanig zijn er ook sociolinguïstische factoren die een rol spelen in de mate van verschuiving: de vrouwelijke sprekers en de oudste generatie zijn over het algemeen behoudender wat de plaats van articulatie van de velair betreft, en laten hem minder makkelijk naar voren schuiven.

Buiten het feit dat de velaire plosief de neiging heeft om te schuiven naar de plaats van articulatie van de volgende klinker, worden Franse plosieven traditioneel beschreven als heel netjes gearticuleerde, maar sterk aangezette, klanken, vrij van ruis. Ook hier ontbreken echter representatieve data. In

hoofdstuk 8 wordt de kwaliteit van de explosie van de verschillende plofklanken van dichterbij bekeken. Het blijkt dat er veel variatie met de uitspraak van deze ploffers gemoeid is; zowel tussen sprekers, als bij één en dezelfde spreker. Vaak is een plosief in het Frans inderdaad heel netjes en ruisloos, in andere gevallen ontstaan er onverwachte realisaties. Het kan dan gaan om een erg hard afgezette plosief, maar ook om affricatisering of aspiratie. Vooral de laatste twee gevallen zijn erg interessant omdat deze normaal gesproken niet geassocieerd worden met standaard Frans. De plaats van articulatie van de plosief en de volgende klinker, gepaard met de articulatorische sterkte waarmee de afsluiting in de mond wordt gecreëerd, kunnen de explosie op een bepaalde manier kleuren. Omdat het voor een spreker onmogelijk is om zijn of haar spraakorganen op exact dezelfde wijze te configureren iedere keer wanneer hij of zij een bepaalde combinatie van klanken moet uitspreken, ontstaat er variatie. Echter, bij sommige sprekers zijn de spraakorganen standaard meer gespannen dan bij anderen: zij produceren bepaalde *noisy* explosies vaker, systematischer, dan anderen, zodanig dat het als een karakteristiek van hun idiolect gezien kan worden.

Conclusie: Fonetiek vs. fonologie

Wanneer we de complementaire evidentie uit de verschillende hoofdstukken combineren, kunnen we concluderen dat er in feite geen reden is om aan te nemen dat er een fonologische klasse van affricaten bestaat. Hiermee sluiten we aan bij de meest radicale opvatting over affricaten, die voornamelijk werd verdedigd door Darlène LaCharité, Nick Clements en Wolfgang Kehrein rond de wisseling van het millennium.

We hebben laten zien dat affricaten alleen goed kunnen worden begrepen wanneer er een duidelijk onderscheid wordt gemaakt tussen de fonologische en fonetische aspecten. De fonetische combinatie van een plosief en een fricatief in één klank zorgt ervoor dat bepaalde typologische patronen ontstaan, die deels overeenkomen met plosieven, deels met fricatieven, en die deels verschillen van de andere obstruenten. Deze patronen kunnen niet verklaard worden op basis van een bepaalde abstracte fonologische representatie. En dit hoeft ook niet: de fonologische representatie legt uiteindelijk uit waarom affricaten zich op een bepaalde manier gedragen met betrekking tot fonologische processen. Het historisch en modern Frans laten duidelijk zien welke fonetische mechanismen er achter het ontstaan van een affricaat kunnen zitten. Wanneer deze affricaten fonemen worden in een taal krijgen ze een bepaalde representatie, afhankelijk van de contrasten binnen die taal. Affricaten zijn fonologisch gezien plosieven,

en ze kunnen zich soms anders gedragen dan normale plosieven op basis van plaats- of manier-kenmerken. Maar affricaten zijn niet in wezen anders dan andere obstruenten omdat ze “affricaat” zijn.

Affricaten hebben gedurende een lange tijd gezorgd voor frictie tussen fonetiek en fonologie. Hopelijk heeft dit proefschrift kunnen laten zien dat die frictie eigenlijk helemaal geen bestaansreden heeft.

Curriculum Vitae

Janine studied Romance Languages and Cultures at the Radboud University Nijmegen (BA: 2006, MA: 2007), and successfully completed the Research Master Language and Communication in 2008 (Radboud University and Tilburg University). In May 2008, she received a Toptalent grant for her PhD project from the *Netherlands Organisation for Scientific Research* (NWO). During this project, Janine taught several BA and MA courses in the department of Romance Languages and Cultures of the Radboud University (French language skills and linguistics). She currently holds a teaching position in the same department, and is a member of the research group *Languages in Transition Stages* of the *Centre for Language Studies* (CLS).