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The Phonological Typology of Coronal Palatalization and Affrication

설정구개음화 및 파찰음화의 음운유형론

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by

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ABSTRACT

The Phonological Typology of Coronal Palatalization and Affrication

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This study explores cross-linguistic patterns of palatalization and affrication of coronal consonants. Although Hume's (1992) Vowel-Place model predicts that coronal palatalization and affrication are distinct phonological phenomena, the results of the previous typological studies (e.g., Bateman 2007; Bhat 1978; Hall & Hamann 2006; Kochetov 2011) have suggested that these two processes have many similar properties. However, given that no previous study has systematically compared coronal palatalization and coronal affrication, it is difficult to determine whether these two processes are different phonological phenomena or not. In order to answer this question, this thesis investigates the two processes separately, in terms of their typology and phonetics. The results of this in-depth survey strongly suggest that they are separate phonological processes which have distinct typological patterns and phonetic backgrounds.

A survey of 69 languages produced the following four implicational universals, two for palatalization and two for affrication. (i) Non-high front vocoids do not trigger palatalization unless high front vocoids do so (the trigger height asymmetry). (ii) Laterals do not undergo palatalization unless nasals do so. Nasals do not undergo palatalization unless obstruents do so (the target manner asymmetry). (iii) High back or central vocoids do not trigger affrication unless high front vocoids do so (the trigger frontness asymmetry). (iv) Voiced stops do not undergo affrication unless voiceless stops do so (the target voicing asymmetry). In addition, the results of the present survey show that coronal palatalization is exclusively triggered by front vocoids whereas coronal affrication is triggered only by high vocoids. Given that coronal palatalization and affrication have different restrictions on their triggers and targets, and that they are subject to the absolute process-specificity of the triggers, the separation of the two processes are typologically supported.

The investigation of the phonetic backgrounds of palatalization and affrication of coronal consonants shows that the typological universals, presented above, correlate well with perceptual asymmetries. The key observations are that more likely target coronals have lower perceptibility of the relevant contrast than less likely ones and that coronal consonants occurring before more likely triggers have lower perceptibility than those occurring before less likely ones. Specifically, I investigated the perceptibility of the feature [anterior] for palatalization and that of the feature [strident] for affrication. First, the perceptibility of the feature [anterior] is mainly determined by the similarity in F2 transitions between alveolar and palatal consonants. They have more similar F2 transitions before high front vocoids than before non-high ones. In addition, alveolar and palatal obstruents (e.g., [s-ʃ]) have less distinct F2 transitions than their nasal counterparts (e.g., [n-ɲ]), which in turn have less distinct F2 transitions than lateral counterparts (e.g., [l-ʎ]). These phonetic facts suggest that the anteriority contrast is less salient before high front vocoids than before non-high ones, and that the anteriority contrast of obstruents is less salient than that of nasals, which in turn is less salient than that of laterals. These findings are consistent with the implicational universals of coronal palatalization (i-ii). Second, the perceptibility of the feature [strident] depends on the similarity in intensity and duration of friction between coronal stops and affricates. The intensity and duration of the stop release noise are higher and more elongated, respectively, and therefore more similar to those of the affricates, before front vocoids than before back or central vocoids. In addition, the intensity and duration of the friction noise of a voiceless stop are higher and longer and thus more like those of its affricate counterpart, than those of a voiced stop. Due to these acoustic properties, the stridency contrast between coronal stops and affricates is less salient before front vocoids than before back vocoids, and the stridency contrast is less salient for voiceless stops and affricates than for voiced ones. These findings are consistent with the implicational universals of coronal affrication (iii-iv).

In order to capture the correlation between the implicational universals and perceptual asymmetries within the framework of Optimality Theory (Prince & Smolensky 2004), I follow the P-map hypothesis (Steriade 2001, 2009) that Faithfulness constraints for perceptually prominent segments and positions are

ranked above those for perceptually less prominent ones. This analysis shows that the typological universals of the two processes can best be explained under the phonetically-based approach to phonology (Hayes, Kirchner & Steriade 2004), especially providing further support for the role of the phonetic perception in shaping phonological grammar (Boersma 1998; Jun 1995, 2004; Steriade 2001, 2009, inter alia).

Keywords: coronal palatalization, coronal affrication, phonological typology, phonetically-based phonology, P-map, linguistic universal

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1. Introduction

This thesis explores cross-linguistic patterns of two phonological processes, coronal palatalization and coronal affrication, both of which target anterior consonants in a prevocalic position. Coronal palatalization refers to a process involving a shift in place of articulation towards the palatal region, which may be accompanied by affrication when a stop is the target. Examples of coronal palatalization can be found in Japanese, as shown in (1), where anterior consonants /t, s, n/ become posterior [t͡ʃ, ʃ, ɲ] before a high front vowel /i/.

(1) Japanese coronal palatalization

a. /ka**t**-itai/ [ka**t͡ʃ**itai] 'win, VOL'

b. /ma**t**-itai/ [ma**t͡ʃ**itai] 'wait, VOL'

c. /ka**s**-itai/ [ka**ʃ**itai] 'borrow, VOL'

d. /o**s**-itai/ [o**ʃ**itai] 'push, VOL'

e. /si**n**-itai/ [ʃi**ɲ**itai] 'die, VOL'

On the other hand, coronal affrication refers to a change from anterior stops to their affricated counterparts. Examples of coronal affrication can also be found in Japanese, as shown in (2), where an anterior stop /t/ becomes its homorganic affricate [t͡s] before a high back vowel /u/.

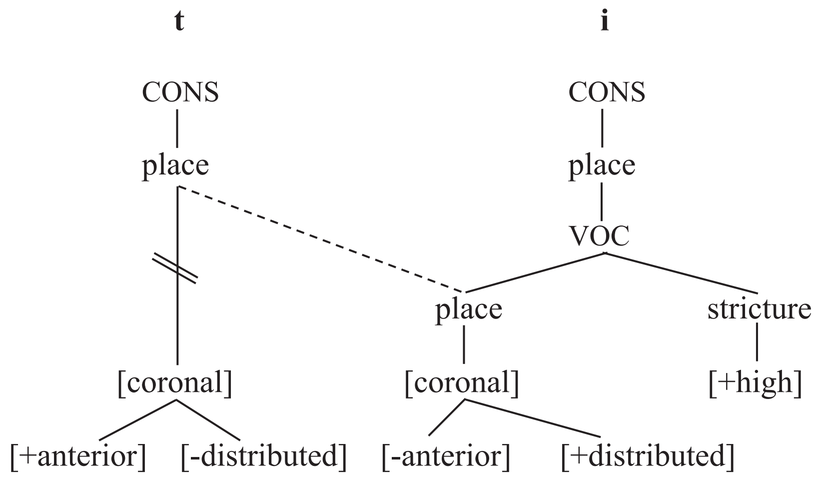
(2) Japanese coronal affrication

a. /ka**t**-u/ [ka**t͡s**u] 'win, PRES'

b. /ma**t**-u/ [ma**t͡s**u] 'wait, PRES'

In this study, coronal affrication is confined to processes involving no change in place of articulation, and thus there is no overlap between processes of coronal palatalization and coronal affrication. The present strict distinction between these two processes is in line with phonological models which have focused on assimilatory properties of coronal palatalization, especially those proposing that front vocoids are specified as a [coronal] place feature (e.g., Clements 1976, 1991; Clements & Hume 1995; Hume 1992). According to these models, coronal palatalization is a natural process in which an anterior consonant assimilates its place-of-articulation to that of an adjacent front vocoid. A process that does not involve changes in place features, such as coronal affrication exemplified in (2), thus cannot be a case of palatalization. As an example of such a Vowel-Place theoretic approach, Hume's (1992) analysis of coronal palatalization, which is referred to as 'coronalization' by Hume, is illustrated in (3).

(3) /t/ → [t͡ʃ] (Hume 1992: 183)



As shown in the above configuration, Hume's (1992) model captures the assimilatory nature of coronal palatalization as spreading the vocalic place node of the front vocoid to the original position of the target segment's consonantal place node. Since spreading of the vocalic place node which dominates a [coronal] feature characterizes coronal palatalization, non-front vocoids which are not specified as [coronal] (e.g., back vowel /u/ which is specified as [labial] and [dorsal]) cannot be a trigger of the process. In addition, this model predicts that an outcome of coronal palatalization should be a laminal posterior consonant since front vocoids are inherently specified as [-anterior] and [+distributed] (Hume 1992: 66ff.). Thus, under this model, coronal palatalization can be defined as a phonological process in which the trigger is a front vocoid, and the outcome is a laminal posterior consonant. This definition of coronal palatalization separates it from coronal affrication which can be triggered by non-front vocoids and does not involve any changes in place features. Furthermore, this model also suggests that affrication of stop consonants which frequently goes with changes in place features, such as the /t/-to-[t͡ʃ] change exemplified in (1a-b), is a by-product, not the defining part, of coronal palatalization (see section 5.1 for the relevant discussion). Since a change in stridency cannot be achieved by spreading the vocalic place node of the front vocoid to the neighboring consonant, under Hume's (1992) model, it is expected that coronal palatalization itself yields the laminal posterior stops (e.g., [c] or [t̠]) as outcomes, rather than posterior affricates (e.g., [t͡ʃ]).

However, contrary to such a Vowel-Place approach to coronal palatalization which claims that only changes in relevant place features (i.e., changes in anteriority and apicality) can define the process, some prior studies (e.g., Bhat 1978; Kochetov 2011) assume that changes in relevant manner features (notably, stridency) can additionally characterize palatalizing processes. Under this view, just as palatalization can occur without changes in manner features (e.g., such as in the /n/-to-[ɲ] change), palatalization can also occur without changes in place features. Thus, this view conflates coronal palatalization and coronal affrication into a single category under the term 'palatalization.' This conflation of coronal palatalization and affrication suggests that they are subject to the same mechanism; it is then expected that these two processes will show obvious commonalities rather than irreconcilable differences.[1]

[1] Some prior studies investigate phonological processes involving changes in stridency and continuancy features, calling them as 'assibilation' (e.g., Hall & Hamann 2006; Kim 2001). These studies also conflate coronal stop palatalization and affrication in their typological surveys and analyses since coronal stop palatalization is almost always accompanied by a

It seems that the results of the previous typological surveys of palatalization (e.g., Bateman 2007; Bhat 1978; Hall & Hamann 2006; Kochetov 2011, and others) support the conflation of the two processes, rather than the separation of them. First, some prior studies (e.g., Bateman 2007; Bhat 1978; Kochetov 2011) report that coronal palatalization can occur in the high central/back vocoid contexts, contrary to the prediction of a Vowel-Place approach (e.g., Hume 1992). Since coronal affrication also occurs in both high front and back vocoid contexts (e.g., Hall & Hamann 2006; Kim 2001), it seems that the two processes in question are not properly distinguished in terms of their occurring contexts. Second, as typological data given by Bateman (2007: 313) shows, although there are a few minor exceptions, coronal palatalization of stop consonants almost always yields posterior affricates rather than posterior stops. This almost obligatory affrication implies that changes in stridency may form an essential part of palatalizing processes, contrary to Hume's (1992: 192) analysis which attributes these changes to a language dependent rule parameter. However, given that no previous study has systematically compared coronal palatalization and coronal affrication, it should not be hastily concluded that these two processes can be conflated into a single category.

This thesis attempts to answer the question of whether coronal palatalization

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change in stridency. Thus, at least regarding the conflation of the two processes, these studies stay in line with those which consider both coronal palatalization and affrication as subtypes of palatalization (e.g., Bhat 1978; Kochetov 2011), contradictory to the Vowel-Place theory which advocates the strict separation of the two processes (e.g., Hume 1992). For this reason, throughout this thesis, I will treat the 'assibilation' approach as belonging to the approaches that categorize affrication without place change as a type of palatalization.

and coronal affrication are fundamentally distinct processes or not, by conducting a systematic comparison between the typological patterns and phonetic underpinnings of coronal palatalization and those of coronal affrication. If the patterns of coronal palatalization show consistently similar properties to those of coronal affrication, as suggested in the previous typological studies (e.g., Bateman 2007; Bhat 1978; Hall & Hamann 2006; Kochetov 2011), then the phonological models which confine palatalization to changes in relevant place features (e.g., Hume 1992) are likely to be flawed. In contrast, if coronal palatalization and coronal affrication have systematically distinct properties from each other, then the separation of the two processes will be supported, casting doubts on the results of the studies which have conflated them into a single category (e.g., Bhat 1978; Hall & Hamann 2006; Kochetov 2011).

In order to achieve this goal, I conducted my own survey on the typology of coronal palatalization and coronal affrication. Several observations that can be made from the results of this typological investigation support the distinction of the two processes, refuting some typological generalizations proposed by the previous studies (Bateman 2007; Bhat 1978; Kochetov 2011; and others). One important observation is that the two processes are distinct in terms of their triggers. Coronal palatalization is exclusively triggered by front vocoids whereas coronal affrication is triggered only by high vocoids (see section 2.4 for the detailed discussion). An additional important observation is that the two processes have distinct typological restrictions on their triggers and targets. When coronal palatalization occurs, (i) non-high front vowels do not trigger palatalization unless high front vocoids do so (the trigger height asymmetry), and (ii) laterals do not undergo palatalization unless nasals do so, and nasals do not undergo palatalization unless obstruents do so (the target manner asymmetry). When coronal affrication occurs, (iii) high back or central vocoids do not trigger affrication unless high front vocoids do so (the trigger frontness asymmetry), and (iv) voiced stops do not undergo affrication unless voiceless stops do so (the target voicing asymmetry). These distinct typological restrictions are not expected from the previous studies which conflate coronal palatalization and coronal affrication (e.g., Bhat 1978; Hall & Hamann 2006; Kochetov 2011).

Furthermore, the results of my investigation of the phonetic sources of the two processes in question also support the distinction of the two processes, presenting remarkable phonology-phonetics correlations. The key observations are that coronal consonants occurring before more likely triggers have lower perceptibility of the relevant contrast than those occurring before less likely ones and that more likely target coronals have lower perceptibility of the relevant contrast than less likely ones. It is worth noting here that different phonetic contrasts are crucial in the two processes in question: the perceptibility of the anteriority contrast correlates with the likelihood of palatalization whereas the perceptibility of the stridency contrast is consistent with the probability of affrication. These correlations between the perceptual contrasts and the likelihood of the occurrence of the two processes also reinforce the view that coronal palatalization and affrication are separate phonological processes, showing that they have phonetic groundings distinct from each other.

Another goal of the current thesis is to develop a proper constraint-based account of the processes. In order to capture the correlation between the typological universals and perceptual asymmetries within the framework of Optimality Theory (Prince & Smolensky 2004), the relevant phonetic facts are formalized in terms of P-map theory (Steriade 2001, 2009). According to P-map theory, Faithfulness constraints for perceptually prominent segments and positions are ranked above those for perceptually less prominent ones. Therefore, the implicational universals can be explained by the interaction between Faithfulness constraints ranked by P-map and a relevant articulatorily-motivated Markedness constraint. The proposed analysis can correctly predict all and only attested patterns of coronal palatalization and affrication. The current analysis thus shows that the typological universals of the two processes can best be explained under the phonetically-based approach to phonology (Hayes, Kirchner & Steriade 2004), especially providing further support for the role of the phonetic perception in shaping phonological grammar (e.g., Boersma 1998; Jun 1995, 2004; Steriade 2001, 2009).

In addition, this phonetically-based analysis has explanatory advantages over the previous accounts, making significant improvements. First, by analyzing coronal palatalization and coronal affrication as a result of interactions between phonetically-based constraints, the present study correctly captures the typological asymmetries of the two processes that can hardly be explained under Hume's (1992) representational model. Second, by incorporating both articulatory and perceptual factors, this study provides phonetically more plausible and better-motivated analyses of the typological patterns of coronal palatalization and affrication than those of the previous accounts which appeal only to articulatory properties (e.g., Bateman 2007) or perceptual backgrounds (e.g., Hall & Hamann 2006).

The thesis is organized as follows. Section 2 describes the typology of coronal palatalization and coronal affrication, providing universal generalizations which support the distinction of the two processes. Section 3 explores the phonetic groundings for the two processes. An examination of the phonetic properties of these processes shows that the perceptual asymmetries are systematically consistent with the typological patterns. In section 4, a constraint-based analysis of the typological patterns of coronal palatalization and coronal affrication is proposed based on Steriade's P-map principles. Section 5 covers some problematic issues: coronal stop palatalization, roles of structure preservation in shaping typological patterns, postvocalic coronal palatalization, and obligatory laminalization in coronal palatalization. In section 6, alternative approaches will be discussed. Finally, section 7 concludes this thesis.

2. Typology

In this section, I investigate the typology of coronal palatalization and coronal affrication. This section is divided into five subsections. In subsection 2.1, I set the stage of my own typological survey on the two processes in question, illustrating the method and data used for this survey. Subsections 2.2 and 2.3 present the results of the survey on coronal palatalization and those of the survey on coronal affrication respectively. In subsection 2.4, I discuss the process-specificity of triggers observed from the results of the survey. Finally, subsection 2.5 summarizes the typological findings of the survey.

2.1. Overview of the survey: methods and data

For the purposes of exploring the typological patterns of coronal palatalization and affrication and answering the question of whether these two processes are fundamentally distinct or not, I conducted a typological survey on these processes. For this survey, I adopted the criteria given in (4).

(4) Criteria for the survey

a. An anterior consonant becomes a laminal posterior consonant before a vocoid (coronal palatalization).

b. An anterior stop becomes an anterior affricate before a vocoid (coronal affrication).

Note that these criteria exclude postvocalic occurrences of the two processes. Given that postvocalic coronal affrication is never or, at best, rarely attested, this study is concerned only with prevocalic occurrences of the two processes which may facilitate the comparison between the two (the postvocalic coronal palatalization will be discussed in section 5.3).

Synchronic phonological processes that qualify the criteria given above were considered in data collection, regardless of their rule domains (lexical *vs*. post-lexical) and types of alternations (morphophonemic *vs.* allophonic), under the assumption that the universal properties of coronal palatalization and coronal affrication do not significantly vary according to these distinctions (cf. Hall & Hamann 2006: 1197 who make a similar assumption).[2] In addition, in order to qualify for the description, I used two additional yardsticks. First, to be sure that the

[2] One may argue that (morpho-)phonemic changes and allophonic changes can have different typological patterns due to structural requirements imposed on phonemic changes (i.e. structure preservation). In section 5.2, I will discuss potential influences of phonemic structure in shaping surface patterns of the two processes in question.

observed patterns are not influenced by diachronic factors or synchronic phenomena that are not relevant to the two processes in question, processes involving changes in the major class features, such as [sonorant] and [approximant] (e.g., Clements 1987), were excluded from my investigation.[3] Second, for the purpose of obtaining an accurate understanding of each pattern, I did my best to investigate the phonetic details involved in it by relying on the relevant phonetic/phonological studies, whenever available.

The list in (5) describes examples of processes which were excluded from investigation:

[3] For example, in Nishnaabemwin, although there are many diachronic sources of /n/, only /n/ which is developed from Proto-Algonquian *θ alternates with /ʒ/ before /i/ (Valentine 2001: 88-89). However, it is worth to noting that excluding such examples from the data did not affect the typological generalizations presented in this section (see APPENDIX II for detailed descriptions of each pattern attested in the surveyed languages).

(5) Examples of excluded phonological processes

a. t, d, n → tʲ, dʲ, nʲ/ __i Watjarri (Douglas 1981)

b. t → s / __i Finnish (Kiparsky 1993)

c. *t, *d > t͡ʃ, d͡ʒ / __j, i Gbe dialects (Capo 1991)

d. t, d, c, ɟ → t͡s, d͡z, t͡ʃ, d͡ʒ / __ t͡s, d͡z, t͡ʃ, d͡ʒ Hungarian (Siptár & Törkenczy 2000)

e. t, d, n, l → c, ɟ, ɲ, ʎ / i__ Basque (Hualde & Urbina 2003)

f. l, r → d͡ʒ, t͡s / __j Tswana (University of Botswana 1999)

The process described in (5a) is secondary palatalization which does not involve a change of the primary articulation, and the process given in (5b) is stop spirantization which results in a fricative outcome rather than an affricate. The Gbe example in (5c) illustrates a diachronic process, including reconstructed forms. In (5d) and (5e), I have presented examples which are not conditioned by a following vocoid. Hungarian stop affrication described in (5d) is triggered by the following affricates, and Basque coronal palatalization exemplified in (5e) occurs under the influence of the preceding high front vowel. Finally, The Tswana example given in (5f) describes a process which involves changes in major class features, [sonorant] and [approximant].

Note that the current study is not the very first survey on coronal palatalization or coronal affrication. The current survey draws largely on three previous typological surveys on the two processes and relevant phonological phenomena (Bhat 1978; Bateman 2007; Hall & Hamann 2006). First, the current typology draws on Bhat (1978) which provided the most notable and largest typological data of palatalization until now. This work encompasses more than 120 languages in which mainly three subtypes of palatalization processes are attested: ‘tongue-fronting,’ ‘tongue-raising,’ and ‘spirantization’ (which roughly correspond to velar palatalization, coronal palatalization, and affrication respectively). From Bhat’s data, the 15 languages that qualify the criteria given in (4) are included in my data.

The current typology also largely draws on Bateman (2007) which is another notable, but more recent, typological investigation on palatalization processes. Bateman (2007) lists 58 languages in which synchronic secondary or primary palatalization (which she calls ‘full palatalization’) are attested, excluding languages showing only non-place changing processes (e.g., coronal affrication). Among these 58 languages included in Bateman’s data, phonological processes which qualify the current typology’s criteria are attested in 25 languages.

This study also bears debt to Hall & Hamann (2006). They investigate the typological patterns of ‘stop assibilation’ processes in which anterior stops undergo changes in stridency. Although they do not focus on place-changing processes, quite a large number of languages which show coronal palatalization accompanied by a change in stridency are listed in their data. 27 out of 44 languages surveyed by Hall & Hamann (2006) show processes that qualify the criteria of the current typology.

Based on these three previous surveys, I constructed a preliminary database consisting of patterns of coronal palatalization and coronal affrication attested in 45 languages altogether. Since the previous studies have different purposes, interests and scopes from the current study, I have carefully checked the validity of each pattern given by them before incorporating it in my database.[4] I then expanded the database by adding patterns from 24 languages which have not been covered by the previous typological surveys, based on descriptions of primary sources of the patterns and other phonetic/phonological studies on them.

To sum up, the patterns of coronal palatalization in 61 languages and coronal affrication in 20 languages were included in my typological dataset. The total number of the surveyed languages were 69 since both processes were attested together in twelve languages.[5] I did my best to include genetically diverse languages in my data. As a result, the sample languages were considerably balanced in terms of their genetic distributions, belonging to 24 language families and 40

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[4] The only exception is Luvale that I could not have accessed to the primary sources cited in Bateman (2007) or any other alternative sources. Regarding this language, I entirely rely on the descriptions provided by Bateman (2007).

[5] These twelve languages can be divided into two groups. First, in five languages (Cheyenne, Fongbe, Maori, Taiof and Tswana), coronal palatalization and coronal affrication are in variation with each other, e.g., /**t**i/ → [**t͡ʃ**i] ~ [**t͡s**i] 'squeeze' (Fongbe; Lefebvre & Brousseau 2002: 25). Second, in seven languages (Dutch, Japanese, Kirundi, Mongo, Romanian, Slovak, and Tota Logba), the two processes occur in different contexts, e.g., /ka**t**-itai/ → [ka**t͡ʃ**itai] 'win, VOL' and /ka**t**-u/ → [ka**t͡s**u] 'win, PRES' (Japanese; Kochetov & Alderete 2016), or target distinct types of consonants, e.g., /ja-do**d**-je/ → [jado**d͡z**e] 'bang, 3RD PAST' and /ja-too**d͡z**-je/ → [jatoː**d͡ʒ**e] 'pick up with, 3RD PAST' (Kirundi; Kochetov 2016: 9).

genera. The genetic classifications of the surveyed languages are primarily based on those of *the World Atlas of Language Structures* (WALS, online version, Dryer & Haspelmath 2013).[6] The full list of the surveyed languages and references are provided in APPENDIX I, and detailed descriptions of coronal palatalization and affrication processes attested in the surveyed languages are given in APPENDIX II.

2.2. Cross-linguistic patterns of coronal palatalization

The description provided in this subsection is based on the data which encompass 61 languages with coronal palatalization. These surveyed languages were genetically balanced, belonging to 22 language families and 37 genera. Before presenting the detailed examination on the typological asymmetries which govern the patterns of the process, the general characteristics of the triggers, targets, and outcomes of the process are briefly described here.

First, the table in (6) gives the distribution of coronal palatalization classified according to height and frontness of the triggering vocoids:

[6] If relevant information was not available in WALS, I referred to *Ethnologue Online* (Simons & Fennig 2018) instead.

(6) The distribution of coronal palatalization by height and frontness trigger vocoids (*n* = 61)

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">frontness</td></tr>
<tr><td>front</td><td>non-front</td></tr>
<tr><td rowspan="3">height</td><td>high</td><td>61</td><td>(1)</td></tr>
<tr><td>mid</td><td>13</td><td rowspan="2">0</td></tr>
<tr><td>low</td><td>(1)</td></tr>
</table>

('(1)' = 'there is one language in which evidence for the presence of the corresponding trigger is controversial')

This table shows that coronal palatalization is almost exclusively triggered by a front vocoid. A front vocoid (e.g., /i/) was a trigger of the process in all 61 languages surveyed. There was only one marginal case where coronal palatalization (potentially) occurs before a non-front vocoid (Mbahám: Cottet 2015). In this respect, my study is not consistent with most prior surveys (Bateman 2007; Bhat 1978; Leung 1991; Kochetov 2011) which have reported that coronal palatalization can occur before a high central or back vocoid at least in the following four languages: Logoori, Mongo, Maori, and Papago. In section 2.4, I will discuss these four cases reported by the previous studies in detail and show that there is not enough evidence to conclude that a high central/back vocoid triggers coronal palatalization in these four languages. In addition, the table in (6) also shows that there is an asymmetrical relationship between the front vocoid triggers. While a high front vocoid (e.g., /i/) triggered the process in all surveyed languages, a mid front vowel (e.g., /e/) did so only in 13 out of 61 languages (21.3%). Among the languages surveyed, Slovak was the only language in which a low front vowel triggered the process (Rubach 1993: 44, 113). However, it is not clear whether the exact height of the trigger vowel is low or mid, at least, in the contemporary Slovak language, given that the low front /æ/ is often merged into the mid front vowel /ɛ/ (Hanulíková & Hamann 2010: 375). According to Short (2002: 534), the low vowel /æ/ is attested only by about five percent of Slovak speakers.

Next, concerning the targets of coronal palatalization, the following table summarizes the results:

(7) The distribution of coronal palatalization by the manner of articulation of the target consonant (*n* = 61)

obstruent		*sonorant*		
stop	*sibilant*	*nasal*	*lateral*	*rhotic*
42	37	31	10	0

The above table illustrates that anterior consonants are palatalized to different degrees, according to their manner-of-articulation. Stops (42 out of 61 languages, 68.9%) and sibilants (37 out of 61 languages, 60.7%) were more frequently attested targets, compared to nasals (31 out of 61 languages, 50.8%). Among sonorant consonants, nasals were more likely targets than laterals (10 out of 61 languages, 16.4%), and there was no language in which a rhotic consonant is targeted by the process. In general, these statistics illustrated in (7) show that there is an asymmetrical tendency between target consonants with different manner features:

obstruent consonants are more likely targets of coronal palatalization, compared to sonorant ones, and among sonorant consonants, nasals are more likely targets of the process, compared to laterals.

Finally, regarding the outcomes of coronal palatalization, there was an interesting observation. While non-stop target consonants were normally palatalized into their posterior counterparts with no change in manner of articulation, stop consonants were usually palatalized as posterior affricates (e.g., [t͡ʃ]), rather than posterior stops (e.g., [t̠, c]).[7] Among the 42 languages in which a stop consonant undergoes coronal palatalization, an outcome of the process was an affricate in 33 languages (78.6%). Posterior stop outcomes were attested in seven languages (Acoma, Nimboran, Nyawaygi, Slovak, Tiwi, Udmurt, and Zoque), and posterior fricative outcomes (e.g., [ʃ]) were found in only two languages (Breton and Latvian). In other words, a typical outcome of coronal stop palatalization was the posterior affricate, rather than other types of consonants including posterior stops.

To sum up, cross-linguistically, coronal palatalization shows the following general characteristics. First, coronal palatalization is triggered by front vocoids. There was one marginal exception to this generalization. Second, all anterior consonants can be targeted by coronal palatalization, excluding rhotic consonants.

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[7] Among the ten languages in which palatalization of lateral consonants is attested, the outcome of the process was a palatal glide [j] rather than a posterior lateral [ʎ] in four languages (Amharic, Breton, Dhivehi, and Harari).

Third, coronal palatalization of stop consonants yields posterior affricates rather than posterior stops, in most cases.

In addition, two typological trends were observed from the results of the survey. First, among the trigger vocoids of coronal palatalization, high front vocoids are more likely triggers of the process, compared to non-high front vocoids. Second, among the target consonants, obstruent consonants are more likely targets of the process, compared to nasals, and nasals are more likely targets, compared to laterals. In the rest of this subsection, I will examine these typological asymmetries in detail, showing that these asymmetries are not just trends but implicational universals.

2.2.1. Trigger height asymmetry

It is well known that the typical triggers of coronal palatalization are front vocoids (e.g., Bateman 2007; Chen 1973). All front vocoids can be a trigger of the process, regardless of their length, rounding, or nasality. Several prior studies found that the differences in such features between front vocoids do not have significant effects on the ability to trigger the process (e.g., Bateman 2007: 63). The results of the current survey also show that such features do not have crucial roles in processes of coronal palatalization. For example, although unrounded front vocoids usually trigger coronal palatalization in most of the surveyed languages, there was also an apparent case in which only a high round vowel /y/ triggers the process (i.e., Cantonese: Alderete et al. 2017). However, unlike other vocalic features, it seems that vowel height is relevant to the distribution of coronal palatalization. Many previous studies have proposed that front vocoids with different heights asymmetrically trigger palatalization processes (Bateman 2007; Chen 1973; Kochetov 2011). The results of the current survey also show such a trend, as described in the table (6): high front vocoids are more likely triggers of coronal palatalization than non-high front vocoids.

In order to understand the effects of vowel height in coronal palatalization more precisely, I examined the patterns of coronal palatalization according to the height of its triggers in detail. The following table (8) shows a summary of the cross-linguistic patterns of coronal palatalization classified by the height of front vocoid triggers. In the below table, 'O' indicates that a relevant front vocoid can trigger coronal palatalization, while 'X' denotes that the corresponding front vocoid cannot trigger it. The mark '-' denotes that there is no corresponding vowel in the phonemic inventory of a given language.

(8) Patterns of coronal palatalization classified by height of front vocoid triggers

	high	non-high	languages
e.g.	*j, i*	*e, ɛ*	
a.	O	O	**13 languages:** Acoma, Amharic, Brazilian Portuguese, Coatzospan-Mixtec, Greek (Naousa), Hausa, Nupe, Polish, Slovak, Tera, Upper Sorbian, Wai Wai, West Futuna-Aniwa.
b.	O	-	**7 languages:** Bunun (Isbukun), Bunun (Takituduh), Cheyenne, Nanai, Nyawaygi, Tiwi, Yonaguni
c.	O	X	**41 languages:** Ainu, Apalai, Atayal, Breton, Cantonese, Dhivehi, Dutch, English, Fongbe, French (Acadian), Greek (Cypriot), Greek (Kos), Harari, Ikalanga, Ilocano, Japanese, Kirundi, Korean, Latvian, Logoori, Luvale, Mandarin, Maori, Marathi, Mbahám, Mina, Mongo, Nimboran, Nishnaabemwin, Oroqen, Romanian, Salar, Sanuma, Shaoxing Wu, Sonora Yaqui, Taiof, Tota Logba, Trentino Italian, Tswana, Udmurt, Zoque.
d.	X	O	**None**

(‘O’ = ‘trigger’, ‘X’ = ‘does not trigger’, ‘-’ = ‘no corresponding segment’)

From the list (8), two observations can be made, which show an implicational asymmetry between coronal palatalization triggers. First, in 13 out of 61 languages in which coronal palatalization is attested, coronal palatalization is triggered by both high and non-high vocoids. For instance, in Amharic, stem-final alveolar consonants undergo coronal palatalization when they are followed by suffixes with initial front vowels, such as a second person imperative marker /-i/ or a first person singular gerund marker /-e/ (Leslau 1995: 14ff). The examples in (9) illustrate the alternation between /t, s/ and posterior sibilants in Amharic.

(9) Coronal palatalization in Amharic (Leslau 1995: 14)

a. /kəffə**t**-i/ [kɨfə**t͡ʃ**i] ‘open, 2ND IMPR’

b. /məllə**s**-i/ [məllɨ**ʃ**i] ‘return, 2ND IMPR’

c. /kəffə**t**-e/ [kɨfə**t͡ʃt͡ʃ**e] ‘having opened, 1ST SG’

d. /məllə**s**-e/ [məllɨ**ʃʃ**e] ‘having returned, 1ST SG’

Second, 41 languages in (8c) show the pattern in which only a high front vocoid triggers coronal palatalization. A typical example of this type is Japanese. As already illustrated in section 1, in this language, coronal palatalization is triggered only by a high front vocoid (examples are adapted from Itô & Mester 1995 and Kochetov & Alderete 2011).

(10) Coronal palatalization in Japanese

a. /ka**t**-itai/ [ka**t͡ʃ**itai] ‘win, VOL’

b. /hana**s**-itai/ [hana**ʃ**itai] ‘talk, VOL’

c. /ka**t**-e/ [ka**t**e] ‘win, IMPR’

d. /hana**s**-e/ [hana**s**e] ‘talk, IMPR’

In (10a-b), coronal palatalization turns /t, s/ into [t͡ʃ, ʃ] before a high front vowel /i/.

However, the same process does not occur when /t, s/ are followed by a non-high vowel /e/, as exemplified in (10c-d).

To sum up, there are two types of languages with regard to triggers of coronal palatalization. In Amharic-type languages, not only high but also non-high front vocoids can be triggers of this process. In Japanese-type languages, however, only high front vocoids trigger it. Furthermore, as in (8d), there is no language in which only a non-high front vowel triggers coronal palatalization. Based on these results, the universal pattern of coronal palatalization triggers can be stated as follows:

(11) The implicational relationship between coronal palatalization triggers

If non-high front vowels trigger coronal palatalization, high front vocoids do so.

This statement is consistent with those of Bateman (2007), Chen (1973), Foley (1977), and Kochetov (2011) who asserted the same implicational relationship between the palatalization triggers. In addition, several studies (Blevins 2004; Guion 1996, 1998; Telfer 2006; Wilson 2006) have established the same type of implicational relationship between the velar palatalization triggers based on Bhat's (1978) data.

However, the implicational relationship in (11) cannot be a simple repetition of the findings of the prior studies; this study makes a distinct contribution from previous studies which propose same or similar typological statements as (11). First, given that Chen (1973) and Foley (1977) examined (coronal) palatalization patterns from a small number of languages (about ten languages which mainly consist of Indo-European languages), their findings can hardly be considered as truly ‘universal.’ The results of an in-depth and wide-scale survey performed in the present study suggest that the typological statement in (11) is a truly linguistic universal, strengthening their findings.

Second, survey studies by Bateman (2007) and Kochetov (2011) examined several distinct processes, including velar, labial, and coronal palatalization, and their generalizations were proposed based on the combined data of all the processes examined. Thus, their findings are not specific about coronal palatalization. Note that there is no guarantee that a generalization made from an entire dataset consisting of several parts should hold for each sub-part.

2.2.2. Target manner asymmetry

Coronal palatalization is a phonological process that turns alveolar consonants into palatal consonants. In principle, all anterior consonants can be targets of coronal palatalization. However, it seems that coronal palatalization does not equally target the anterior consonants with different manner features. According to Bateman (2007: 56), there is a typological tendency for targets of palatalization processes: obstruent consonants are palatalized most frequently, and the next likely targets are nasals followed by laterals. The same typological tendency was also observed from the results of the current survey. As already described in (7), obstruents are more likely to undergo coronal palatalization than nasals, and nasals are more likely to undergo the process than laterals.

In this subsection, this observed target asymmetry will be stated in a more restrictive way, based on the results of the more detailed examination of the coronal palatalization targets. The results of this in-depth survey presented in the following table show that the asymmetrical relationship between target consonants with different manner features is not just a typological tendency but an implicational universal.

(12) Patterns of coronal palatalization classified by target manners

	obstruent	nasal	lateral	languages
e.g.	*t, s*	*n*	*l*	
a.	O	O	O	**9 languages:** Amharic, Breton, Dhivehi, Greek (Cypriot), Harari, Korean, Latvian, Slovak, Udmurt.
b.	-	O	O	**1 language:** Greek (Kos).
c.	O	O	-	**7 languages:** Acoma, Apalai, Japanese, Kirundi, Nimboran, Taiof, Wai Wai.
d.	O	O	X	**13 languages:** Dutch, Ikalanga, Logoori, Luvale, Mandarin, Nanai, Nyawaygi, Polish, Shaoxing Wu, Tiwi, Trentino Italian, Tswana, Zoque.
e.	-	O	X	**1 language:** Mongo.
f.	O	X	-	**5 languages:** Ainu, Cheyenne, Maori, Nishnaabemwin, Yonaguni.
g.	O	X	X	**25 languages:** Atayal, Brazilian Portuguese, Bunun (Isbukun), Bunun (Takituduh), Cantonese, Coatzospan-Mixtec, English, Fongbe, French (Acadian), Greek (Naousa), Hausa, Ilocano, Marathi, Mbahám, Mina, Nupe, Oroqen, Romanian, Salar, Sanuma, Sonora Yaqui, Tera, Tota Logba, Upper Sorbian, West Futuna-Aniwa.
h.	X	O	X	**None**
i.	X	X	O	**None**
j.	X	O	O	**None**

(‘O’ = ‘targeted’, ‘X’ = ‘untargeted’, ‘-’ = ‘no corresponding segment’ or ‘targeted by an alternative phonological process’)

In the above table, ‘O’ indicates that a consonant produced with the corresponding manner-of-articulation can be a target of coronal palatalization, and ‘X’ denotes that a consonant with the corresponding manner is not a target of the process. The symbol ‘-’ indicates that there is no corresponding consonant in the phonemic inventory or that a corresponding consonant undergoes alternative phonological processes in the context where coronal palatalization targets other consonants. Such alternative phonological processes are attested in two languages. First, in Kos Greek (12b; Kochetov 2016: 22; Newton 1972: 167), a palatal glide /j/ undergoes glide strengthening after /t, s, z/ (e.g., /kra**sj**a/ → [kra**sc**a] ‘wines’), with the preceding consonant unchanged. Second, in Mongo (12e; Kenstowicz & Kisseberth 1979: 156; de Rop 1958: 9ff.), /t, d/ are affricated into [t͡s, d͡z] before high vocoids /i, j, w/, whereas /n/ palatalizes into [ɲ] only before front /i, j/.

In nine languages listed in (12a), coronal palatalization targets not only obstruent consonants but also nasal and lateral consonants. For example, in Slovak, /t, d, n, l/ undergo coronal palatalization before suffixes with initial front vowels. The examples given below describe this process (from Rubach 1993).

(13) Coronal palatalization in Slovak

a. /mies**t**-ɛ/ [mies**c**ɛ] ‘place, LOC SG’

b. /hra**d**-ɛ/ [hra**ɟ**ɛ] ‘castle, LOC SG’

c. /bah**n**-ɛ/ [bah**ɲ**ɛ] ‘ram, LOC SG’

d. /soko**l**-ɛ/ [soko**ʎ**ɛ] ‘falcon, LOC SG’

In contrast, only obstruent and nasal consonants undergo coronal palatalization in 13 languages in (12d). For instance, Dutch coronal palatalization can target any alveolar consonants excluding the lateral /l/, as illustrated in (14) (from Booij 1995: 151).[8]

(14) Coronal palatalization in Dutch

a. Ha**d** je? [hɑ**t͡ʃ**jə] ~ [hɑ**t͡ʃ**ə] 'had you?'

b. Wa**s** je? [ʋɑ**ʃ**jə] ~ [ʋɑ**ʃ**ə] 'were you?'

c. Ka**n** je? [kɑ**ɲ**jə] ~ [kɑ**ɲ**ə] 'can you?'

d. Za**l** je? [zɑ**l**jə] 'will you?'

Finally, only obstruent consonants undergo coronal palatalization in the languages listed in (12f-g). A useful example of this type is coronal palatalization in Naousa Greek. In this language, only alveolar sibilants /t͡s, s, z/ undergo coronal palatalization (15a-c), while the same process does not target alveolar sonorants /n/ and /l/ (15d-e).

[8] Among these Dutch examples, only (14a-c) are from Booij (1995: 151). Thanks to Clemens Poppe (personal communication, February 2018), the phonetic transcriptions are slightly modified with the addition of the example (14d).

(15) Coronal palatalization in Naousa Greek (Kappa and Sipitanos 2016: 64-65)

a. /korí**t͡s**i/ [kurí**t͡ʃ**i] 'girl, NOM SG'

b. /ská**s**i/ [ʃká**ʃ**i]~[ská**ʃ**i] 'it will burst'

c. /pé**z**i/ [pé**ʒ**i] 'play, 3RD SG'

d. /**n**istía/ [**n**iʃtía] 'fasting'

e. /ski**l**í/ [ʃci**l**í] 'dog, NOM SG'

In sum, it seems that there is an apparent implicational relationship between target consonants. If a lateral consonant undergoes coronal palatalization, then a nasal does so. In a similar fashion, if a sonorant consonant undergoes coronal palatalization, then an obstruent does so. There is no language in which only a nasal or a lateral undergoes coronal palatalization, as shown in (12h-j). Consequently, the implicational statement can be proposed as in (16).

(16) The implicational relationship between coronal palatalization targets

a. If laterals are targets of coronal palatalization, so are nasals.

b. If nasals are targets of coronal palatalization, so are obstruents.

This is consistent with, but more restrictive than, that of Bateman (2007: 56-57) which is a universal tendency. On the other hand, this finding is not in accordance with Bhat's (1978: 70-71) observation that apical nasals are the most frequent targets of palatalization processes along with sibilants. Since Bhat's data include many heterogeneous phonological processes (e.g., stop spirantization and secondary palatalization) simultaneously, it is quite dubious whether Bhat's generalization can independently be established for coronal palatalization targets. Note that no typological studies other than Bateman (2007) and Bhat (1978) clearly mentioned asymmetric relationships between non-rhotic target consonants. Although some studies (Hall 2000; Wlash Dickey 1997) have discussed the rare occurrence of rhotic palatalization across languages, they do not make any claim concerning the asymmetry between non-rhotic consonants.

2.3. Cross-linguistic patterns of coronal affrication

In this subsection, typological patterns of coronal affrication will be described, based on the results of the survey on 20 languages which encompasses 8 language families and 11 genera. As in the last subsection, the general characteristics of coronal affrication are described first, and then the asymmetries observed from the results will be examined in detail.

First, the statistics presented in (17) illustrates the occurrence rates of coronal affrication triggers:

(17) The distribution of coronal affrication by the height and frontness of the triggering vocoid (n = 20)

<table>
<tr><td colspan="2"></td><td colspan="3">frontness</td></tr>
<tr><td colspan="2"></td><td>front</td><td>central</td><td>back</td></tr>
<tr><td rowspan="2">height</td><td>high</td><td>19</td><td>1</td><td>6</td></tr>
<tr><td>non-high</td><td colspan="3">0</td></tr>
</table>

The above table shows that coronal affrication is only triggered by high vocoids, without exception. At least in my data, there was no language in which coronal affrication is conditioned by non-high vowels (e.g., /e, o, a/). Note that this result is in a sharp contrast with the pattern of coronal palatalization triggers. As generalized in the last subsection, coronal palatalization is (almost) exclusively triggered by front vocoids. There was only marginal evidence which shows that coronal palatalization can be triggered by non-front vocoids.

In addition, the table in (17) also shows that there exists an asymmetrical trend between the affrication triggers: in general, high front vocoids are more likely triggers of coronal palatalization, compared to high central/back vocoids. High front vocoid triggers were attested in most of the surveyed languages in which coronal affrication is attested (19 out of 20 languages, 95%), whereas high back vocoid triggers were attested in a relatively small number of languages (6 out of 20 languages, 30%). There was only one language in which a high central vowel trigger is attested (Papago: Hale 1965). This asymmetrical trend shown between coronal affrication triggers will be examined in detail in the following subsection 2.3.1.

Second, the occurrence rates of the target stop consonants according to their voicing is given in the following table:

(18) The distribution of coronal affrication by voicing of target consonants (n = 20)

voiceless	*voiced*
19	9

This table shows that there is an evident asymmetry between the target stops of coronal affrication. Among the 20 languages with coronal affrication, a voiceless stop (e.g., /t/) undergoes the process in 19 languages (95%) whereas a voiced stop (e.g., /d/) does so in only nine languages (45%). Thus, it can be stated that voiceless stops are more likely targets of coronal affrication, compared to voiced stops.

To sum up, the general characteristics of coronal affrication can be summarized as follows: coronal affrication is triggered exclusively by high vocoids, turning anterior stops into corresponding anterior affricates. There was no exception to this generalization. In addition, it seems that there are typological trends regarding the triggers and the targets of coronal affrication. First, high front vocoids are more likely triggers of coronal affrication, compared to high central/back vocoids. Second, voiceless stops are more likely targets of coronal affrication, compared to voiced stops. In the rest of this subsection, I will closely examine these two typological trends. As in coronal palatalization, the results of the survey show that these two asymmetrical relationships are implicational universals, rather than just typological trends which allow exceptions.

2.3.1. Trigger frontness asymmetry

The table given below sorts the typological data of coronal affrication according to the frontness of the trigger vocoids:

(19) Patterns of coronal affrication classified by frontness of high vocoid triggers

	front	central/back	languages
e.g.	*i, j*	*ɨ, u, w*	
a.	O	O	**5 languages:** Maori, Mongo, Papago, Taiof, Tota Logba,
b.	-	O	**1 language:** Japanese.
c.	O	X	**14 languages:** Axininca Campa, Blackfoot, Cheyenne, Dutch, Fongbe, French (Quebec), German, Kirundi, Plains Cree, Romanian, Samoan, Slovak, Tswana, West Greenlandic.
d.	X	O	**None**

(‘O’ = ‘trigger’, ‘X’ = ‘does not trigger’, ‘-’ = ‘trigger an alternative process’)

In the preceding table, ‘O’ indicates that coronal affrication is triggered by the corresponding class of high vocoids. ‘X’ indicates that the corresponding high vocoids do not trigger coronal affrication. Additionally, the symbol '-' denotes that the corresponding vocoid triggers an alternative phonological process. Only one language falls in this category. In Japanese (19b; Itô & Mester 1995 and Kochetov & Alderete 2011), coronal stops are targeted by coronal palatalization before high front vocoids, as already exemplified in (1).

This table shows that high front and central/back vocoids tend to trigger coronal affrication to a different degree. First, both high front and central/back vocoids trigger coronal affrication in five languages listed in (19a). Tota Logba would be an example of this type of languages. In Tota Logba, /t, d/ are usually affricated before /i, u/, being realized as [t͡s, d͡z] (Dorvolo 2008: 34). Examples of Tota Logba coronal affrication are given below:

(20) Coronal affrication in Tota Logba (Dorvolo 2008: 18, 34)

a. /a**t**í/ [a**t͡s**í] 'night'

b. /u**t**í/ [u**t͡s**í] 'father'

c. /o**t**ú/ [o**t͡s**ú] 'hill'

d. /o**d**ú/ [o**d͡z**ú] 'river'

Second, in fourteen languages listed in (19c), coronal affrication is triggered only by high front vocoids. For instance, in Quebec French, coronal affrication occurs only before high front vocoids such as [i, j, y, ɥ] (Pappen 1998: 165; Kim

2001: 91-92). The following examples illustrate coronal affrication in Quebec French:

(21) Coronal affrication in Quebec French (Kim 2001: 91-92)

a.	***t**ype*	[**t͡s**i]pe	'type'
b.	***t**iens*	[**t͡s**j]ens	'(I) hold'
c.	***T**urc*	[**t͡s**y]rc	'Turk'
d.	***t**uer*	[**t͡s**ɥ]er	'to kill'
e.	***t**outou*	[**t**u]tou	'puppy'

Furthermore, there is no language in which coronal affrication is triggered only by high central or back vocoids. Therefore, the results of the typological survey discussed thus far can be formulated as an implicational statement between the triggers of coronal affrication:

(22) The implicational relationship between coronal affrication triggers

If high central/back vocoids trigger coronal affrication, high front vocoids do so.

To the best of my knowledge, no previous studies have proposed this statement specifically about coronal affrication. Kochetov (2011: 1673) made the corresponding statement for the triggers of palatalization, but his term 'palatalization' refers to not only coronal affrication but also several other processes including coronal palatalization. Recall from section 2.2 that the triggers of coronal palatalization are subject to even stricter restrictions, that is that only front, as opposed to central or back, vocoids are attested as a trigger of coronal palatalization. Consequently, patterns of coronal affrication and palatalization show distinct universal restrictions with respect to the triggering segments, suggesting that the two processes may be fundamentally distinct.

2.3.2. Target voicing asymmetry

As pointed out by Hall & Hamann (2006), voiceless stops (e.g., /t/) are more likely to be targeted than voiced ones (e.g., /d/) by coronal affrication (and other assibilating processes, e.g., stop spirantization). As illustrated in (19), the current typology also shows such a pattern: in general, voiceless stops (attested in 19 out of 20 languages) are more likely to undergo coronal affrication than voiced stops (attested in 6 out of 20 languages).

The table in (23) summarizes all the attested patterns according to the voicing of coronal affrication target stops:

(23) Patterns of coronal affrication classified by target stop voicing

	voiceless	voiced	languages
e.g.	*t*	*d*	
a.	O	O	**8 languages:** Fongbe, French (Quebec), Japanese, Mongo, Papago, Slovak, Taiof, Tota Logba.
b.	-	O	**1 language:** Kirundi.
c.	O	-	**1 language:** Romanian.
d.	O	-	**8 languages:** Axininca Campa, Blackfoot, Cheyenne, Maori, Plains Cree, Samoan, Tswana, West Greenlandic.
e.	O	X	**2 languages:** Dutch, German.
f.	X	O	**None**

('O' = 'targeted', 'X' = 'untargeted', '-' = 'no corresponding segment' or 'targeted by an alternative phonological process')

In the above table, the symbol 'O' denotes that a stop with the corresponding voicing value can be targeted, while 'X' indicates that a consonant with the corresponding voicing value cannot be targeted. The '-' mark refers to cases in which there is no voicing contrast between stops or represents that a corresponding consonant undergoes alternative phonological processes in the coronal affrication context. Such alternative processes are attested in two languages. First, in Kirundi (23b; Kochetov 2016: 8), /t/ undergoes spirantization into /s/ before /j/ (e.g., /ja-roo**t**-je/ → [jaɾoː**s**e] 'dream 3RD SG PAST'). Second, in Romanian (23c; Chitoran 2002: 187; Hall & Hamann 2006: 1204), /d/ undergoes spirantization into /z/ (e.g., /kru**d**-ime/ → [kru**z**ime] 'cruelty') in the context where /t/ undergoes coronal affrication.

Let us consider each pattern in (23). First, eight languages in (23a) show coronal affrication which targets both voiceless and voiced stops. A case in point is coronal affrication in Mongo. In this language, not only voiceless /t/ but also voiced /^{n}d/ undergo coronal affrication before high vocoids /i, j/ and /w/, being realized as alveolar affricates [t͡s] and [^{n}d͡z] respectively (de Rop 1958: 9ff; Kenstowicz & Kisserberth 1979: 156). Examples of Mongo coronal affrication are shown in (24).

(24) Coronal affrication in Mongo (de Rop 1958: 9-10)

a.	/bo-lo**t**-i/	[bolo**t͡s**i]	'fugitive'
b.	/bɔ-kɛ^{n}**d**-wá/	[bɔkɛ^{n}**d͡z**wá]	'inconstant'

Second, in two languages listed in (23e), only voiceless stops undergo coronal affrication. A typical example of this pattern can be drawn from German. According to Hall (2004), in German, /t/ undergoes coronal affrication before a high front glide /j/ (25a), but the same process does not target /d/ (25b).

(25) Coronal affrication in German (Hall 2004)

a.	*Konsor**t**ium*	[kɔnˈzɔɐ**t͡s**jʊm]	'syndicate'
b.	*Stu**d**ium*	[ʃtuː**d**jʊm]	'studies, SG'

Also, as in (23f), there is no case where coronal affrication exclusively targets voiced stops. Therefore, from the results of the typology summarized in (23), the following implicational universal can be derived:

(26) The implicational relationship between coronal affrication targets

If voiced stops are targets of coronal affrication, so are voiceless stops.

Although several previous studies reported the preference for voiceless stop targets over voiced ones, none of them were specifically about coronal affrication. Hall & Hamann (2006) established an implicational relationship, equivalent to (26), for the combined data of assibilation processes, one of which is coronal affrication. As mentioned in section 2.2.1, note that a generalization made from the combined data of several different processes does not necessarily hold for the data of each individual process.

2.4. Process-specificity of triggers

In this section, the results of the typological survey showed the dependency between the front vocoid triggers and coronal palatalization and that between the high vocoid triggers and coronal affrication. As presented above, coronal palatalization is exclusively triggered by front vocoids, and coronal affrication is only triggered by high vocoids. Among the 69 surveyed languages, there was only one exception to this generalization: coronal palatalization in Mbahám.

According to Cottet (2015: 213), in Mbahám, anterior stops /t, d, ^{n}d/ allophonically alternate with [t͡ʃ, d͡ʒ, ^{n}d͡ʒ] before high vocoids /i, j, u, w/ which precede other vowels. E.g., /**t**úon/ → [**t͡ʃ**ú.on] ‘thigh’ and /^{n}**d**úoŋ/ → [^{n}**d͡ʒ**ú.oŋ] ‘to cut’ (Cottet 2015: 213). However, it seems that this cannot be considered as crucial evidence for the presence of the non-front palatalization triggers due to the following reasons. First, although Cottet (2015) describes the outputs of this process using IPA symbols for palato-alveolar affricates, she does not explicitly mention the exact place-of-articulation of these outcomes in phonetic terms. In fact, it seems that this palatalizing process is not a categorical one. In Cottet (2014), she illustrates that these outcomes can have variable surface forms, including alveolar affricates (e.g., [t͡s]), thus suggesting coronal affrication rather than palatalization. Second, there is a description which is inconsistent with that of Cotte (2014, 2015). According to Flassy (1987: 25ff.), Mbahám coronal stops have palato-alveolar stop allophones, such as [t̠, d̠] (which he describes [tʲ, dʲ]), only before a high front vocoid, for example, /wa’**t**jaːkop/ → [wa’**t̠**akopʰ] ‘turtle’. For those occurring before high back vocoids, he does not report such a palatalizing process, for example, /**t**we**t**we/ → [**t**wɛ**t**wɛ] ~ [**d**wɛ**d**wɛ] ‘vegetable’ (Flassy 1987: 28). Although I followed Cottet’s (2015) description since it is based on the results of the more recent field work, for the aforementioned reasons, it was difficult to establish whether high back vocoids /w, u/ may trigger coronal palatalization in this language or not.

Note that this observed process-specificity of triggers is not consistent with the typological descriptions of some previous typological studies (e.g., Bateman 2007; Kochetov 2011). According to the previous studies (Bateman 2007; Kocehtov 2011), there is an apparent trigger asymmetry in palatalization processes: if palatalization is triggered by a central/back vocoid, then it is also triggered by a high front vocoid. This generalization about the trigger frontness asymmetry in palatalization processes cannot stand with the process-specificity proposed in this study since it implies that high central/back vocoids can trigger not only coronal affrication but also coronal palatalization. The cases which have been illustrated as having a high central/back vocoid trigger in previous studies (Bhat 1978; Bateman 2007; Cottet 2015; Leung 1991; Kochetov 2011) are described in below (27).[9]

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[9] According to some previous studies (Bateman 2007; Bhat 1978) not only languages described in (27) but also some other languages also show palatalization processes before a central/back vocoid. However, I did not discuss these additional cases in detail since these cases do not satisfy the criteria of the current study given in (4). First, although Bhat (1978) describes that /s/ can be palatalized before a high back vowel in Basque, I was able to find only evidence of postvocalic coronal palatalization after a high front vocoid in this language (see section 5.3 for more details). Second, Sentani coronal palatalization is also not considered here because it only occurs in the postvocalic context (Bateman 2007). Furthermore, as I will discuss in Note 15 in section 5.3, the presence of the high back vowel trigger in this language is not obvious. Third, although Bhat (1978) also describes that anterior consonants were palatalized before a high back vowel in Tepehuan and Proto-Iranian, these cases are clearly not synchronic processes (see Miller 1967 for Tepehuan and Andersen 1968 for Proto-Iranian). Fourth, in Coatzospan Mixtec, only secondary palatalization of /t, ^{n}d/ is conditioned by high back vowel /ɨ, u/, resulting in [t^{j}, nd^{j}] (Grefen

(27) Palatalization processes triggered by high central/back vocoids

a. In Logoori, /n̪/ alternates with [ɲ] before a back vowel /u/ (Leung 1991: 45-46).

b. In Maori, /t/ is basically affricated to [t͡s] before a final devoiced /i/ or /u/, and sometimes it optionally alternates with [tç] in the same context (Bateman 2007: 410-2; Bauer 1993).

c. In Mongo (also known as Lomongo), alveolar stops are palatalized before high front and high central/back vocoids. E.g., /kond-wa/ → [kond͡ʒwá] 'cover with sand, PASS' (Kochetov 2011: 1672; Kenstowicz & Kisserberth 1979).

d. In Papago (also known as Tohono O'Odham), before /i, e, u/, /t, d/ undergo coronal palatalization into [t͡ʃ, d͡ʒ], and /n/ undergoes secondary palatalization into [nʲ] (Bhat 1978: 54; Bateman 2007: 477-8; Mason 1950).

According to the prior studies (Bhat 1978; Bateman 2007; Kochetov 2011), phonological processes described in (27) can be supportive evidence for the presence of the non-front palatalization triggers. However, these cases need to be

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1999). To the best of my knowledge, this language, Coatzospan Mixtec, is the only language in which the presence of any kind of synchronic palatalization triggered by non-front vocoid is supported by phonetic observations.

examined in more detail since the evidence from other phonetic/phonological studies suggests that coronal palatalization in the languages listed in (27) in fact do not occur before a high central/back vowel, or at least that the evidence for such a process is highly questionable.

First, Leung's analysis of Logoori (27a) is based only on the fact that the [n̪u] sequence never occurs at the surface. In this language, a posterior nasal [ɲ] can be found before /i/ and /u/ while a dental nasal [n̪] does not occur in these contexts; in the non-high vowel contexts, however, these two nasal consonants are phonemically contrastive, as in [kʊman̪a] 'to know' *vs*. [kʊt͡ʃuːkaɲa] 'to stir' (Leung 1991: 46). Based on this distribution of the two coronal nasal segments, Leung (1991) argues that a dental /n̪/ is neutralized into a posterior /ɲ/ before /i/ and /u/. The evidence of this neutralization is easily observable before the high front vowel /i/, as in /kʊ-kɪ-j̪en̪-a/ → [kʊt͡ʃeːn̪a] 'to want it' *vs*. /kʊ-kɪ-j̪en̪-i/ → [kʊt͡ʃeːɲi] 'we have just wanted it' (Leung 1991: 45). However, as admitted by Leung (1991: 45), there is no supportive evidence which shows an alternation between /n̪/ and /ɲ/ before the high back vowel /u/. That is, unlike the neutralization before the high front vowel /i/, there is no empirical reason for considering that the non-occurrence of the dental nasal before /u/ is a result of coronal palatalization into the posterior nasal. Furthermore, given that Logoori has an additional coronal nasal phoneme /n/, it is also possible to claim that /n̪/ is neutralized into [n], rather than [ɲ], before /u/, based on the same observation regarding the distribution of nasal sounds. Due to these reasons, it is difficult to ensure that /n̪/ is palatalized into [ɲ] not only before /i/ but also /u/.

Second, in Maori (27b), /t/ is usually affricated, rather than palatalized, before unstressed and devoiced high vowels such as /i, u/, being realized as [t͡s] (Bauer 1993: 521; Harlow 2006: 76). Although Bateman (2007: 411) gives an example in which /t/ is realized as [t͡s] or [t͡ç] in the [_i] context based on Bauer (1993: 521, /iti/ → [it͡si] ~ [it͡çi] 'small'), she does not give an example of optional palatalization in the high back vowel context.[10] Whereas coronal affrication is apparent in the both high front and back contexts in Maori, it is highly obscure whether the optional coronal palatalization really targets /t/ in the high back context or not.

Third, although Kochetov (2011: 1672) illustrates that Mongo alveolar stops are neutralized into palatal affricates even before /w/ as in (27c), it seems that this description does not agree with Kenstowicz & Kisseberth's (1979) which is the source of Kochetov's description. Kenstowicz & Kisseberth (1979: 156) states that "there is a rule whereby *t*, *d* and *l* are affricated to *ts*, *j* (= *dz*), and *j* (= *dz*), respectively, when followed by a glide, *w* or *y*." In addition, de Rop (1958) also describes these Mongo affricates as alveolars rather than palatals.

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[10] Note that Bateman's description about Maori affrication is largely based on Bauer (1993: 521) who states that "[w]ith /t/, affrication is also heard before a devoiced final /i/ or /u/, which is unstressed. (Biggs (1969, 9) comments that /t/ may be palatalized in this environment), thus the following pronunciations can be heard:

piu	'swing'	[pç(i)u]
iti	'small'	[it͡si] [it͡çi] "

However, I could not find any comments about optional palatalization in the [_u] context from the recent edition of Biggs's (1998) book or any other sources.

Fourth, Bateman's description of the phonological processes in Papago (27d) is also not consistent with the many phonetic or phonological descriptions about this language. According to the studies on Papago phonetics and phonology (Dart 1993; Hale 1965; Saxton 1963), Papago /t, d/ and /n/ are neutralized into laminal alveolar consonants /t͡s, d͡z/ and /n̻/, respectively, rather than into /t͡ʃ, d͡ʒ/ and /nʲ/, before high vowels /i, ɨ, u/. Furthermore, although Bateman (2007) describes that not only high vowels /i, u/ but also a front vowel /e/ trigger palatalization processes in this language, in fact, there is no front /e/ in Papago language (Dart 1993; Hale 1965). This is a misinterpretation of a high central vowel /ɨ/, possibly due to the orthographic convention. [11] Therefore, Papago alveolar consonants undergo coronal affrication and laminalization before /i, ɨ, u/, rather than coronal palatalization and secondary palatalization before /i, e, u/.

Consequently, it can be concluded that the presence of the frontness asymmetry in palatalization processes proposed by the previous studies (Bhat 1978; Bateman 2007; Kochetov 2011) is highly questionable. Based on the detailed observations described here, I introduce the following generalizations on the triggers of the two processes, contrary to the descriptions provided by the previous studies:

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[11] The results of the detailed phonetic investigation conducted by Dart (1993) clearly support the claim that Papago does not have palatal affricates and non-high front vowels. According to Dart, a laminal alveolar consonant, such as /d͡z/, is produced without palatal articulation, and the F2 values of /ɨ/ are almost same with those of /a/, indicating that this sound is not a front vowel.

(28) Process-Specificity of Triggers

a. Coronal palatalization is exclusively triggered by front vocoids.

b. Coronal affrication is exclusively triggered by high vocoids.

2.5. Summary

In this section, the results of the typological survey on coronal palatalization and coronal affrication were presented. The current typological survey yielded four implicational statements, two about coronal palatalization and two about coronal affrication, which are summarized in (29).

(29) The implicational statements about coronal palatalization and affrication

a. Trigger height asymmetry in coronal palatalization

   Non-high front vocoids do not trigger palatalization unless high front vocoids do so.

b. Target manner asymmetry in coronal palatalization

   Laterals do not undergo palatalization unless nasals do so, and nasals do not undergo palatalization unless obstruents do so.

c. Trigger frontness asymmetry in coronal affrication

   High back or central vocoids do not trigger affrication unless high front vocoids do so.

d. Target voicing asymmetry in coronal affrication

   Voiced stops do not undergo affrication unless voiceless stops do so.

Given that the present survey was performed separately and exclusively on coronal palatalization and affrication, none of the above universals should simply be considered as a repetition of the finding reported in the previous studies which have conflated several distinct phonological processes into one (Bateman 2007; Hall & Hamann 2006; Kochetov 2011). First, as I already mentioned, there is no guarantee that a generalization made from an entire dataset consisting of several parts should hold for each sub-part. In other words, a generalization that is established in a set of several phonological phenomena is not necessarily valid for each of those phenomena. For example, although the previous studies have suggested that the trigger height asymmetry (29a) may hold for coronal affrication or that the trigger frontness asymmetry (29c) may be established for coronal palatalization (e.g., Bateman 2007; Kochetov 2011), the results of the current typological survey show that this is not really the case. Second, although Bateman (2007) reports that there is a cross-linguistic tendency involving an asymmetry among manners of articulation of the target consonants, which is possibly equivalent to (29b), this generalization is in fact less restrictive than (29b). While Bateman's generalization is just a typological tendency which is observed across several distinct 'palatalization' processes (including not only coronal palatalization but also velar palatalization or secondary palatalization), this study clearly shows that, at least about coronal palatalization, there is a stronger restriction on the targets of the process.

Besides these implicational relationships, the results of the current survey also showed that there is an obvious process-specificity of triggers, which is almost certainly an absolute universal. As stated in (28), coronal palatalization is exclusively triggered by front vocoids while coronal affrication is only triggered by high vocoids. At least in my typology, there was no indisputable evidence which can falsify this generalization. To the best of my knowledge, there is no previous typological literature which stated this process-specificity of triggers. This is not surprising, given the fact that the current survey is the very first survey which systematically compares the typology of coronal palatalization and that of coronal affrication.

In summary, the results of the current typology, in general, showed that each of the two processes has its own trigger and target asymmetries and that there exists an evident process-specificity of triggers. Thus, based on these results, it can be suggested that these two processes are at least phonologically distinct from each other, casting doubt on the conventional assumption which considers them as subtypes of a single phonological phenomenon (e.g., Bhat 1978; Hall & Hamann 2006; Kochetov 2011). By contrast, the typological results of the current study are consistent with the Vowel-Place approach to palatalization which asserts that only processes involving changes in relevant place features can be considered as coronal palatalization and predicts that only front vocoids can be grammatically licit triggers of the process (e.g., Hume 1992; Clements & Hume 1995).

At the same time, however, these results also show various typological patterns that are not predicted by the Vowel-Place approach, such as implicational universals presented in (29) since this approach does not consider vowel height or manner features as crucial factors. For instance, Hume's (1992) model described in (3) predicts that all front vocoids, including a low front /æ/, equally well trigger coronal palatalization. Although this model correctly predicts that the dependency between front vocoid - coronal palatalization (28a) and properly captures the differences between coronal palatalization and affrication, there is no way to explain these observed implicational universals in this model. After investigating the phonetic underpinnings of the two processes in the next section, a new analysis which can provide an account for these typological asymmetries will be suggested in section 4.

3. Phonetic Groundings

In the last section, I have proposed that coronal palatalization and coronal affrication are phonologically separate processes based on the results of the cross-linguistic investigation. Bearing this conclusion of the last section in mind, this section discusses the phonetic underpinnings of these two processes and their cross-linguistic asymmetries. The crucial questions are twofold. First, why do these two processes show such different typological patterns? Second, why are certain types of segments preferred as triggers or targets of the two processes compared to other types of segments? In seeking answers to these questions, throughout this section, I will discuss the phonetic properties of the two processes, especially focusing on the relevant acoustic and perceptual properties. As a result of this investigation, it will be shown that the relative perceptibility of the contrast involved in each of the two processes, namely ‘the anteriority contrast’ for coronal palatalization and ‘the stridency contrast’ for coronal affrication, correlates well with its observed typological asymmetries.

3.1. Phonetics of coronal palatalization

This subsection discusses the acoustic cues and perceptual properties of coronal consonants in the prevocalic context, mainly focusing on the perceptibility of the feature [anterior]. Note that the contrast between anterior and posterior consonants, the anteriority contrast, includes not only a contrast between anterior and laminal posterior consonants (e.g., [s] *vs*. [ʃ]) but also that between anterior and apical posterior ones (e.g., [s] *vs*. [ʂ]). Since this section aims at the investigation of the phonetic relevance of coronal palatalization, I focus here on the anteriority contrast between anterior and laminal posterior consonants which are the typical targets and outcomes of palatalization, respectively. As a basis for this phonetic investigation, an overview of potential sources for the cues to the anteriority contrast is given here.

Let us start with potential acoustic cues that are available for stops. It is well known that stop burst noise and formant transitions play important roles in the perception of the place of stop consonants (e.g., Dorman et al. 1977). Although both acoustic sources can provide sufficient cues to the place contrasts for stops, speakers generally rely more on the formant transition to detect a place of stop consonants (Wright 2004: 43). For example, according to Walley & Carrell (1983), when the release spectrum and the F2 transition provide conflicting cues to the contrasts between velar, coronal, and labial stops, listeners perceive place of stop consonants based on the information provided by the formant transition.

Regarding the contrasts between coronal stops, mainly three acoustic sources have been considered as potential cues to place contrasts among coronal stops: the stop burst spectra, consonant-to-vowel (henceforth CV) F2 transition, and vowel-to-consonant (henceforth VC) F3 transition.

First, the stop burst noise may provide cues to the contrasts between coronal stops (Ohala & Ohala 2001). However, it seems that the differences in burst noise spectra between the four coronal stops, [t], [t̪], [ʈ], and [t̠], charicaterize their apicality, rather than their anteriority. According to Ladefoged and Maddieson (1996: 30), mean spectra of the release bursts of the two apical coronal stops, [t] and [ʈ], are almost same, showing the strong mid-frequency peak. Similary, the burst spectra of the two laminal coronal stops [t̪] and [t̠] are also not much different, showing tendency for "amplitude to decrease monotonically as frequency increases." Therefore, it seems that the anteriority contrast between apical coronals or between laminal coronals cannot easily be distinguished by their differences in burst noise spectra. Furthermore, Ladefoged (2001: 142-143) shows that the difference in burst noise between these four coronal stops is, in fact, very subtle, especially in terms of their frequencies. Although a laminal anterior [t̪] has a relatively higher burst frequency and a laminal posterior [t̠] has a lower burst frequency compared to those of [t] and [ʈ], their differences are not significant (about 3,200Hz for [t̠], 3,800Hz for [ʈ], 4,000Hz for [t], and 4,200Hz for [t̪] respectively; rough estimation from the spectrograms provided by Ladefoged 2001: 143). Given these phonetic facts, it can be expected that the burst noise cue can only give cues to the apicality contrast among coronal stops, rather than giving cues to the anteriority contrast between coronal stops in general.

The second is the F2 transition. It may also provide cues to the contrast between coronal consonants, especially in the CV context. Most of all, it is quite clear that F2 formant transition can provide cues to the contrast between a laminal posterior stop, [t̠] or [c], and other coronal stops, since laminal posterior stops are clearly distinguished by their higher F2 values from the other coronal stops, signaling that the stop closure is formed behind of the alveolar zone. However, at the same time, it seems that the F2 transition cannot provide a sufficient cue to the contrast between other non-palatal coronal stops, such as [t], [t̪], or [ʈ]. It has also been argued that F2 frequencies of alveolars, such as [t], and those of dentals, such as [t̪], are almost identical in the CV contexts (Hamilton 1996; Evans 1985), and the formant values of an alveolar stop [t] and those of an apical posterior stop [ʈ] are also indistinguishable in the CV context. Formant loci averages for Gooniyandi coronal stops shown in (30) may well illustrate these differences in formant values between coronal stops (McGregor 1990: 56). In the below data, while the higher F2 frequencies for the laminal posterior stop (2,200Hz) are clearly detectable, the differences in the F2 values of other three coronal stops are relatively small (1,600Hz for [t̪], 1,750Hz for [t], and 1,600Hz for [ʈ] respectively).

(30) Stop loci averages for Gooniyandi

	t̪	t	ʈ	t̠
F2	1,600	1,750	1,600	2,200
F3	2,500	2,750	1,800	3,000

Third, the listeners may rely on the VC F3 transition in order to identify the place of coronal stops. It has been widely argued that listners rely more on the VC F3 transition cue in the perception of the contrasts between the coronal stops, especially those between the retroflex stop [ʈ] and other coronal stops (Hamilton 1996; Öhman 1966; Narayanan & Kaun 1999; Steriade 1995). As illustrated in (30), a laminal posterior [t̠] has relatively higher F3 values (3,000Hz) compared to anterior stops [t̪] and [t] (2,500Hz and 2,750Hz respectively), and the F3 values of these anterior stops are significantly distinguished from those of an apical posterior [ʈ] (1,800Hz).

Based on these phonetic observations, we can expect that each of these three potential acoustic cues (the stop burst spectra, the CV F2 transition, and the VC F3 transition) contribute differently in the perception of the contrasts between coronal stops. First, the contribution of the burst spectra may not be significant, although they can provide cues to the apicality contrast between the coronal stops in a limited fashion (e.g., [t, ʈ] *vs*. [t̪, t̠]). Second, the F2 transition in the CV context only can provide a reliable cue to the contrast between a laminal posterior consonant [t̠] and other coronal stops. The contrasts between other coronal stops, [t], [t̪], and [ʈ], are not properly cued by the F2 transition. Third, the listeners may rely on the VC F3 transition rather than the CV F2 transition, in order to discriminate [ʈ] from anterior coronal stops [t] and [t̪].

Bearing these phonetic observations in mind, consider Anderson's (1997) perception data from Western Arrente. In this perception experiment, Anderson compares rates of correct identification for stops with different place features, namely four coronal stops [t̪, t, ʈ, t̠] and two non-coronal stops [p, k], both in CV and VCV conditions. The results of Anderson's test show that, among coronal stops, only a laminal posterior stop [t̠] is correctly indentified by listeners in both VCV and CV conditions (99% in the VCV condition and 94% in the CV condition) while other coronal stops ([t̪, t, ʈ]) are easily confused with each other in the CV condition. First, the rates of the correct identification of an apical anterior [t] and an apical posterior [ʈ] are significantly decreased in the CV condition (35% for [t], and 19% for [ʈ]), compared to those in the VCV situation (70% for [t], and 74% for [ʈ]). In the CV condition, [t] is usually misidentified as [ʈ] (28%) or [t̪] (27%), and [ʈ] is generally confused with [t] (18%) or [t̪] (47%). Second, the rates of the correct identification of a laminal anterior [t̪] is also decreased, but to a lesser degree, in the CV situation (83%) compared to those in the VCV condition (96%). The listeners occasionally misidentified [t̪] as [t] or [ʈ] in the CV condition (4% for each apical stops). In contrast, the listeners did not misperceive [t̠] as any of the other coronal stops, nor the other way around, in both CV and VCV conditions.

From the results of Anderson's (1997) test, the following conclusions can be drawn. First, it seems that the listeners do not rely much on either stop burst spectra and or CV F2 transitions, in the perception of the place contrasts between [t], [t̪], and [ʈ]. Although these cues were available in both VCV and CV contexts, the rates of the correct identification of these non-palatal stops were siginficantly decreased in the CV situation. Second, it seems that the listeners rely much on the CV F2 transition in order to distinguish a laminal posterior [t̠] from other three coronal stops. Although it is also possible to attribute the observed inconfusability between the two apical consonants and [t̠] to the differences in stop burst spectra between apical and laminal stops, given the fact that the two laminal consonants [t̪] and [t̠] which have similar burst spectra are rarely confused with each other, it can be concluded that the role of the stop burst spectra in the perceptual discrimination of [t̠] from other coronal stops is, at best, limited. Third, given the fact that the rates of the misidentification of non-palatal stops were significantly increased in the CV context in which the CV F3 cues are not available, it can be concluded that the CV F3 transition is important to correctly identify the place of non-palatal coronal stops, namely [t], [t̪], and [ʈ].

For sibilants, the frication noise spectrum and formant transitions can provide potential cues to the anteriority contrast. Although some studies have pointed out that the F2 transition can provide a sufficient cue to the place contrast for sibilants without the help of the frication noise (Mann & Repp 1980; Nittrouer & Studdert-Kennedy 1987; Whalen 1981), it has been widely argued that the spectral mean or Center of Gravity (CoG) of the noise is a more reliable cue to the contrast between sibilants (e.g., Boersma & Hamann 2008; Jongman et al. 2000). However, it seems that contribution of the frication noise in anteriority perception is quite relative across languages.

Note that CoG values are not solely determined by the anteriority/posteriority of the sibilants. Instead, it seems that CoG values are affected by other factors, such as lip rounding or the presence of a sublingual cavity, resulting in significantly lowered CoG values (Ladefoged & Maddieson 1996: 158, 358). In a language like English or French, a lip-rounded palato-alveolar [ʃʷ] has a distinctly lower spectral mean (about 4,000 Hz) compared to that of an anterior [s] (about 6,500 Hz) since the addition of lip-rounding to a sibilant significantly lowers the spectral mean values. According to Jongman et al. (2000), the difference in spectra mean between English anterior /s, z/ and posterior /ʃ, ʒ/ was about 2,000 Hz. Similarly, an apical posterior, such as [ʂ], can be reliably discriminated from an anterior [s] since its retracted and flat tongue gesture creates a sublingual cavity which significantly lowers CoG values. In Polish, a CoG value of /ʂ/ (2,803 Hz) makes a clear contrast with that of /s/ (8,438Hz), with a difference of nearly 6,000 Hz between the former and latter.

By contrast, it seems that the difference in CoG values between an alveolar [s] and laminal posterior sibilants, such as [ʃ], may not be so significant. The following table describes the mean CoG values of sibilant sounds across seven languages, based on the data provided in Gordon et al. (2002).

(31) Average gravity centers in Hz of sibilants in seven languages

language	Chiksaw	Western Apache	Gaelic	Western Aleut	Montana Salish	Hupa	Toda
[s]	5,163	5,461	4,884	5,129	4,601	4,797	4,529
[ʃ]	4,679	4,859	4,396	4,648 ([ç])	4,134	4,440	4,704
difference ([s]-[ʃ])	483	602	488	481	467	357	-157

Although CoG values for anterior sibilants are consistently higher than posterior sibilants in six languages except for Toda, the differences in CoG values between the two sibilants are relatively insignificant, compared to those between English or Polish sibilants. Other languages also show relatively small differences in CoG between two sibilants (e.g., Dutch: Ooijevaar 2011, Japanese: Toda 2007; Li et al. 2009). Note that such a relatively small difference in CoG values between anterior and posterior sibilants can make it hard to distinguish two sibilants based only on the spectral information. In such languages which have relatively confusable internal cues, the listeners may rely on the transitional cue to detect a place of sibilant consonants since laminal posterior sibilants, such as [ɕ] or [ʃ], can easily be distinguished from an anterior [s] or an apical [ʂ] by their higher F2 values (Bladon et al. 1987; Gordon et al. 2002; Li et al. 2009; Nowak 2006; Ooijevaar 2011; Toda 2007; Li et al. 2009).

Nasals have internal nasal resonance (murmur) and formant transitions as cues to the place contrast. The formant structure of the nasal consonant during the closure is weakened by the anti-resonance (nasal zero) and a low-frequency resonance (nasal pole), and the patterns of these nasal murmurs can provide the listeners with cues to the place contrast (Kurowski and Blumstein 1984; Recasens 1983). Although it has been generally argued that the listeners rely more on the transitional cue than the nasal murmurs when they identify the place of articulation of nasal consonant (e.g., Malécot 1956), it seems that in many cases the murmurs can provide a sufficient cue to the identification of the place of nasals. For example, according to Recasens's (1983) experiment on the perception of the place for nasals shows that the contrast between a velar [ŋ] and alveolar [n] can be properly distinguished by the murmurs. However, this result does not mean that the anteriority contrast between the coronal nasals can also be properly cued by the nasal murmurs. Although a platal nasal [ɲ] can be differentiated from other coronal nasals, such as [n̪, n, ɳ], by its significantly different nasal resonances (Tabain et al. 2016b), Recasens (1983) also showed that the listners more rely on the formant transition than the murmurs in order to correctly identify the palatal nasal [ɲ] from other nasals, such as [n].

Laterals have relatively transparent formant structures which can provide an internal cue to the place contrast, adding to the external formant transitions (Wright 2004: 37, 39). Anterior lateral [l] has lower F2 and quite high F3 frequencies throughout its duration, making the relatively greater gap between F2 and F3 which are clearly distinct from narrower gaps of the laminal posterior [ʎ] or palatal glide [j] whose F2 is very close to F3. The data from three Australian languages (Arrente, Pitjantjatjara, and Warlpiri) show that there are only subtle differences in F3 values among four coronal laterals [l̪, l, ɭ, ʎ] while laminal posterior [ʎ] is clearly distinguished by its higher F2 values (Tabain et al. 2016a).

These potential sources of cues to the anteriority contrast are summarized below:

(32) Potential sources of cues to the anteriority contrast

segment types	cue types
stops	formant transitions, stop burst noise
sibilants	formant transitions, frication noise
nasals	formant transitions, nasal murmur
laterals	formant transtions, formant structures

Although there are listeners or language-dependent variations, all these acoustic cues may play roles in the perception of the anteriority contrast. In the following subsections, however, I will mainly focus on the formant transitions rather than other acoustic cues due to the following reasons. First, given that the scope of the current study is restricted to the CV context, the perceptibility of the anteriority contrast may vary significantly in the transitional cues across different vocoid contexts. Internal cues do not vary as much according to the vocalic contexts, remaining quite stable across all conditions that will be considered in this section. Second, except for the formant transitions, all other cues to the anteriority contrast are manner-specific. Without the support of the elaborate experiments, it is impossible to directly compare the contribution of one manner-specific cue with those of other cues (e.g., stop burst noise *vs*. nasal murmur). Third, as I reviewed above, especially in the prevocalic context, formant transitions can provide more reliable cues to the contrast between laminal posterior consonants and other coronal consonants than other potential cues such as stop burst noise or, to a lesser extent, fricative noise spectrum.

In this section, the relative perceptibility of cues to the anteriority contrast between coronal consonants will be discussed under the following conditions, mainly in light of the similarity in the second formant (F2) transition between anterior and (laminal) posterior consonants. Each of these conditions corresponds to each of the implicational universals in (29a-b):

(33) a. Consonants occurring before front vocoids with different heights (trigger height)

b. Consonants with different manner features occurring before front vocoids (target manner)

3.1.1. Trigger height

This subsection deals with the F2 transition of a coronal consonant which varies according to the height of the following vocoid. By investigating the F2 transition in different vocalic contexts, it will be shown that the anteriority contrast may not be properly cued by the F2 transition in certain contexts.

Although the typical F2 frequencies of front vocoids and coronal consonants are relatively higher than those of non-front vocoids and non-coronal consonants, F2 varies according to the height of the front vocoid or the anteriority of the consonant (Flemming 2002; Zsiga 2012). The difference in F2 frequencies among coronal consonants and front vocoids can be schematized as in Figure 2.1.

	[i]	[ɪ]	[e]	[ɛ]	*front vocoids*
	[c]	[t͡ʃ]	[t]	[t̪]	*coronal consonants*
Higher F2	←			→	**Lower F2**

Figure 2.1

Relative F2 frequencies of front vocoids and coronal consonants

Hence, in coronal consonant - high vocoid sequences, the precise shape of F2 transitions can vary according to the F2 values of the preceding consonant and the following vocoid. The spectrograms given in Figure 2.2 illustrate this. First, the F2 transition from the anterior consonant toward the high front vocoid is moderately upward, since F2 frequencies of anterior consonants are generally lower than those of high front vocoids (Figure 2.2a). Second, the F2 transition from the posterior consonant into the high front vocoid is flat or slightly upward, since both posterior consonant and high front vocoid have the highest F2 (Figure 2.2b). Third, the F2 transition from the anterior consonant into the non-high front vowel is flat or slightly upward, since both anterior consonants and non-high front vowels have a relatively lower F2 (Figure 2.2c). Finally, the F2 transition from the posterior consonant into the non-high front vowel is drastic and downward, because F2 values of posterior consonants are much higher than those of non-high front vowels (Figure 2.2d).

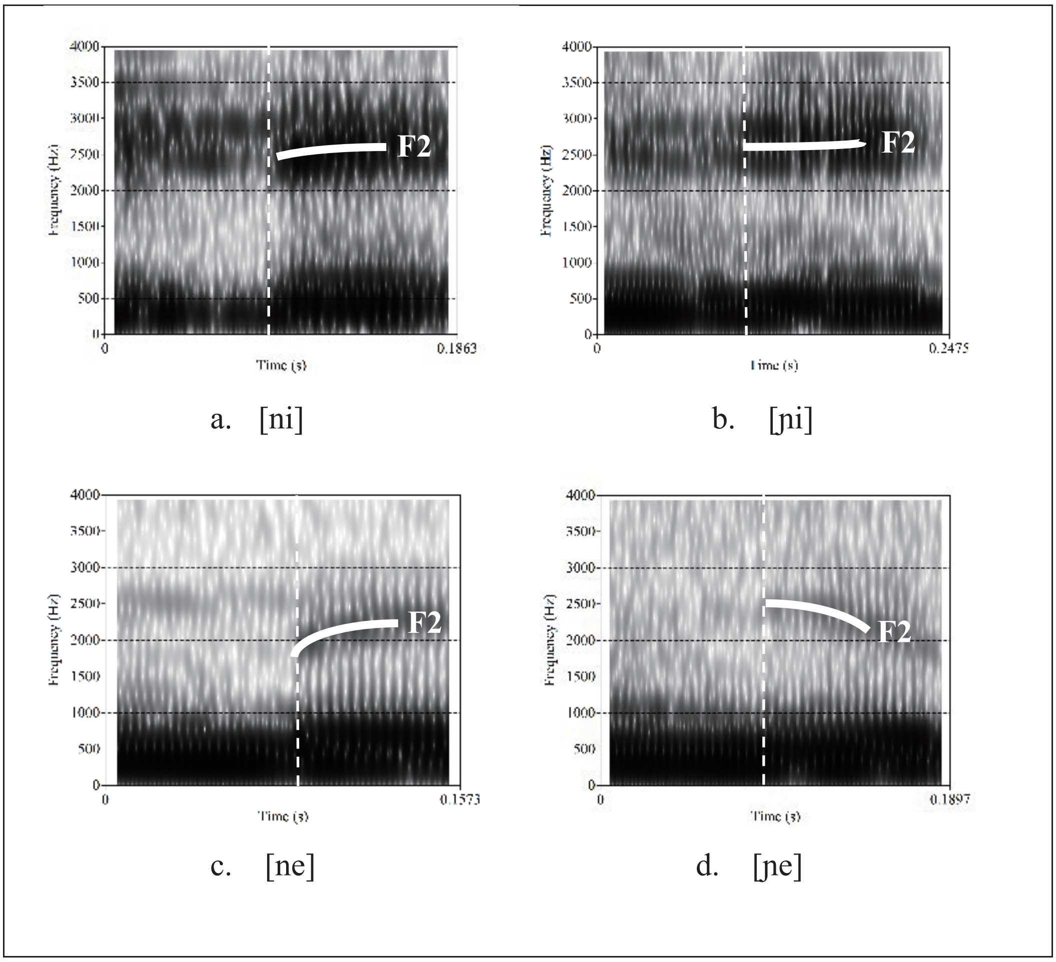

Figure 2.2

Spectrograms of the F2 transitions from the nasal consonants into the front vocoids produced by a Latvian female speaker which were extracted from the recordings provided by the UCLA Phonetics Laboratory (2007). (a) [ni] in /lini/ 'tench ACC'; (b) [ɲi] in /liːɲi/ 'tench NOM PL'; (c) [ne] in /kaneːlis/ 'cinnamon'; (d) [ɲe] in /kaɲepes/ 'hemp'

In summary, the F2 transition from an anterior consonant into a high front vocoid is similar to that from a posterior consonant toward a high front vocoid (Figure 2.2a-b), whereas the F2 transition from an anterior consonant into a non-high front vowel is quite different from that from a posterior consonant toward a non-high front vowel (Figure 2.2c-d). Recall that the perceptibility of the anteriority contrast is mainly determined by the similarity in F2 transitions. Since anterior consonants and their posterior counterparts have more similar F2 transitions before high front vocoids than before non-high ones, the F2 transition from the anterior consonant into the high front vocoid yields a less salient anteriority contrast than the F2 transition toward the non-high front vowel. This asymmetry in the perceptibility of the anteriority contrast can be stated as follows:

(34) The perceptual asymmetry between coronal palatalization targets according to the vocalic contexts

The cue to the anteriority contrast is less distinctive and salient before a high front vocoid than before a non-high front vocoid.

This perceptual asymmetry is consistent with the trigger height asymmetry in coronal palatalization stated in (29a). If coronal palatalization occurs in the non-high front vowel context where the anteriority contrast is more distinctive and salient, then it also occurs in the high front vocoid context where the contrast is less distinctive and salient.

3.1.2. Target manner

F2 values at the edge of a coronal consonant vary according to its closure or constriction location. Backing the closure or constriction location toward the hard palate leads to F2 raising, while fronting it causes F2 lowering (Fant 1960; Recasens & Espinosa 2009). Thus, the palatal consonants (e.g., [c, ç, ɲ, ʎ]) generally have higher F2 than post-alveolar consonants (e.g., [t͡ʃ, ʃ]), and these post-alveolar consonants have higher F2 than anterior consonants (e.g., [t, s, n, l]). These differences in F2 frequencies between coronal consonants are summarized in the following table.

(35) The F2 values of coronal consonants according to their manners-of-articulations and places-of-articulations.

		obstruent			sonorant		F2
		stop	affricate	fricative	nasal	lateral	
posterior	palatal	c	c͡ç	ç	ɲ	ʎ	higher
	alveolopalatal	(c̟)	t͡ɕ	ɕ	(ɲ̟)	(ʎ̟)	↕
	palato-alveolar	(t̠)	t͡ʃ	ʃ	(n̠)	(l̠)	
anterior	alveolar	t	t͡s	s	n	l	
	denti-alveolar	t̪	t͡s̪	s̪	n̪	l̪	lower

Note that anterior consonants with different manner features palatalize to posterior consonants with different closure/constriction locations. First, alveolar obstruents are generally palatalized to palato-alveolar sibilants. For example, /t/ and /s/ palatalize into palato-alveolar consonants, such as [t͡ʃ] and [ʃ], in most cases. Second, anterior sonorants are palatalized to palatal consonants which are usually produced further back in the palatal zone, such as [ɲ] or [ʎ], since they do not have close post-alveolar counterparts.[12]

Accordingly, closure or constriction locations of obstruent consonants in question are closer to each other than those of sonorant consonants in general.[13] For this reason, in the coronal palatalization context, the difference in F2 values at the edge of consonant is smaller between anterior obstruents (e.g., [t, s, t͡s]) and their post-alveolar counterparts (e.g., [t͡ʃ] or [ʃ]) than that between anterior sonorants (e.g., [n, l]) and their palatal counterparts (e.g., [ɲ, ʎ]).

In addition, this difference in F2 values between the input and output of

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[12] It seems that this cross-linguistic tendency arises from the phonetic properties of non-sibilants. Since a laminal non-sibilant consonant inherently involves a larger contact than an apical consonant, the contact of a laminal alveolar non-sibilant (e.g., [t̻, n̻, l̻]) extends not only over the alveolar region but over the palato-alveolar one. Due to this wide contact, in principle, there are no palato-alveolar non-sibilant consonants which can be articulatory and acoustic distinguished from laminal alveolar non-sibilants (e.g., [t̻, n̻, l̻]).

[13] According to Recasens (2013), posterior consonants (e.g., [c, ɲ, ʎ]) which have been described as 'palatal' consonants, au fond, exhibit alveolopalatal constrictions in many cases (therefore, more exactly [t̠ʲ, n̠ʲ, l̠ʲ] or [ç, ɲ̟, ʎ̟] rather than [c, ɲ, ʎ]). Even so, a relative distance between two constriction locations for sonorants is also less close than that for obstruents since alveolopalatal consonants are produced further back in the palatal zone compared to palato-alveolar sibilants.

palatalization is larger for lateral consonants than for nasal ones, since usually an anterior lateral [l] has lower F2 than other alveolar consonants (e.g., Latvian: Ambrazevičius 2010, 2012; Mapudungun: Fasola et al. 2015; English: Olive, Greenwood & Coleman 1993; Catalan: Recasens 1985). This is possibly due to the fact that F2 frequencies are inversely related to the volume of the back cavity during a closure or constriction (Bladon 1979: 502; Ladefoged & Maddieson 1996: 196). Although it cannot be asserted as an uncontroversial universal, at least there is a strong cross-linguistic tendency that a tongue blade or body is much lower below the palate area when the anterior lateral is produced than when other anterior consonants are produced, apparently to make a lateral escape easier (Ladefoged & Maddieson 1996: 183). For this reason, the anterior lateral has a lower F2 than other anterior consonants, and thus differences in F2 values between anteriors and posteriors are maximized for lateral consonants. The following figure illustrates how [l] and [t] are produced differently, resulting in the difference in the volume of the oral-pharyngeal cavity behind the closure.

Figure 2.3

X-tracings of [l] and [t] produced by a German speaker (based on data in Wängler 1961)

These differences in the onset F2 values ($\Delta_{onset\ F2}$) between consonant pairs with different manner features yield differences in the direction and the degree of the F2 transition. Figure 2.4 schematically illustrates these differences. First, the direction and the degree of the F2 transition from an anterior obstruent into a front vocoid are not much different from those from a post-alveolar obstruent into a front vocoid, since $\Delta_{onset\ F2}$ for obstruent pairs (e.g., [s-ʃ]) is smaller than that for sonorant pairs (Figure 2.4a). Second, the direction and the degree of the F2 transition from an anterior nasal into a front vocoid are moderately different from those from a palatal nasal into a front vocoid, because $\Delta_{onset\ F2}$ for nasal pairs is larger than that for obstruent pairs but smaller than that for lateral pairs (Figure 2.4b). Finally, the direction and the degree of the F2 transition from an anterior lateral into a front vocoid are quite different from those from a palatal lateral toward a front vocoid, because $\Delta_{onset\ F2}$ is largest for lateral pairs (Figure 2.4c).

a. [si-ʃi] b. [ni-ɲi] c. [li-ʎi]

Figure 2.4

Schematic illustrations of F2 transitions in the [_i] context

Since the greater modulation of the degree and the direction of the transition enhances the salience of the acoustic cues (Fry 1979: 139; Kawasaki 1982; Ohala 1992), the larger difference in onset F2 values between an anterior consonant and its posterior counterpart, the more salient acoustic cue to the anteriority contrast. Consequently, the F2 transition from an anterior lateral into a front vocoid yields a better anteriority contrast than the F2 transition from an anterior nasal into a front vocoid, and the F2 transition from an anterior nasal into a front vocoid, in turn, yields a better anteriority contrast than the F2 transition from an anterior obstruent into a front vocoid.

(36) The perceptual asymmetry between coronal palatalization targets with different manner features

The cue to the anteriority contrast of obstruents is less distinctive and salient than that of nasal consonants. Likewise, the cue to the anteriority contrast of nasals is less distinctive and salient than that of lateral consonants.

The perceptual asymmetry stated in (36) is consistent with the implication statement regarding coronal palatalization targets in (29b). If coronal palatalization targets an anterior nasal, then it also targets an anterior obstruent which is perceptually less distinctive from its posterior counterpart than an anterior nasal. Similarly, if coronal palatalization targets an anterior lateral, then it also targets an anterior nasal which is perceptually less distinct from its palatal counterpart than an anterior lateral.

3.2. Phonetics of coronal affrication

This section discusses the relative perceptibility of cues to the stridency contrast between anterior stops and affricates, under the two conditions given in (37) which correspond to the implicational statements in (29c-d).

(37) a. Stops occurring before high vocoids with different frontness (trigger frontness)

b. Stops with different voicing values occurring before high vocoids (target voicing)

Note that the more intensive and longer frication phase provides more salient cues to the stridency contrast since the intensity and the duration of the frication noise are crucial to the manner contrast between alveolar stops and sibilants (Flemming 2002: 24; Wright 2004: 39). Other things being equal, it is thus expected that the stridency contrast will be less distinct in the context where the intensity and duration of the stop release noise are high and elongated, respectively, than in the context where they are low and short.

3.2.1. Trigger frontness

The intensity (loudness, with respect to perception) and the duration of the frication noise vary as a function of the area of the supra-glottal constriction. First, the intensity of the frication noise changes according to a particle velocity of the air flow, and this particle velocity is greater when the air passage is narrower. For this reason, the narrower constriction, the louder the noise is (Catford 1977; Johnson 2003; Stevens 1971; Shadle 1990; Ohala & Solé 2010). Second, the duration of the noise is also longer when the constriction is narrower. Acoustically, when a vocoid follows an anterior stop, supra-glottal air is condensed during a stop closure. The condensed air releases through the passage shaped by the following vocoid. This escape that produces audible turbulence is maintained longer when the passage is narrower (Hall et al. 2006; Kim 2001; Pintér 2015). Therefore, since the area of constriction is narrower in the high vocoid context than in the non-high vocoid context, the noise is louder and more prolonged in the high vocoid context than that in the non-high vocoid context (Clements 1999; Cottet 2015; Hall & Hamann 2006; Hall et al. 2006; Kim 2001; Kirchner 1998; Pintér 2015; Ohala 1983).

For the same reason, the degrees of the intensity and the duration of the noise are also different between the high front and back vocoid contexts. It seems that the noise is louder and longer in the high front context than in the high back context since the constriction is narrower and more extensive in the high front context (e.g., [_j] or [_i]) than in the high back context (e.g., [_w] or [_u]). Figure 2.5 presents X-ray tracings of German [i] and [u] based on the data provided in Wängler (1961). When a high front [i] is produced, the tongue rises toward the hard palate. In this context, the area of constriction is extremely narrow (Figure 2.5a). In contrast, when a high back [u] is articulated, the tongue rises close to the velum, creating a relatively wider constriction than that formed in the [_i] context (Figure 2.5b).

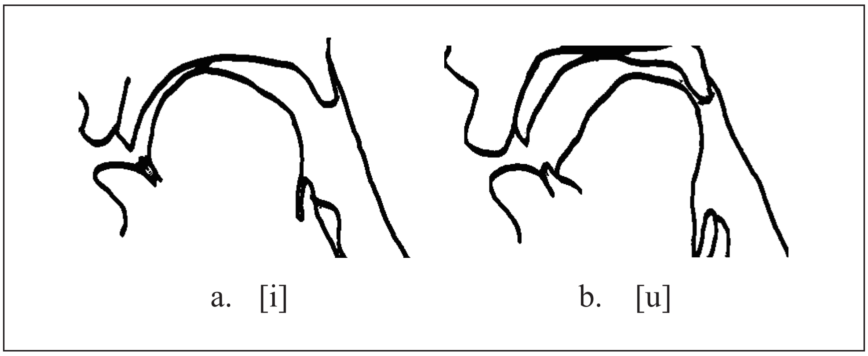

Figure 2.5

X-tracings of [i] and [u] produced by a German speaker (based on data in Wängler 1961)

The data provided in Baer et al. (1991) also shows that the constriction formed in the articulation of [i] is narrower than that in the articulation of [u]. The cross-sectional area of the constriction which is formed in the articulation of [i] and [u] were about 0.5 cm^2 and 0.7-0.8 cm^2, respectively, at their narrowest points. Furthermore, the area of supra-glottal constriction which is narrow enough to create audible frication (about < 1.0 cm^2) is more broadly formed in the articulation of [i] (about 4-5 cm in length in the palatal zone) than in the articulation of [u] (about 2 cm in length in the velum). Due to these differences in the shape of the constriction between the high front and high back vocoids, the intensity and the duration of the noise are louder and more prolonged in the high front context than in the high back context. [14]

[14] Several experimental studies have reported that the transition noise of alveolar stop in the [_i] or [_j] context is longer than that in the [_u] context (Dorman et al. 1977 for English; Hamann & Velkov 2005: 9 for German; Kim 2001: 99 for Korean) and the relative

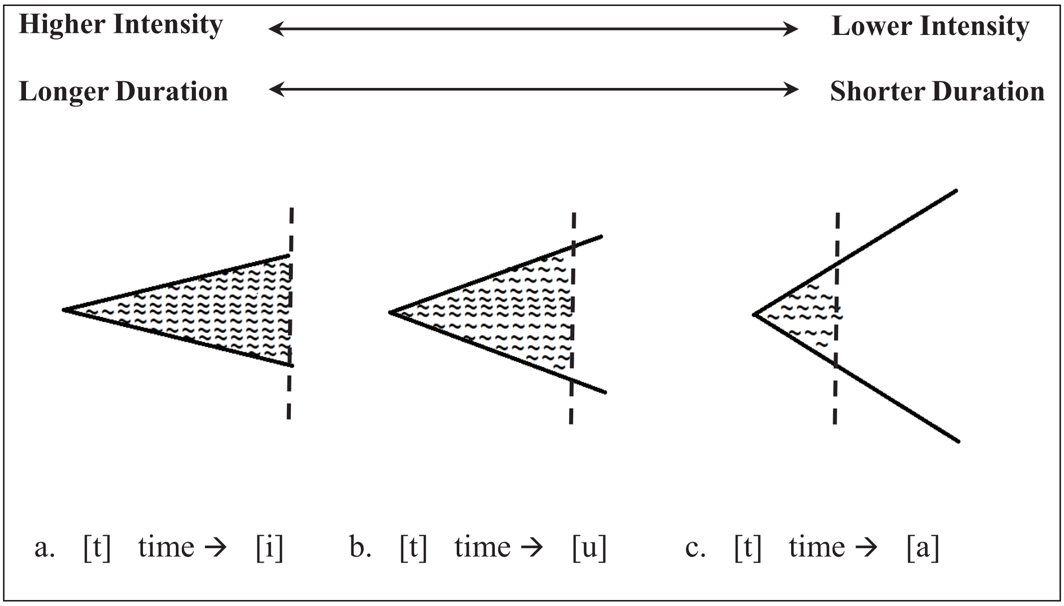

Figure 2.6

The frication noise after the release of an alveolar stop [t] in different vowel contexts. '~' = turbulent airflow; '---' = threshold for turbulent airflow (adapted from Clements 1999 and Kim 2001)

On the basis of the phonetic facts discussed in this subsection, Figure 2.6 models releases of an alveolar voiceless stop into different vocoid contexts. First, the noise in the high front context is the most prolonged and loudest compared to other vocalic contexts, since the stricture is narrowest in this condition (Figure 2.6a). Second, the constriction in the high back context is slightly wider than in the high front vowel context, yielding a relatively less intensive and shorter frication phase than that in the high front context (Figure 2.6b). Finally, in the low vowel context,

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amplitude of the frication noise in the articulation of sibilants is higher in the [_i] context than in the [_u] context (Jongman et al. 1998: 201).

the frication noise is diffused and short, due to the wide constriction and the rapid opening (Figure 2.6c).

In sum, for these acoustic reasons, the perceptual salience of the cues to the stridency contrast between alveolar stops and affricates asymmetrically vary across the vowel contexts, as in (38).

(38) The perceptual asymmetry between coronal affrication targets in different vocalic contexts

The cues to the stridency contrast between anterior stops and affricates are less distinctive and salient before the high front vocoid than before the high back vocoid.

This perceptual asymmetry is comparable with the typological asymmetry between triggers of coronal affrication suggested in (29c). The consistency is evident: if alveolar stops with the more salient cues to the manner contrast between affricates and stops undergo coronal affrication, alveolar stops with less salient cues do so.

3.2.2. Target voicing

Voicing can best be maintained when supra-glottal air pressure is lower than the sub-glottal pressure. Thus, to create an optimal condition for phonation, a speaker should maximize a difference between supra-glottal and sub-glottal pressure (Ohala 1997). However, since an obstacle in the oral cavity that impedes airflow (e.g., a stop closure or a narrow constriction for high vocoids) causes higher pressure above the glottis, the presence of such an obstacle creates a hostile environment for phonation (Jaeger 1978: 312). On the other hand, the frication noise is more intensive and longer when there is a narrow constriction in the oral cavity. Since frication noise is optimally produced when a difference between oral pressure and atmospheric pressure is maximized, an increase in supra-glottal pressure is unavoidable to produce audible frication noise (Ohala 1997; Ohala & Solé 2010). To sum up, the hospitable environment for phonation is hostile to frication, and the hospitable condition for frication is hostile to phonation.

For these aerodynamic reasons, it is hard to maintain a sufficiently long and intensive frication noise immediately after the release of a voiced stop (Fry 1979; Hall et al. 2006; Żygis et al. 2012). It is expected that the intensity and the duration of the noise are decreased and shortened in the optimal environment for phonation (e.g., low supra-glottal pressure), while voicing is impeded in the optimal environment for frication (e.g., high supra-glottal pressure). Therefore, voiced stops (e.g., /d/) naturally have a less intensive and shorter frication phase than voiceless stops (e.g., /t/), and thus crucially distinct from the more intensive and longer frication phase of affricates. Recall that the stridency contrast depends on the similarity in intensity and duration of friction noise between stops and affricates. Since more intensive and prolonged frication noise is produced after the release of the voiceless stop than after that of the voiced stop, cues to the stridency contrast are less salient between voiceless stops and affricates than that between voiced stops and affricates. This perceptual asymmetry can be stated as in (39).

(39) The perceptual asymmetry between coronal affrication triggers according to their voicing features

The cues to the stridency contrast between voiceless anterior stops and affricates are less distinctive and salient than that between voiced anterior stops and affricates.

This perceptual asymmetry is consistent with the implicational universal between coronal affrication targets in (29d). If a stop with the more salient cues to the manner contrast (e.g., a voiced stop) undergoes coronal affrication, then a stop with the less salient cues (e.g., a voiceless stop) does so.

3.3. Summary

In this section, I pointed out that there are evident consistencies between the typological universals and the perceptual asymmetries. These findings can be summarized as in (40).

(40) Consistencies between the implicational universals and the perceptual asymmetries

a. Trigger height in the coronal palatalization context

If coronal palatalization occurs in the non-high front vowel context, then it also occurs in the high front vocoid context where the anteriority contrast is less distinctive than in the non-high front context.

b. Target manner in the coronal palatalization context

i) If coronal palatalization targets an anterior nasal, then it also targets an anterior obstruent which is perceptually less distintive from its posterior counterpart than an anterior nasal.

ii) If coronal palatalization targets an anterior lateral, then it also targets an anterior nasal which is perceptually less distintive from its posterior counterpart than an anterior lateral.

c. Trigger frontness in the coronal affrication context

If coronal affrication occurs in the high back vocoid context, then it also occurs in the high front vocoid context where the stridency contrast is less distinctive than in the high back context.

d. Target voicing in the coronal affrication context

If coronal affrication targets an anterior voiced stop, then it also targets an anterior voiceless one which is perceptually less distintive from its affricate counterpart than a voiced stop.

In a nutshell, there are two types of correlations between phonology and phonetics. First, if a consonant with more salient acoustic cues to the anteriority contrast undergoes coronal palatalization, a consonant with less salient cues does so (40a-b). Second, if a stop with more salient cues to the stridency contrast undergoes coronal affrication, a consonant with less salient cues does so (40c-d).

In addition, the results of this phonetic investigation also imply that coronal palatalization and coronal affrication are related to different phonetic factors. The F2 transition which provides cues to the anteriority contrast is related to the palatalization context (front vocoid context), and the intensity and the duration of frication noise which provide cues to the stridency contrast are related to the coronal affrication context (high vocoid context). These relationships between different phonetic factors and the two processes in question are also comparable with the process-specificity of triggers proposed in (28), reinforcing the view that coronal palatalization and coronal affrication have distinct and independent backgrounds from each other.

Although these results of the phonetic investigation provide further supportive evidence for the separation of the two processes which is assumed in the Vowel-Place approach (e.g., Hume 1992), as I already stated in the summary of the previous section, this classic auto-segmental approach is not sufficiently capable of explaining the attested asymmetrical patterns of the two processes. Furthermore, under Hume's model, there is also no way to provide an explanation for the consistencies shown between typological and perceptual asymmetries found in this section. It is now obvious that a phonetically-based analysis that can provide a proper account of the typological and phonetic facts concerning coronal palatalization and coronal affrication is required.

In the following section, I will develop such an analysis of coronal palatalization and affrication based on Steriade's (2001, 2009) P-map theory, in order to provide more proper analysis which can predict and explain all and only typologically attested patterns of coronal palatalization and coronal affrication. This new analysis will provide an account of the remarkable consistencies between the typological universals and the perceptual asymmetries, linking up the cross-linguistic patterns of these two processes with their phonetic backgrounds.

4. Analysis

This section proposes a formal account of coronal palatalization and coronal affrication. The main proposal is established based on Steriade's (2001, 2009) P-Map theory. By implementing P-map principles within the framework of Optimality Theory (OT; Prince & Smolensky 1993), the cross-linguistic patterns of coronal palatalization and coronal affrication can be successfully analyzed. In the following subsections, it will be shown that the proposed analysis adequately explains both universal and language-specific patterns of coronal palatalization and coronal affrication, incorporating perceptual backgrounds discussed in the previous section and the articulatory motivations which will be formally implemented as Markedness constraints in this section.

4.1. Preliminary

4.1.1. P-map theory

The P-map (where P stands for 'perceptibility') is a hypothetical component of the grammar which is "a set of statements about relative perceptibility of different contrasts, across the different contexts where they might occur" (Steriade 2009: 151). For instance, speakers can possess the knowledge of the relative perceptibility of the voicing contrast between [p] and [b] in different contexts. The P-map statements given in (41) demonstrate this mental knowledge about relative perceptibilities of [p-b] contrasts in four different contexts, intervocalic (V_V), prevocalic (_V), postvocalic (V_) and preconsonantal (_C). In the statements below, '$\Delta(x\text{-}y/K_i) > \Delta(w\text{-}z/K_j)$' denotes that the pair of strings *x-y* in the context K_i is perceptually more distinctive than the pair *w-z* in the context K_j.

(41) Δ(p-b/V__V) > Δ(p-b/__V) > Δ(p-b/V__) > Δ(p-b/__C)

According to the P-map statements given above, the optimal context for the perception of the voicing contrast is intervocalic, and the worst context is preconsonantal (Steriade 2009: 156). The prevocalic context and the postvocalic context are ranked between them. Note that these P-map statements can be mapped into relevant correspondence constraints:

(42) P-map projects correspondence constraints (Steriade 2009: 164)

a. Let $\Delta(x\text{-}y)\_\_K_i$ stand for the perceptual difference between members of sound classes *x* and *y* in context K_i.

b. If $\Delta(x\text{-}y)\_\_K_i > \Delta(w\text{-}z)\_\_K_j$, then there exist distinct sets of correspondence conditions, CORRESP ($x\text{-}y/\_\_K_i$) and CORRESP ($w\text{-}z/\_\_K_j$).

Each of the contrasts is mapped onto different correspondence constraints, and their ranking is regulated by the relevant P-map. Consequently, the more distinctive contrasts are protected by ranking the relevant correspondence constraints higher.

(43) Ranking correspondence constraints by relative distinctiveness (Steriade 2009: 164)

If $\Delta(x\text{-}y)\_\_K_i > \Delta(w\text{-}z)\_\_K_j$, then any correspondence constraint referring to $\Delta(x\text{-}y)\_\_K_i$ outranks any parallel constraint referring to $\Delta(w\text{-}z)\_\_K_j$.

For example, the P-map fragments in (44) induce a ranking of IDENT constraints as follows. In the below ranking, due to the undominated IDENT(voice)/V__V, the voicing contrast between [p] and [b] in the intervocalic context is more protected than that in other contexts.

(44) IDENT(voice)/V__V ≫ IDENT(voice)/__V ≫ IDENT(voice)/V__ ≫ IDENT(voice)/__C

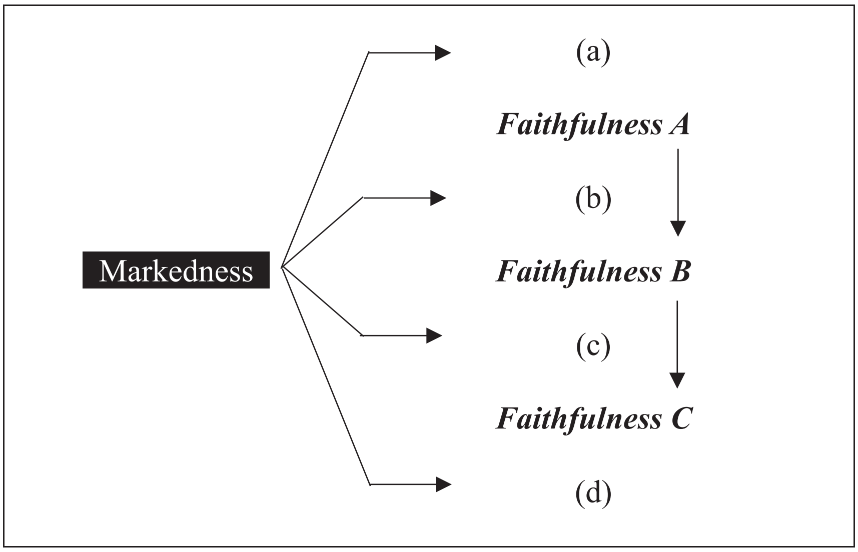
There is a direct and simple relation between the P-map and the phonological grammar: a universal ranking of correspondence constraints is regulated by the P-map. As a result, the phonological grammar always prefers the perceptually minimal modification (cf. Kohler 1990).

4.1.2. Main proposal

Many previous studies based on the Phonetically-based Phonology (Hayes 1999; Hayes & Steriade 2004) have argued that typological properties in phonology are explicable in terms of articulatory and perceptual considerations, from a variety of perspectives (e.g., Flemming 2002, 2017; Jun 1995, 2004; Kaun 2004; Kirchner 1998, 2004; Kochetov & So 2007; Moreton 2008; Wilson 2006). The current model also assumes that articulatory and perceptual requirements are reflected in the grammar, especially following Jun's (1995, 2004) view. According to Jun (2004: 70), speech production can be understood in terms of reconciling ease-of-articulation and ease-of-perception (see also Lindblom 1983, 1990). In the current model, these conflicting requirements are reflected in two different classes of constraints: Markedness constraints are motivated by ease-of-articulation, and Faithfulness constraints are universally ranked reflecting relevant P-map statements.

In order to illustrate the current model in detail, let us consider three hypothetical contexts A, B, and C, and a feature [F]. Suppose that the perceptual contrast between [+ F] and [- F] is most distinct in the context A and least distinct in the context C. Then the ranking of relevant Faithfulness constraints will be Faithfulness A ≫ Faithfulness B ≫ Faithfulness C. As illustrated in (45), various typological patterns can arise from interactions between these inherently ranked Faithfulness constraints and an articulatorily motivated Markedness constraint which drives the featural modification:

(45)



First, as in (45a), if the Markedness constraint dominates all relevant Faithfulness constraints, the modification occurs in all contexts. Second, as in (45b), if the Markedness constraint is dominated only by Faithfulness constraint A, the modification occurs only in contexts B and C. Third, as in (45c), if the Markedness constraint dominates only the Faithfulness constraint relevant to the context C, then the change occurs only in the context C. Finally, the modification does not occur in all contexts, if the Markedness constraint is dominated by all Faithfulness constraints as in (45d).

In the following subsections, it will be shown that the typological patterns of coronal palatalization and affrication are well explained under the model presented above. In section 4.2, the implicational universals of coronal palatalization, namely the trigger height (29a) and the target manner (29b), will be analyzed in terms of interactions between an articulatorily motivated Markedness constraint (CORPAL: "No anterior consonant before a front vocoid") and internally ranked IDENT(anterior) constraints. In a similar manner, in section 4.3, the implicational universals of coronal affrication, the trigger frontness (29c) and the target voicing (29d), will be also analyzed as interactions between a Markedeness constraint which formalizes the articulatory motivation of the affrication process (CORAFFR: "No non-strident obstruent before a high vocoid") and relevant IDENT(strident) constraints.

4.2. Asymmetries in coronal palatalization

4.2.1. Articulatory motivation

When anterior consonants are articulated, the tongue tip and blade are usually curved upwards to the alveolar ridge. In contrast, when the front vocoid is articulated, the tongue body should be raised, turning tongue tip and blade downwards (Flemming 2003: 366; Keating 1993). Due to this articulatory conflict between two gestures, it is hard to maintain a tongue tip or blade gesture of an alveolar consonant when the front vocoid immediately follows it. This articulatory motivation can be implemented by a Markedness constraint which militates against maintaining anterior articulation before a front vocoid:

(46) $*\begin{bmatrix} \text{C} \\ \text{+ anterior} \end{bmatrix} \begin{bmatrix} \text{V} \\ \text{+ front} \end{bmatrix}$ (**CORPAL**)

no anterior consonant before a front vocoid

This Markedness constraint interacts with Faithfulness constraints which reflects a mental knowledge about the relative distinctiveness of the anteriority contrast in different contexts, yielding the typological patterns observed in section 2.2: the trigger height and the target manner asymmetries.

4.2.2. Trigger height asymmetry

As summarized in (34), the cue to the anteriority contrast is less distinctive before a high front vocoid (e.g., /i/) than before a non-high front vocoid (e.g., /e/). This means that the Faithfulness for anteriority is weaker before high front vocoids than non-high front vowels. The P-map statements in (47) represent the mental knowledge about this relative perceptual distinctiveness of the anteriority contrast.

(47) P-map (Δ (a-b) = the perceptual distinctiveness between a and b))

$$\Delta([+\text{anterior}] - [-\text{anterior}]/\_\_ \begin{bmatrix} \text{V} \\ +\text{front} \\ -\text{high} \end{bmatrix}) \quad >$$

$$\Delta([+\text{anterior}] - [-\text{anterior}]/\_\_ \begin{bmatrix} \text{V} \\ +\text{front} \\ +\text{high} \end{bmatrix})$$

These P-map statements induce the following ranking of Faithfulness constraints. Since the anteriority contrast is distinguished by the value of the phonological feature [anterior], the P-map hierarchy presented above can be formalized by ranking an IDENT constraint for the feature [anterior] in different vocoid contexts: IDENT(anterior) before non-high vowels is ranked higher than that before high vocoids.

(48) Ranking of Faithfulness constraints

$$\text{IDENT(anterior)}/\_\_\begin{bmatrix} \text{V} \\ +\text{front} \\ -\text{high} \end{bmatrix} \gg \text{IDENT(anterior)}/\_\_\begin{bmatrix} \text{V} \\ +\text{front} \\ +\text{high} \end{bmatrix}$$

(abbreviations: ID(ant)/__e ≫ ID(ant)/__i)

Interactions between these Faithfulness constraints and the Markedness CORPAL constraint suggested in (46) yield the trigger height asymmetry. Each possible pattern expected from the factorial typology of these constraints is compatible with the cross-linguistic patterns of coronal palatalization, as illustrated in the table below.

(49) Factorial typology of the height asymmetry in coronal palatalization

	ranking	***expected pattern***	***example***
a.	CORPAL ≫ ID(ant)/__e ≫ ID(ant)/__i	*both high and non-high front vocoids trigger palatalization*	(9)
b.	ID(ant)/__e ≫ CORPAL ≫ ID(ant)/__i	*only high front vocoids trigger palatalization*	(10)
c.	ID(ant)/__e ≫ ID(ant)/__i ≫ CORPAL	*no palatalization*	-

First, if CORPAL dominates both ID(ant)/__e and ID(ant)/__i, as in (49a), coronal palatalization occurs not only before a high-front vocoid but also before a non-high front vowel. For instance, both /i/ and /e/ trigger coronal palatalization in Amharic, as demonstrated in (9). The analysis of coronal palatalization in Amharic is illustrated in two tableaux below. Both tableaux show the analyses of the input forms with /s/ occurring before a front vowel. A non-palatalized candidate [s] fatally violates high-ranked CORPAL, and a palatalized candidate [ʃ] satisfies it, being an optimal candidate in both tableaux:

(50) Analysis of coronal palatalization in Amharic

a. /məllə**s**-e/ → [məllɨʃ**ʃ**e] 'having returned, 1ST SG'

Input: /se/	CORPAL	ID(ant)/__e	ID(ant)/__i
se	*!		
☞ ʃe		*	

b. /məllə**s**-i/ → [məllɨ**ʃ**i] 'return, 2ND IMPR'

Input: /si/	CORPAL	ID(ant)/__e	ID(ant)/__i
si	*!		
☞ ʃi			*

Next, by ranking CORPAL below ID(ant)/__e and above ID(ant)/__i, as in (49b), coronal palatalization occurs only before a high front vocoid in languages like Japanese. As illustrated in (10), in Japanese, coronal palatalization is triggered only by high front vocoids, while non-high front vowels do not trigger it. The tableaux given in (51) show the analysis of coronal palatalization in Japanese. In the first tableau (51a), an input /se/ does not undergo any modification of [anterior] feature since the palatalized candidate violates high ranked ID(ant)/__e. By contrast, in (51b), the palatalized candidate which satisfies CORPAL is selected as optimal since CORPAL outranks ID(ant)/__i.

(51) Analysis of coronal palatalization in Japanese

a. /hana**s**-e/ → [hana**s**e] 'talk, IMPR'

Input: /se/	ID(ant)/__e	CORPAL	ID(ant)/__i
☞ se		*	
ʃe	*!		

b. /hana**s**-itai/ → [hana**ʃ**itai] 'talk, VOL'

Input: /si/	ID(ant)/__e	CORPAL	ID(ant)/__i
si		*!	
☞ ʃi			*

4.2.3. Target manner asymmetry

Like the trigger height asymmetry, the target manner asymmetry can also be explained by interactions between CORPAL and relevant Faithfulness constraints. As demonstrated in (36), in the coronal palatalization context, the anteriority contrast is perceptually more distinct between laterals than that between nasals, and it is also more distinct between nasals than that between obstruents. This perceptual asymmetry can be represented by P-map statements as in (52).

(52) P-map (Δ (a-b) = the perceptual distinctiveness between a and b))

$$\Delta\left(\begin{bmatrix}+\text{ lateral}\\+\text{ anterior}\end{bmatrix}-\begin{bmatrix}+\text{ lateral}\\-\text{ anterior}\end{bmatrix}\right) > \Delta\left(\begin{bmatrix}+\text{ nasal}\\+\text{ anterior}\end{bmatrix}-\begin{bmatrix}+\text{ nasal}\\-\text{ anterior}\end{bmatrix}\right) >$$

$$\Delta\left(\begin{bmatrix}-\text{ sonorant}\\+\text{ anterior}\end{bmatrix}-\begin{bmatrix}-\text{ sonorant}\\-\text{ anterior}\end{bmatrix}\right)$$

From the P-map statements presented above, the ranking of Faithfulness constraints is derived as in (53). The IDENT$_{LAT}$(anterior) constraint that preserves anteriority of lateral consonants is ranked higher than IDENT$_{NAS}$(anterior) which preserves anteriority of nasal consonants, and in turn, IDENT$_{NAS}$(anterior) outranks IDENT$_{OBS}$(anterior) that preserves the anteriority of obstruent consonants.

(53) Ranking of constraints

IDENT$_{LAT}$(anterior) ≫ IDENT$_{NAS}$(anterior) ≫ IDENT$_{OBS}$(anterior)

(abbreviations: ID$_{LAT}$(ant) ≫ ID$_{NAS}$(ant) ≫ ID$_{OBS}$(ant))

Three IDENT constraints, ID$_{LAT}$(ant), ID$_{NAS}$(ant), and ID$_{OBS}$(ant), interact with CORPAL which motivates coronal palatalization process. Since the ranking among these three Faithfulness constraints is universally fixed, there are in total four possible rankings, depending on the relative rank of CORPAL. The factorial typology is given below:

(54) Factorial typology of the manner asymmetry in coronal palatalization

	ranking	***expected pattern***	***example***
a.	CORPAL ≫ IDLAT(ant) ≫ IDNAS(ant) ≫ IDOBS(ant)	*obstruents, nasals, and laterals undergo palatalization*	(13)
b.	IDLAT(ant) ≫ CORPAL ≫ IDNAS(ant) ≫ IDOBS(ant)	*only obstruents and nasals undergo palatalization*	(14)
c.	IDLAT(ant) ≫ IDNAS(ant) ≫ CORPAL ≫IDOBS(ant)	*only obstreunts undergo palatalization*	(15)
d.	IDLAT(ant) ≫ IDNAS(ant) ≫ IDOBS(ant) ≫ CORPAL	*no palatalization*	-

First, as in (54a), if all IDENT constraints are dominated by CORPAL, then coronal palatalization can target all types of anterior consonants, regardless of their manner-of-articulations. As already exemplified in (13), Slovak coronal palatalization is such a case. In Slovak, not only /t, d/ but also /n, l/ are targeted by coronal palatalization before front vowels. The tableaux in (55) illustrate the analysis of Slovak coronal palatalization. Due to the topmost CORPAL, palatalized outputs are always preferred.

(55) Analysis of coronal palatalization in Slovak

a. /soko**l**-ɛ/ →[soko**ʎ**ɛ] ‘falcon, LOC SG’

Input: /lɛ/	CORPAL	IDLAT(ant)	IDNAS(ant)	IDOBS(ant)
lɛ	*!			
☞ ʎɛ		*		

b. /bah**n**-ɛ/ → [bah**ɲ**ɛ] ‘ram, LOC SG’

Input: /nɛ/	CORPAL	IDLAT(ant)	IDNAS(ant)	IDOBS(ant)
nɛ	*!			
☞ ɲɛ			*	

c. /mies**t**-ɛ/ → [mies**c**ɛ] ‘place, LOC SG’

Input: /tɛ/	CORPAL	IDLAT(ant)	IDNAS(ant)	IDOBS(ant)
tɛ	*!			
☞ cɛ				*

Second, when only IDLAT(ant) outranks CORPAL and other Faithfulness constraints are dominated by CORPAL, as in (54b), coronal palatalization only targets nasal and obstruent alveolars. Languages like Dutch shows such a pattern. The analysis of Dutch coronal palatalization is demonstrated in (56). In the first tableau (56a), a lateral /l/ does not undergo coronal palatalization before /j/, since the palatalized candidate [ʎj] violates undominated IDLAT(ant). In contrast, as in (56b) and (56c), /n/ and /d/ are targeted by coronal palatalization in the same context, because palatalized candidates satisfy CORPAL which outranks IDNAS(ant) and IDOBS(ant).

(56) Analysis of coronal palatalization in Dutch

a. /za**l** je/ → [za**l**jə] 'Will you?'

Input: /lj/	IDLAT(ant)	CORPAL	IDNAS(ant)	IDOBS(ant)
☞ lj		*		
ʎj	*!			

b. /ka**n** jə/ → [ka**ɲ**jə] 'Can you?'

Input: /nj/	IDLAT(ant)	CORPAL	IDNAS(ant)	IDOBS(ant)
nj		*!		
☞ ɲj			*	

c. /ha**d** jə/ → [ha**t͡ʃ**jə] 'Had you?'

Input: /dj/	IDLAT(ant)	CORPAL	IDNAS(ant)	IDOBS(ant)
dj		*!		
☞ t͡ʃj				*

Finally, if CORPAL dominates only IDOBS(ant) as in (54c), coronal palatalization only targets obstruent consonants. Because IDLAT(ant) and IDNAS(ant) outrank CORPAL, /n/ and /l/ do not undergo the process. The tableaux given in (57) show the analysis of palatalization in Naousa Greek, which is illustrated in (15).

(57) Analysis of coronal palatalization in Naousa Greek

a. /ski**l**í/ → [ʃci**l**í] 'dog NOM SG'

Input: /li/	IDLAT(ant)	IDNAS(ant)	CORPAL	IDOBS(ant)
☞ li			*	
ʎi	*!			

b. /**n**istía/ → [**n**iʃtía] 'fasting'

Input: /ni/	IDLAT(ant)	IDNAS(ant)	CORPAL	IDOBS(ant)
☞ ni			*	
ɲi		*!		

c. /ská**s**i/ → [ská**ʃ**i] 'It will burst'

Input: /si/	IDLAT(ant)	IDNAS(ant)	CORPAL	IDOBS(ant)
si			*!	
☞ ʃi				*

In tableaux (57a) and (57b), faithful candidates are optimal because palatalized candidates fatally violate IDLAT(ant) and IDNAS(ant) which outrank CORPAL. In contrast, a fricative /s/ undergoes coronal palatalization in (57c), due to the domination of CORPAL over IDOBS(ant).

4.3. Asymmetries in coronal affrication

4.3.1. Articulatory motivation

Articulatorily, coronal affrication is motivated by the natural frication in the high vocoid contexts. It is difficult to articulate an alveolar stop without frication noise before a high vocoid because a formation of a narrow constriction which yields audible noise immediately follows a stop release (cf. Kirchner 1998: 104, 117). In other words, since an articulatory gesture of the alveolar stop and that of the following high vocoid are easily mingled in this context, an effortful and intentional articulation is required to minimize frication. This articulatory motivation can be formulated as the constraint given in (58).

(58) $*\begin{bmatrix} -\text{sonorant} \\ -\text{strident} \end{bmatrix} \begin{bmatrix} \text{V} \\ +\text{high} \end{bmatrix}$ (**CORAFFR**)

no non-strident obstruent before a high vocoid

In common with CORPAL constraint, CORAFFR also interacts with relevant Faithfulness constraints whose ranking is guided by P-map, yielding the two different asymmetries in coronal affrication, namely the target frontness and the target voicing.

4.3.2. Trigger frontness asymmetry

As stated in (38), the degree of the perceptual distinctiveness of the stridency contrast between alveolar stops and affricates varies according to the frontness of the following vocoids: the stridency contrast is less distinctive before a high front vocoid than before a high central or back vocoid. The following P-map hierarchy reflects this perceptual asymmetry.

(59) P-map

$$\Delta([+\text{ strident}] - [-\text{ strident}]/\_\_\begin{bmatrix} \text{V} \\ -\text{ front} \\ +\text{ high} \end{bmatrix}) \quad >$$

$$\Delta([+\text{ strident}] - [-\text{ strident}]/\_\_\begin{bmatrix} \text{V} \\ +\text{ front} \\ +\text{ high} \end{bmatrix})$$

The ranking between relevant IDENT constraints is fixed, reflecting the P-map given above. Because the contrast between anterior stops and affricates can be distinguished by the value of the phonological feature [strident], the above P-map hierarchy can be formalized by ranking an IDENT constraint for the feature [strident] in different vocoid contexts: IDENT(strident) before a high central or back vocoid outranks IDENT(strident) before a high front vocoid, as in (60).

(60) Ranking of constraints

$$\text{IDENT(strident)}/\_\_\begin{bmatrix} \text{V} \\ -\text{ front} \\ +\text{ high} \end{bmatrix} \gg \text{IDENT(strident)}/\_\_\begin{bmatrix} \text{V} \\ +\text{ front} \\ +\text{ high} \end{bmatrix}$$

(abbreviations: ID(strid)/__u ≫ ID(strid)/__i)

The Markedness constraint CORAFFR which drives coronal affrication process interacts with these IDENT(strid) constraints presented above, yielding several typological predictions. There are three possible rankings which result in distinct typological patterns, and these predicted patterns are compatible with the results of the typological survey, as demonstrated in (61).

(61) Factorial typology of the frontness asymmetry in coronal affrication

	ranking	***expected pattern***	***example***
a.	CORAFFR ≫ ID(strid)/__u ≫ ID(strid)/__i	*both high front and high back vocoids trigger affrication*	(20)
b.	ID(strid)/__u ≫ CORAFFR ≫ ID(strid)/__i	*only high front vocoids trigger affrication*	(21)
c.	ID(strid)/__u ≫ ID(strid)/__i ≫ CORAFFR	*no affrication*	-

In the ranking given in (61a), CORAFFR dominates ID(strid)/__u and ID(strid)/__i. Due to the dominance of CORAFFR over the Faithfulness constraints, coronal affrication occurs not only in the high front vocoid context but also in the high central/back vocoid context. For instance, as illustrated in (20), an anterior stop /t/ undergoes coronal affrication before /i/ and /u/ in Tota Logba.

The tableaux given in (62) below demonstrate the analysis of Tota Logba coronal affrication. In tableau (62a), a candidate which preserves the input form, [tú], is ruled out due to the violation of the high-raked CORAFFR. Similarly, a candidate [tí] is also ruled out due to the fatal violation of the Markedness constraint, as in (62b). Instead, affricated candidates [t͡sú] and [t͡sí] are chosen as optimal candidates in (62a) and (62b), respectively.

(62) Analysis of coronal affrication in Tota Logba

a. /o**t**ú/ → [o**t͡s**ú] 'hill'

Input: /tú/	CORAFFR	ID(strid)/__u	ID(strid)/__i
tú	*!		
☞ t͡sú		*	

b. /a**t**í/ → [a**t͡s**í] 'night'

Input: /tí/	CORAFFR	ID(strid)/__u	ID(strid)/__i
tí	*!		
☞ t͡sí			*

On the other hand, when CORAFFR is ranked between ID(strid)/__u and ID(strid)/__i as in (61b), coronal affrication can occur only before a high front vocoid. Quebec French shows such a case, as demonstrated in (21). In this language, coronal affrication targets alveolar stops only before high front vocoids. The analysis is given in (63).

(63) Analysis of coronal affrication in Quebec French

a. /**t**utu/ → [**t**utu] 'puppy'

Input: /tu/	ID(strid)/__u	CORAFFR	ID(strid)/__i
☞ tu		*	
t͡su	*!		

b. /**t**ip/ → [**t͡s**ip] 'type'

Input: /ti/	ID(strid)/__u	CORAFFR	ID(strid)/__i
ti		*!	
☞ t͡si			*

An alveolar stop /t/ cannot be a target of coronal affrication before a high back vowel /u/ since an affricated candidate [t͡su] fatally violates dominant ID(strid)/__u as in (63a). In contrast, as shown in tableau (63b), /t/ is affricated before /i/, due to the domination of CORAFFR over ID(strid)/__i.

4.3.3. Target voicing asymmetry

The results of the phonetic investigation showed that the acoustic cues to the manner contrast between an alveolar stop and affricate are weaker when the stop is voiceless than when the stop is voiced, as summarized in (39). In other words, perceptual distinctiveness between voiced stops and affricates (e.g., [d] vs. [d͡z]) is larger than that between voiceless stops and affricates (e.g., [t] vs. [t͡s]). This difference in the degree of distinctiveness can be represented as a P-map hierarchy in (64).

(64) P-map

$$\Delta(\begin{bmatrix} +\text{ voice} \\ +\text{ strident} \end{bmatrix} - \begin{bmatrix} +\text{ voice} \\ -\text{ strident} \end{bmatrix}) \quad >$$

$$\Delta(\begin{bmatrix} -\text{ voice} \\ +\text{ strident} \end{bmatrix} - \begin{bmatrix} -\text{ voice} \\ -\text{ strident} \end{bmatrix})$$

This P-map hierarchy can be formulated as a ranking of relevant Faithfulness constraints, as demonstrated in (65).

(65) Ranking of constraints

IDENTVOICED(strident) ≫ IDENTVOICELESS(strident)

(abbreviations: IDVCD(strid) ≫ IDVCLS(strid))

Three typological patterns arise from the interactions between two IDENT constraints and CORAFFR. Compare the factorial typology given in (66) and the typological results presented in (23). The compatibility is evident: the typological predictions are born out by reranking of CORAFFR.

(66) Factorial typology of the target voicing asymmetry in coronal affrication

	ranking	***expected pattern***	***example***
a.	CORAFFR ≫ IDVCD(strid) ≫ IDVCLS (strid)	*both voiceless and voiced stops undergo affrication*	(24)
b.	IDVCD(strid) ≫ CORAFFR ≫ IDVCLS(strid)	*only voiceless stops undergo affrication*	(25)
c.	IDVCD(strid) ≫ IDVCLS (strid) ≫ CORAFFR	*no affrication*	-

In (66a), CORAFFR outranks both IDVCD(strid) and IDVCLS(strid), and thus coronal affrication targets not only voiceless stops but also voiced ones. The tableaux in (67) illustrate this type of coronal affrication shown in Mongo. As already demonstrated in (24), Mongo coronal affrication targets not only /t/ but also /d/. Due to the undominated CORAFFR, faithful candidates, such as [ti] and [di], are never chosen as optimal outputs in both tableaux:

(67) Analysis of coronal affrication in Mongo

a. /bɔ-kɛn**d**-wá/ → [bɔkɛn**d͡z**wá] 'inconstant'

Input: /dw/	CORAFFR	IDVCD(strid)	IDVCLS(strid)
dw	*!		
☞ d͡zw		*	

b. /bo-lot-**t**i/ → [bolo**t͡s**i] 'fugitive'

Input: /ti/	CORAFFR	IDVCD(strid)	IDVCLS(strid)
ti	*!		
☞ t͡si			*

Next, in (66b), CORAFFR is ranked between IDVCD(strid) and IDVCLS(strid). Therefore, coronal affrication only targets voiceless stops, since affrication of a voiced stop causes a critical violation of IDVCD(strid) which is ranked higher than

CORAFFR. German is a typical example of this kind of grammar. Only a voiceless stop /t/ can be targeted by coronal affrication in this language, as illustrated in (25). The following tableaux show the relevant analyses:

(68) Analysis of coronal affrication in German

a. /stuːdjum/ → [ʃtuː**dj**ʊm] 'studies SG'

Input: /dj/	IDVCD(strid)	CORAFFR	IDVCLS(strid)
☞ dj		*	
d͡zj	*!		

b. /konsor**t**jum/ → [kɔnˈzɔɐ**t͡s**jʊm] 'syndicate'

Input: /tj/	IDVCD(strid)	CORAFFR	IDVCLS(strid)
tj		*!	
☞ t͡sj			*

In tableau (68a), the unfaithful candidate with [d͡z] is ruled out since it violates dominant IDVCD(strid) which requires a preservation of the stridency value of the input voiced stop. On the other hand, in tableau (68b), affricated [t͡sj] is optimal, because it violates only low-ranked IDVCLS(strid), and its competitor [tj] violates the higher-ranked CORAFFR.

4.4. Summary

In this section, I claimed that the correlation between the implicational universals and perceptual asymmetries which were observed in previous sections can best be explained under the phonetically-based approach to phonology. By implementing P-map principles within the framework of Optimality Theory, all and only typologically attested patterns of coronal palatalization and affrication are properly predicted, capturing the difference between the two processes.

5. Discussion

This section discusses remaining topics, from both empirical and theoretical standpoints. The first subsection discusses why coronal stop palatalization commonly results in affricated outcomes. In the second subsection, the potential influence of the structure preservation in shaping the observed typological patterns of the two processes, especially the target asymmetries, will be discussed. In the third subsection, a brief typology and analysis of the postvocalic coronal palatalization will be provided. Finally, the fourth subsection discusses how obligatory laminalization that comes with coronal palatalization can be explained under the current approach.

5.1. Why is coronal stop palatalization almost always accompanied by affrication?

When anterior stops undergo coronal palatalization, affrication almost always occurs at the same time. In my data, the most frequent outcomes of coronal stop palatalization are post-alveolar affricates, such as [t͡ʃ] and [d͡ʒ], rather than [t̠, d̠] or [c, ɟ]. Among the 42 languages in which a stop consonant undergoes coronal palatalization, posterior stop outcomes were attested only in seven languages (Acoma, Nimboran, Nyawaygi, Slovak, Tiwi, Udmurt, and Zoque).

From the viewpoint of phonetics, the affricated outcomes of coronal stop palatalization can be attributed to phonetic instabilities of posterior coronal stops. Posterior stops have laminal gestures in general (excluding retroflex stops which have an apical posterior gesture), and this gesture produces a very narrow and extensive closure toward the hard palate. For this reason, the transition noise of the laminal posterior stop is significantly longer and more intense than that of other stops, having an inherently affricated release (Ladefoged & Johnson 1993: 170; Ladefoged & Maddieson 1996: 30). Therefore, affricated outcomes of coronal stop palatalization can be considered as a by-product of the palatalizing process, rather than the result of intended coronal affrication (cf. Flemming 2002: 103ff., who suggests an alternative analysis of velar palatalization as a by-product of enhancing contrasts). This articulatory motivation can be captured by Markedness constraint as in (69).

(69) $* \begin{bmatrix} -\text{sonorant} \\ -\text{anterior} \\ -\text{strident} \end{bmatrix}$ (***POSTSTOP**)

No non-strident posterior obstruent.

This by-product analysis of palatal affricates thus explains why affricated outcomes can result from a palatalization process even in the context of non-high front vowel (e.g., [_e]), where coronal affrication never occurs. Recall that not only a high front /i/ but also a non-high front /e/ trigger coronal palatalization which turns /t/ into an affricate /t͡ʃ/ in Amharic (e.g., /kəffət-e/ → [kɨfət͡ʃt͡ʃe] 'having opened, 1ST SG'). This affrication in the [_e] context can be analyzed by implementing an undominated *POSTSTOP constraint, as in the tableau in (70).

(70) /kəffət-e/ → [kɨfət͡ʃt͡ʃe] 'having opened, 1ST SG'

Input: /te/	*POSTSTOP	CORPAL	ID(ant)/__e	ID(ant)/__i
te		*!		
☞ t͡ʃe			*	
t̠e	*!		*	

In the above tableau, the optimal candidate is palatalized and affricated [t͡ʃe], since this candidate does not violate the topmost constraints, *POSTSTOP and CORPAL. On the other hand, the non-palatalized [te] and the non-affricated [t̠e] are ruled out by the crucial violations of CORPAL and *POSTSTOP respectively.

5.2. Target asymmetries and structure preservation

In the previous sections, I have claimed that there are two implicational universals concerning targets of coronal palatalization and coronal affrication and provided a phonetically-based account for these universals. However, one may argue that these implicational relationships can be attributed to the language-specific structural motivations, rather than the phonetic properties discussed in this thesis. The Structural Analogy principle suggested by Blevins (2004) would be a good example of such an argument against the phonetically-based explanations of the observed typological asymmetries.

(71) Structural Analogy (Blevins 2004: 154)

> In the course of language acquisition, the existence of a (non-ambiguous) phonological contrast between A and B will result in more instances of sound change involving shifts of ambiguous elements to A or B than if no contrast between A and B existed.

What this principle suggests is simple: a sound change occurs more easily when the output of the process is a pre-existing category or structure, compared to a change whose output is not an established category or structure. According to Blevins (2004: 154), "[u]nder Structural Analogy, language-specific priming effects play a role in the course of language acquisition precisely where contrasts are unambiguous." In principle, such an argument can be made for the target asymmetries observed in the current typology, namely the target manner asymmetry in coronal palatalization (29b) and the target voicing asymmetry in coronal affrication (29d). Under the assumption that this 'language-specific priming' has significant effects on the processes of coronal palatalization and coronal affrication, it can be argued that these observed asymmetries can simply be interpreted as results of differences in phonemic structures, i.e., absence or presence of a potential outcome in the phonemic inventory of a given language.

For example, based on such an assumption, one may argue that the target asymmetry between nasal and lateral consonants in coronal palatalization (29b) is due to the fact that languages which show this discrepancy have phoneme inventories with a potential outcome of /n/-palatalization but without that of /l/-palatalization. In fact, the results of my typological survey are consistent with this assumption. Among the 13 languages in which /n/ is targeted by coronal palatalization whereas /l/ is not targeted (Dutch, Ikalanga, Logoori, Luvale, Nanai, Nyawaygi, Mandarin, Polish, Shaoxing Wu, Tiwi, Trentino Italian, Tswana, Zoque), there was no language which has a laminal posterior lateral, such as /ʎ/, in its phonemic inventory. Note also that the same sort of claim can also be made about the target asymmetry between coronal affrication targets (29d) based on the typological fact. Among the two languages in which coronal affrication only targets a voiceless /t/ (Dutch and German), there was no language which has a phonemic voiced affricate /d͡z/.

However, this kind of explanation which attributes the observed target asymmetries to the phonemic structure preservation can only provide a restricted account for the patterns of phonemic alternations. In other words, this explanation cannot explain the target asymmetries in allophonic changes. Among the afore-mentioned 13 languages which show systematic target asymmetry between anterior nasal and lateral consonants, at least in the five languages (Dutch, Nyawaygi, Mandarin, Shaoxing Wu, and Tiwi), not only /ʎ/ but also /ɲ/ did not exist in their phonemic inventories. Dutch coronal palatalization would be a typical example of such an allophonic change. The examples of Dutch coronal palatalization suggested in (14) is repeated in below (72):

(72) Coronal palatalization in Dutch

a.	Ha**d** je?	[hɑ**t͡ʃ**jə] ~ [hɑ**t͡ʃ**ə]	'had you?'
b.	Wa**s** je?	[ʋɑ**ʃ**jə] ~ [ʋɑ**ʃ**ə]	'were you?'
c.	Ka**n** je?	[kɑ**ɲ**jə] ~ [kɑ**ɲ**ə]	'can you?'
d.	Za**l** je?	[zɑ**l**jə]	'will you?'

As illustrated in (72), in Dutch, only the obstruent consonants and the nasal /n/ undergo coronal palatalization before /j/, excluding /l/. Since Dutch does not have any phonemic contrasts between anterior and posterior consonants (Booij 1995: 7), this asymmetry shown in Dutch cannot be attributed to the structure preservation.

Similarly, German coronal affrication (25), which is exemplified again in (73), cannot also be explained in terms of the structure preservation.

(73) Coronal affrication in German (Hall 2004)

a. *Konsor**t**ium* [kɔnˈzɔɐ**t͡s**jʊm] ‘syndicate’

b. *Studium* [ʃtuːdjʊm] ‘studies, SG’

Given the fact that German does not have both voiced and voiceless anterior affricates in its phoneme list (Kohler 1999: 86), it is impossible to argue that /d/ does not undergo coronal affrication in German due to the lack of /d͡z/.

Thus, it seems obvious that the structure-preserving account cannot provide a proper explanation of the target asymmetries which hold for non-phonemic changes. Although I do not deny potential roles of the structure preservation, it is difficult to integrate the patterns of phonemic changes and allophonic alternations under the structure-preserving account. Of course, one may argue that the patterns of phonemic alternations and those of allophonic ones are shaped by the different causes, i.e., the structure preservation and the perceptual asymmetries respectively. However, I do not accept this option here because considering that the patterns of phonemic and allophonic processes arise from the same mechanism is more plausible, or at least economical. Adopting this alternative explanation makes it difficult to capture the common properties of these phonemic and allophonic changes, undermining the integrity of the analysis.

5.3. Postvocalic coronal palatalization

In section 2, I excluded postvocalic occurrences of coronal palatalization from investigation, in order to compare coronal palatalization with coronal affrication which does not occur in the postvocalic context. The reason why coronal affrication does not occur after a high vocoid is now apparent: the preceding vocoid does not have effects on the release of the stop, contrary to the following high vocoid which conditions an affricated release of the preceding stop. In contrast, postvocalic coronal palatalization occurs in many languages. This subsection attempts to give an explanation for this postvocalic coronal palatalization, integrating it into the analysis of prevocalic coronal palatalization presented in section 4.

Before analyzing the postvocalic coronal palatalization, in order to figure out whether there are clear differences between postvocalic palatalization and prevocalic palatalization, I conducted a simple typological survey on the seven languages with postvocalic coronal palatalization that is largely built on the data provided by Bateman (2007). The results of this typological survey on postvocalic palatalization are summarized in (74). In the following table, 'X' indicates that the corresponding segment class does not have the corresponding triggers or targets. The symbol '-' denotes that there is no corresponding segment in the phonemic inventory of a given language.

(74) The mini typology of postvocalic coronal palatalization

language	trigger		target		
	high front	mid front	obstruents	nasal	lateral
Basque	/i/	X	/t/ → [c]	/n/ → [ɲ]	/l/ → [ʎ]
Carib	/i, iː/	X	/s/ → [ʃ]	/n/ → [ɲ]	-
Karok	/j, i/	/e/	/s/ → [ʃ]	X	-
Sentani[15]	/j, i/	X	/t/ → [c] /d/ → [ɟ]	/n/ → [ɲ]	X
Western Shoshoni	/i/	/a͡i/	/s/ → [ʃ] /t͡s/ → [t͡ʃ] ~ [ʒ] /tt͡s/ → [t͡ʃt͡ʃ]	X	-
Yagua	/j, i/	X	/s/ → [ʃ]	X	-
Yimas	/j, i/	-	/t/ → [c]	/n/ → [ɲ]	-

('X' = 'does not trigger or untargeted', '-' = 'no corresponding segment')

This table shows that the trigger asymmetry (29a) and the target manner asymmetry

[15] The outcome consonants and occurring contexts of Sentani coronal palatalization described here are controversial. Although Cowan (1965: 4) suggests that [t'], [d'], and [ñ] as palatalized allophones of /t/, /d/, and /n/ which are attested after /j/ and /i/, it is not obvious whether these [t'], [d'], and [ñ] are secondarily palatalized or fully palatalized. According to Hartzler's (1976) description, among these allophonic consonants, it seems that at least [ñ] is an alveolo-palatal rather than a secondarily palatalized [n^{j}]. However, Hartzler (1976) does not describe palatalized allophones of stop consonants. In addition, although Cowan (1965: 6) implies that the palatalized stops, [t'] and [d'] even can occur adjacent to /w/ and /u/, as discussed in Bateman (2007: 459), it seems that the realization of these allophones after a high back vocoid is "not indicated but assumed" by Cowan (1965); there is no clear example which shows coronal palatalization triggered by high back vocoids in Cowan (1965).

(29b), both of which were proposed to explain typological patterns of prevocalic coronal palatalization, may also hold for those of postvocalic coronal palatalization. First, among the seven languages surveyed, there was no language in which only a non-high front vocoid triggers coronal palatalization. The presence of the mid-front vowel trigger implied the existence of the high front vocoid trigger as in prevocalic palatalization. Second, there was also no language in which only sonorants undergo coronal palatalization excluding obstruents or only laterals undergo the process excluding nasals. Thus, it is suggested that the same target manner asymmetry holds for both prevocalic and postvocalic palatalization.

In addition, the perceptual asymmetries holding for prevocalic coronal palatalization context, discussed in section 3, also hold for the postvocalic context. Although it has been widely argued that the VC formant transition provides relatively less prominent cues to the place contrasts between consonants (e.g., Jun 2004: 64), to a certain extent, it can play an important role in the identification of the place of consonants (e.g., Ohde & Sharf 1981). Thus, in principle, it can be expected that the perceptibility of the feature [anterior] is determined not only by the similarity in CV transitions between anterior and posterior consonants but also, more or less, by that in VC transitions. Furthermore, other things being equal, the phonetic characteristics of the VC transitions are not much different from those of the CV transitions. That is, for example, the F2 frequencies characterizing the place of a consonant vary depending not only on the following vocoid but also on the preceding vocoid. To sum up, these phonetic observations suggest that the anteriority contrast is less salient after high front vocoids than after non-high ones, and that the anteriority contrast of obstruents is less salient in the VC context than that of nasals, which in turn is less salient than that of laterals, in the same manner as observed in the CV contexts.

Based on these typological and phonetic asymmetries observed in the postvocalic contexts and the consistencies shown between them, the phonetically-based analysis of postvocalic palatalization can be developed. In the rest of this subsection, palatalization in Basque will be analyzed in order to present such a phonetically-based analysis of the postvocalic coronal palatalization.

In Basque, after a high front vowel /i/, /n, l, t, d/ are palatalized into [ɲ, ʎ, c, ɟ] respectively while non-high front vowel, such as /e/, does not trigger the same process. Examples of Basque palatalization are illustrated in (75):

(75) Postvocalic coronal palatalization in Basque (Hualde & de Urbina 2003: 38)

a. /mendi-**t**ik/ [mendi**c**ik] 'from the mountain'

b. /et͡ʃe-**t**ik/ [etʃe**t**ik] 'from the house'

In (75a), postvocalic coronal palatalization turns /t/ into [c] after a high front vowel /i/. In contrast, the same process does not occur after a mid front vowel /e/, as exemplified in (75b).

In order to analyze this process, exemplified in (75), I introduce a new Markedness constraint which triggers postvocalic palatalization and a set of

Faithfulness constraints which are inherently stratified by the guide of P-map. First, the Markedness constraint which militates against maintaining anterior articulation after a front vocoid can be suggested as in (76). This constraint is a postvocalic counterpart of CORPAL constraint. Unlike CORPAL constraint which penalizes a surface anterior consonant – front vocoid sequence, this constraint penalizes a realization of a front vocoid – anterior consonant sequence.

(76) $*\begin{bmatrix} \text{V} \\ \text{+ front} \end{bmatrix} \begin{bmatrix} \text{C} \\ \text{+ anterior} \end{bmatrix}$ (**POSTVCORPAL**)

no anterior consonant after a front vocoid

As in prevocalic palatalization, this POSTVCORPAL constraint may interact with the following Faithfulness constraints:

(77) Ranking of Faithfulness constraints

$\text{IDENT(anterior)}/\begin{bmatrix} \text{V} \\ \text{+ front} \\ \text{– high} \end{bmatrix}\_\_ \gg \text{IDENT(anterior)}/\begin{bmatrix} \text{V} \\ \text{+ front} \\ \text{+ high} \end{bmatrix}\_\_$

(abbreviations: ID(ant)/e__ ≫ ID(ant)/i__)

These Faithfulness constraints are ranked by P-map, reflecting the differences in perceptibility of the anteriority contrast, like their prevocalic counterparts introduced in (48).

By ranking the POSTVCORPAL constraint between the two Faithfulness constraints suggested in (77), postvocalic coronal palatalization in Basque exemplified in (75) can be analyzed as follows:

(78) Analysis of postvocalic coronal palatalization in Basque

a. /et͡ʃ**e-t**ik/ → [et͡ʃ**et**ik] 'from the house'

Input: /e-t/	ID(ant)/e__	POSTVCORPAL	ID(ant)/i__
☞ et		*	
ec	*!		

b. /mend**i-t**ik/ → [mend**ic**ik] 'from the mountain'

Input: /i-t/	ID(ant)/e__	POSTVCORPAL	ID(ant)/i__
it		*!	
☞ ic			*

An alveolar stop /t/ cannot be a target of coronal palatalization after a mid front vowel /e/, since a palatalized candidate [ec] is penalized by dominant ID(ant)/e__ as in (79a). In contrast, as shown in tableau (79b), /t/ is palatalized after /i/, due to the domination of PostVCorPal over Id(ant)/i__. The target manner asymmetry in postvocalic palatalization can be analyzed in a similar way, by using a postvocalic version of CorPal constraint and Faithfulness constraints presented in (53) (analysis not shown for brevity).

5.4. Laminalization

Coronal palatalization always results in laminal posterior consonants, not apical ones. Hume (1992) explains this obligatory laminalization that comes with a change in anteriority by spreading of an inherent [+distributed] from the front vocoids, as illustrated in (3). Under the current analysis, however, this obligatory laminalization cannot properly be captured since a potential mechanism that may drive a change in apicality is not formalized in section 4. Consider coronal palatalization attested in Mandarin Chinese as an example:

(79) Coronal palatalization in Mandarin (Dumanu 2000)

a. /**t͡s**ian/ [**t͡ɕ**ian] 'sharp'

b. /**t͡sʰ**ian/ [**t͡ɕʰ**ian] 'owe'

c. /**s**ian/ [**ɕ**ian] 'thread'

d. /**n**ian/ [**nʲ**an] ~ [**ɲ**an] 'year'

In this language, anterior sibilants and a nasal undergo coronal palatalization before a high front vowel /i/, being realized as laminal posterior consonants. Thus, a proper analysis should rule out apical posterior consonants, such as [t͡ʂ, t͡ʂʰ, ʂ, ɳ], correctly deriving attested laminal outcomes. However, as presented in (80), the current analysis cannot properly rule out the apical posterior candidates.

(80) Analysis of /sian/ → [ɕian] 'thread'

Input: /si/	ID(ant)/__e	CORPAL	ID(ant)/__i
si		*!	
☞ ʂi			*
☞ ɕi			*

The tableau in (80) illustrates an analysis of Mandarin /s/-palatalization (79c), predicting that both the palatalized [ɕi] and the posteriorized [ʂi] can be optimal outputs. This is quite problematic since turning an anterior consonant into apical posterior one is not a common strategy to alleviate the articulatory efforts. Rather, it seems that apical posterior – front vocoid sequences are not preferred cross-linguistically (Flemming 2003; Hamann 2003; Lee-Kim 2014, and references there in). Thus, it is now evident that the current analysis developed in this thesis should be supplemented in order to treat this problem more appropriately.

Recall from section 4 that I introduced the CORPAL constraint (46) based on the articulatory properties of an anterior consonant before a front vocoid. Contrary to the coronal consonant that is articulated by the tongue-tip or blade, the articulation of the front vocoid requires raising and fronting of the tongue body which naturally turns the tongue tip and blade downwards. To maintain these two conflicting gestures, a speaker should carefully control her articulators. This articulatory effortness is reflected in the CORPAL constraint which militates against the sequence of the anterior consonant – front vocoid articulations.

Like this CORPAL constraint, in principle, it is possible to formalize other Markedness constraints which militate against the different combinations of sounds based on the articulatory facts. As a basis of introducing such a new Markedness constraint to the current analysis, in Figure 5.1, the articulatory differences between an anterior, laminal posterior, and apical posterior consonants with regard to the following front vocoid are schematized:

Figure 5.1

Schematic configurations for (a) an anterior [s], (b) apical posterior [ʂ], and (c) laminal posterior [ɕ], based on the X-ray data (Ladefoged & Wu 1984) and the real-time MRI data (Proctor et al. 2012) of Mandarin sibilants. For the purpose of comparison with the gesture of the front vocoid, a schematic configuration of a high front vowel [i] is suggested in the gray lines.

First, consider an anterior [s] (Figure 5.1a). This consonant is articulated with the tongue tip and blade which is near the front teeth, forming a slightly curved gesture. As noted above, this gesture of anterior consonants causes a conflict with that of the following front vocoid which is articulated with the raised tongue body (the gray lines in the above figure). Note that this kind of articulatory conflict is also observed regarding the apical posterior consonant, in a more severe way, since the apical posterior articulation involves significant curvature of the tongue tip and blade forming constriction behind the alveolar ridge (Figure 5.1b). As discussed in Flemming (2003: 339), "[e]ven more modest retroflexion is problematic with a front tongue body, because forming a palatal constriction for a front vowel involves raising the front of the tongue body, which tends to roll the tongue tip forward and down.” By contrast, laminal posterior consonants are produced by the raising of the front part of the tongue body or the slightly raised tongue blade (Figure 5.3). This articulatory gesture naturally turns tongue tip and blade downward, just as in the following front vocoid. Broadly speaking, there are no crucial differences in articulatory gestures between the laminal posterior consonant and the front vocoid (see also Hume 1992; Flemming 2003).

Based on these articulatory facts, the following articulatorily-based Markedness constraint can be introduced:

(81) $$*\begin{bmatrix} \text{C} \\ \text{- anterior} \\ \text{- distributed} \end{bmatrix}\begin{bmatrix} \text{V} \\ \text{+ front} \end{bmatrix}$$ (***APICPOST-FRONT**)

no apical posterior consonant before a front vocoid

This Markedness constraint penalizes an apical posterior consonant – front vocoid sequence, such as [ʂi]. Under the assumption that a constraint which penalizes a sound sequence which articulatorily requires more effort is inherently ranked above that which militates against a sound sequence which articulatorily requires less effort (Hayes & Steriade 2004), the ranking of this constraint and CORPAL constraint can be determined based on the articulatory observations discussed above.

(82) *[C, -anterior, - distributed][V, +front] (***APICPOST-FRONT**) ≫

*[C, + anterior][V, +front] (**CORPAL**)

These Markedness constraints, *APICPOST-FRONT and CORPAL interact with ID(ant) constraints which have a priori fixed ranking based on the relevant P-map (e.g., constraints introduced in (48): ID(ant)/__e ≫ ID(ant)/__i).

By introducing *APICPOST-FRONT constraint and ranking it above CORPAL, coronal palatalization in Mandarin Chinese can properly be captured in this analysis.

(83) Analysis of /sian/ → [ɕian] 'thread'

Input: /si/	*APICPOST-FRONT	ID(ant)/__e	CORPAL	ID(ant)/__i
si			*!	
ʂi	*!			
☞ ɕi				*

In contrast to the analysis provided in (80) that employs only CORPAL as a relevant articulatorily-based Markedness constraint, in the grammar presented in (83), a non-laminalized candidate [ʂi] can be ruled out by the fatal violation of the topmost *APICPOST-FRONT constraint.

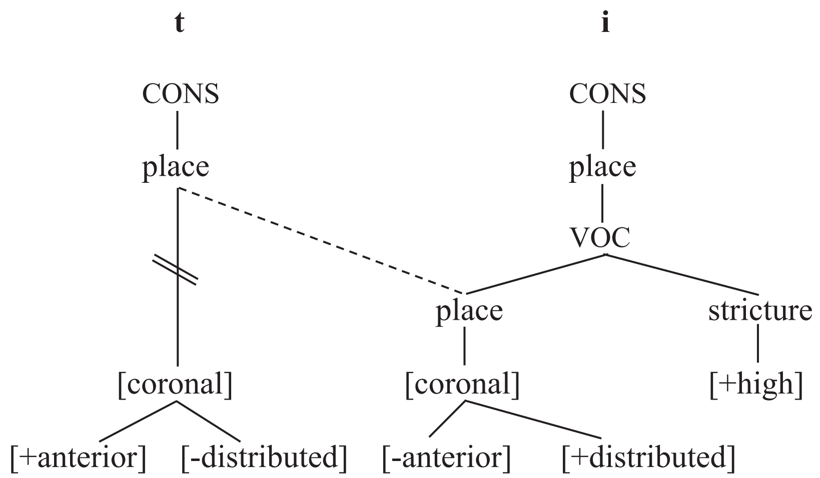
6. Alternative approaches

In this section, I investigate the following three alternative approaches. First, Hume (1992) suggests a classical representational approach to various CV interactions involving coronal consonants and front vocoids. Second, Bateman (2007) explains palatalization processes including coronal palatalization under the articulatorily-based model. Third, Hall & Hamann (2006) try to give an explanation of the assibilation processes which encompass coronal affrication and coronal stop palatalization by implementing perceptually-based Markedness constraints. Although these approaches have their own advantages, however, in this section it will be shown that they also have some critical problems and explanatory gaps which do not arise under the current model.

6.1. Hume (1992)

As briefly discussed in the introduction of this thesis, the Vowel-Place theory (Clements 1991; Hume 1992; Clements & Hume 1995) gives explanations of various coronal consonant - front vocoid interactions based on the representational proposal. For example, in this theory, coronal palatalization is explained as spreading of vocoidal [coronal] feature from the V-place node of the front vocoid to the C-place node of the adjacent consonant. An example of Hume's (1992) Vowel-Place analysis of coronal palatalization which was described in (3) is repeated here:

(84) /t/ → [t͡ʃ] (Hume 1992: 183)



This model predicts that a phonological process that is not triggered by a front vocoid or that does not involve changes of relevant place features is not coronal palatalization. Strictly speaking, in Hume's (1992) model (and also in other Vowel-Place models), affrication which comes with coronal palatalization and coronal affrication are not part of palatalization process. In sections 2 and 3, I suggested that this prediction is correct, based on the typological data and the results of the phonetic investigation: coronal palatalization and coronal affrication are different phonological processes which have distinct phonetic backgrounds and typological patterns.

However, although Hume's (1992) prediction is right, it also has apparent limitations. The first problem is that this model is unsuitable to analyze the typological asymmetries proposed in section 2. For example, since the stricture node that dominates vowel height features cannot spread into the adjacent consonant, it is impossible to analyze the different realization of coronal palatalization according to the trigger height. In principle, Hume's (1992) model predicts that all front vocoids can equally trigger the process without differences, even including a low-front /æ/ that almost never triggers the process as presented in section 2.2.

The second problem which arises from Hume's model is an inability in explaining coronal affrication. As I have shown throughout this thesis, coronal affrication can be considered as a kind of CV interaction since it occurs under the influence of the apparent vocoidal triggers (high vocoids). However, in Hume's model which considers CV interaction as featural assimilation, coronal affrication that only involves changes in manner features cannot receive a proper explanation. Although Hume (1992: 179) suggests that "[t]he most straightforward account" of coronal affrication like a process shown in Japanese (2) is "to attribute affrication before a high back vowel to assimilation to the feature value [+continuant] of the vowel," this cannot be a proper explanation of this process since all vocoids have feature [+continuant] regardless of their height or backness. Under such an account to coronal affrication, it is impossible to explain why coronal affrication only occurs before a high vocoid.

In contrast, as shown in sections 4 and 5, the current study gives an analysis of coronal palatalization and coronal affrication, without any stipulation about the representation (e.g., [coronal] for front vocoids). By capturing changes of coronal consonants under the influences of the trigger vocoids as results of mediation by phonetically-based constraints, the current analysis not only correctly captures the typological patterns of coronal palatalization that can barely be handled under Hume's (1992) model but also gives a proper explanation of coronal affrication.

6.2. Bateman (2007)

In order to explain the typological patterns of palatalization, Bateman (2007) implements gesturally-based constraints within the Optimality Theoretic framework, which are largely based on the Articulatory Phonology theory (e.g., Browman & Goldstein 1992, 1993; Gafos 2002; Davidson 2003, 2004). In this gestural approach to palatalization, especially two articulatory variables are significantly considered: 'constriction location' and 'constriction degree' (Bateman 2007: 190). For example, articulatory properties of a front vowel [e] are represented by [palatal] constriction location and [mid] constriction degree, and those of a high back vowel [u] are represented by [velar] constriction location and [narrow] constriction degree; a high front vowel, such as [i], has [palatal] and [narrow] features.

Under Bateman's model, among the vocalic gestural features, especially [palatal] and [narrow] are relevant to palatalization processes. When a consonant is adjacent to a vocoid which has a [palatal] or [narrow] gesture, coordination of the vocalic gesture at the center of consonantal gesture (or at the release of the consonant, in case of secondary palatalization) is demanded. In other words, palatalization occurs before a non-high front vowel in order to coordinate the [palatal] gesture at the center of the consonantal gesture, and similarly, it occurs before a high back vowel due to the gestural coordination of the [narrow] feature. The high front context is optimal for triggering palatalization since this environment requires gestural coordination of both [palatal] and [narrow] features. The trigger height and trigger frontness asymmetries in palatalization processes thus can be explained by articulatory mechanisms. A high front vocoid, such as /i/, is a more likely trigger for palatalization because it requires not only gestural coordination of [palatal] but also that of [narrow], compared to /e/ or /u/ which only requires the gestural coordination of [palatal] or [narrow] respectively.

In order to formalize these requirements for gestural coordination, Bateman employs CV-COORD [F] (CV [F]) constraints which align the landmark of consonantal gesture with the onset of vowel gesture.[16] The universal ranking of

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[16] According to Bateman (2007: 211-214), there are two types of CV-COORD constraints. A constraint which requires alignment of the center of consonantal gesture with the onset of vocalic gesture (CV-COORD-Center), and one which requires alignment of the release of consonantal gesture with the onset of vocalic gesture (CV-COORD-Release). The former

relevant gesturally-based constraints thus can be suggested as in (85).

(85) CV [palatal, narrow] ≫ CV [palatal], CV [narrow]

These CV constraints interact with IDENT-CL which requires the preservation of the constriction of the tongue tip/body gesture of the input consonant, inducing the factorial typology given in (86). First, if IDENT-CL is dominated by all CV constraints, both high and front vocoids trigger palatalization processes (86a). Second, if IDENT-CL dominates only CV [narrow] or CV [palatal], palatalization exclusively occurs in the front vocoid contexts or high vocoid contexts (86b-c). Third, if IDENT-CL is dominated only by CV [narrow, palatal], then palatalization is triggered only by high front vocoids (86d). Finally, if IDENT-CL dominates all CV constraints, then palatalization processes do not occur (86e).

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constraint drives primary palatalization and the latter one motivates secondary palatalization, since the former requires more gestural overlap than the latter. In this section, I only discuss CV-COORD-Center constraints which motivate primary palatalization.

(86) Typological patterns of the trigger asymmetries (Bateman 2007: 281)

	ranking	*patterns*
a.	CV [palatal, narrow] ≫ CV [palatal], CV [narrow] ≫ IDENT-CL	*both high and front vocoids trigger palatalization*
b.	CV [palatal, narrow] ≫ CV [palatal] ≫ IDENT-CL ≫ CV [narrow]	*only front vocoids trigger palatalization*
c.	CV [palatal, narrow] ≫ CV [narrow] ≫ IDENT-CL ≫ CV [palatal]	*only high vocoids trigger palatalization*
d.	CV [palatal, narrow] ≫ IDENT-CL ≫ CV [palatal], CV [narrow]	*only high front vocoids trigger palatalization*
e.	IDENT-CL ≫ CV [palatal, narrow] ≫ CV [palatal], CV [narrow]	*no palatalization*

Batemans' model has at least two advantages. First, it provides comprehensive explanations for diverse palatalization processes, including velar palatalization and secondary palatalization. Second, it captures articulatory effects in palatalization by implementing gestural constraints. Since consonant-to-vowel coarticulation is one of well-defined motivation for palatalization (e.g., Hyman 1975; Kitting 1993), a proper analysis of palatalization processes should consider this factor. However, despite these advantages, this model fails to explain the diverse aspects of coronal palatalization, facing some empirical challenges.

First, the gestural approach to palatalization processes cannot properly capture the target manner asymmetry in coronal palatalization. Since anterior consonants, such as /t/ and /n/, are not different in their constriction location and degree, Bateman's model cannot deal with anterior targets with different manner feature separately. For example, it is impossible to posit an IDENT-CL constraint which evaluates only obstruent alveolar or nasal ones, since there is no difference in constriction location between alveolar obstruents and nasals. On the other hand, the current approach provides an explanation to the target manner asymmetry in coronal palatalization by implementing perceptually-based Faithfulness constraints, as shown in section 4.2.2.

Second, Bateman's model fails to explain why certain types of outcomes are preferred than others. For example, a change from /t/ into [t͡ʃ] cannot be predicted in Bateman's model, since this model only appeals to the gestural blending without additional considerations. The gestural coordination of a vocalic [front] or [narrow] feature at the center of a [t] gesture only results in [c] or [t̠], rather than [t͡ʃ]. In contrast, as discussed in section 5.1, the current model provides additional explanation for the prevalence of the affricated outcomes in coronal stop palatalization, implementing higher-ranked *POSTSTOP constraint that has clear articulatory motivations.

Third, it is suspicious that the employment of CV [narrow] constraint can be properly justified. Note that there is no language which shows a clear place-changing palatalization process in the high back vocoid context, as demonstrated in section 2.4. Therefore, this constraint is quite redundant in the analysis of primary palatalization processes. Additionally, if this CV [narrow] constraint is not appropriately justified, then CV [palatal, narrow] is also hardly justified, since CV [palatal, narrow] is a local conjunction of CV [palatal] and CV [narrow] (Bateman 2007: 276; see also Itô & Mester 1996). Consequently, the trigger height asymmetry in palatalization processes cannot be explained by ranking CV [palatal, narrow] over CV [palatal]. In comparison, the current model captures the trigger height asymmetry by the perceptually-stratified IDENT constraints and the articulatorily-motivated CORPAL constraint which are well-grounded by phonetic evidence, reducing problems in formalization.

6.3. Hall & Hamann (2006)

Contrary to Bateman (2007), Hall & Hamann (2006) suggest a perceptually-based account of stop assibilation.[17] In their model, Markedness constraints are ranked reflecting perceptibility scales: *tj ≫ {*ti, *dj} ≫ *di. Because the duration of frication noise is longest in the [tj] sequence and shortest in the [di] sequence (Hall et al. 2006), it is expected that the perceptual contrast between anterior stops and

[17] Note that Hall & Hamann's (2006: 1995) term 'stop assibilation' encompasses coronal stop palatalization, coronal affrication, and spirantization of anterior stops (e.g., /t/ → [s]).

sibilants is most distinct in the [di] sequence and least distinct in the [tj] sequence.

In Hall & Hamann's model, the typological patterns of assibilation processes arise from the interactions between aforementioned Markedness constraints and IDENT-[strident]. This is illustrated in (87). First, if IDENT-[strident] is outranked by all Markedness constraints, assibilation of /t/ and /d/ occurs before both /j/ and /i/ (87a). Second, if IDENT-[strident] is dominated only by *tj and *dj but dominates over *ti and *di, assibilation of /t/ and /d/ occurs only before /j/ (87b). Third, if IDENT-[strident] is outranked only by *tj and *ti, then assibilation targets only a voiceless stop /t/ (87c). Fourth, if only *tj dominates over IDENT-[strident], assibilation is observable in the /tj/ sequence (87d). Finally, if IDENT-[strident] dominates over all Markedness constraints, there is no assibilation processes (87e).

(87) Factorial typology of assibilation

	ranking	*targeted contexts*
a.	*tj ≫ {*ti, *dj} ≫ *di ≫ ID-STRI	*/tj/, /ti/, /dj/, and /di/*
b.	*tj ≫ *dj ≫ ID-STRI ≫ *ti ≫ *di	*/tj/ and /dj/*
c.	*tj ≫ *ti ≫ ID-STRI ≫ *dj ≫ *di	*/tj/ and /ti/*
d.	*tj ≫ ID-STRI ≫ {*ti, *dj} ≫ *di	*/tj/*
e.	ID-STRI ≫ *tj ≫ {*ti, *dj} ≫ *di	*no assibilation*

By appealing to perceptual phonetics, Hall & Hamann's model quite successfully intermediates the typological patterns and phonetics, providing an explanation for assibilation processes in the high front context. However, it also reveals some problems, especially when it encounters empirical evidence presented outside the high front vocoid contexts with which they treat.

First, Hall & Hamann's perceptually-based account cannot predict the process-specificity of triggers. Note that Hall & Hamann suppose that assibilation processes have a specific phonetic relevance: the difference in the perceptibility of the contrast between coronal stops and sibilants in different vocalic contexts. This account thus predicts that so-called assibilation processes will show the same pattern in the same vocalic context. For example, this model does not predict any difference between coronal stop palatalization and coronal affrication in the high vocoid context. Similarly, it is also expected that there is no critical difference between coronal stop palatalization and affrication in the other vocalic contexts, as provisionally proposed by Hall & Hamann (2006: 1226). However, as shown in section 2, coronal stop palatalization is exclusively triggered by front vocoids, and coronal affrication is triggered only by high vocoids. The current model provides more competitive explanations for the typological patterns of coronal palatalization and coronal affrication than those of Hall & Hamann, analyzing these two processes separately.

Second, Hall & Hamann's model also fails to explain commonalities within coronal palatalization processes. Since Hall & Hamann's account provides explanations only for assibilation processes, an explanation of coronal stop palatalization cannot properly be integrated into other possible explanations for coronal palatalization processes which target non-stop anterior consonants. For example, although Hall & Hamann's model predicts that high front vocoid contexts are optimal for triggering assibilation processes, it cannot explain why these contexts are also optimal for coronal non-stop palatalization, such as /n/ → [ɲ]. In contrast, the current approach accurately explains why the high front vocoid contexts are optimal for triggering both coronal stop palatalization and non-stop palatalization.

Third, this perceptually-based approach to assibilation processes fails to explain why assibilation is preferred as a solution for avoiding specific CV sequences (e.g., [tj]). For example, not only assibilation of /t/ but also a vowel change (e.g., /tj/ → [te]) can satisfy the *tj constraint. In order to solve this problem, Hall & Hamann posit a high-ranked IDENT constraint which militates against the vowel change. Hall & Hamann (2006: 1219) argues that the potential IDENT constraint can be ranked ahead of other constraints, "[s]ince the kind of vowel changes described above are not the kind of repair strategy one encounters in the languages of the world." However, due to the diversity of potential repair strategies (e.g., /t/-deletion, vowel epenthesis, nasalization etc.), their assumption cannot solve this problem fundamentally. It is quite dubious that a lot of undominated IDENT constraints which penalize all potential solutions can be implemented based only on the typological observations. Note that the same problem may hold for the current analysis. However, if these non-prevalent repair strategies result in perceptually more salient or articulatorily more effortful changes, higher-ranked Faithfulness or Markedness constraints which prevent these repair strategies can be reasonably assumed in the current model as I introduced a series of articulatorily-based Markedness constraints in the last section.

7. Concluding remarks

This thesis makes the following important contributions. First, concerning the descriptive aspects of coronal palatalization and affrication, I proposed four implicational universals which govern the typological patterns, two for coronal palatalization (the trigger height and target manner asymmetries) and two for coronal affrication (the trigger frontness and target voicing asymmetries), based on the results of a survey of 69 languages. In addition, this thesis also argued that there is a process-specificity of triggers, that is, the exclusive triggering of coronal palatalization by front vocoids and coronal affrication by high vocoids. The results of this typological survey support the separation of coronal palatalization and affrication.

Second, concerning the theoretical aspects of coronal palatalization and affrication, this study clearly showed that the cross-linguistic patterns of coronal palatalization and affrication can best be explained under the phonetically-based approach which appeals not only articulatory properties but also perceptual ones. Typological patterns of coronal palatalization and affrication are properly explained by interactions of articulatorily-motivated Markedness and perceptually-driven Faithfulness constraints. Moreover, this thesis analyzed coronal palatalization and affrication separately, based on the empirical evidence provided from the in-depth typological and phonetic investigations. This separation allowed precise and accurate analyses of coronal palatalization and affrication, predicting all and only attested patterns.

APPENDIX I. The list of surveyed languages

1. Coronal Palatalization

	Languages	*References*	*Triggers*	*Targets*	*Outcomes*
1	Ainu	Bugaeva (2004)	/i/	/t, s/	[t͡ʃ, ʃ]
2	Acoma	Miller (1966)	/i, e/	/t, d, n/	[t̠, d̠, ɲ]
3	Amharic	Leslau (1995); Hayward & Hayward (1999)	/i, e/	/t, d, s, z, t', s', n, l/	[t͡ʃ, d͡ʒ, ʃ, ʒ, t͡ʃ', t͡ʃ', ɲ, j]
4	Apalai	Koehn & Koehn (1986)	/i/	/t, n/	[t͡ʃ, ɲ]
5	Atayal	Huang (2012)	/i/	/t, s/	[t͡ʃ, ʃ]
6	Brazilian Portuguese	Cristófaro-Silva & Guimarães (2009)	/i, e/	/t, d/	[t͡ʃ, d͡ʒ]
7	Breton[18]	Iosad (2012)	/i/	/t, d, s, z, n, l/	[ʃ, ʒ, ʃ, ʒ, ɲ, j]

[18] After /s/ and before /i/, /t/ turns into [t͡ʃ] rather than [ʃ].

	Languages	*References*	*Triggers*	*Targets*	*Outcomes*
8	Bunun (Isbukun)	Huang (2004, 2008)	/i/	/t, s/	[t͡ʃ, ʃ]
9	Bunun (Takituduh)	Huang (2004, 2008)	/i/	/t͡s, s/	[t͡ʃ, ʃ]
10	Cantonese	Alderete et al. (2017)	/y/	/t͡s, t͡sʰ, s/	[t͡ʃ, t͡ʃʰ, ʃ]
11	Cheyenne[19]	Davis (1962); Leman (1979)	/i/	/t/	[t͡ʃ]
12	Coatzospan Mixtec	Grefen (1999)	/i, e/	/t, ⁿd/	[t͡ʃ, ⁿd͡ʒ]
13	Dhivehi	Cain (2000)	/i/	/t, d, ⁿd, n, l/	[t͡ʃ, d͡ʒ, ⁿd͡ʒ, ɲ, j]
14	Dutch	Booij (1995); Collins & Mees (2003)	/j/	/t, d, s, z, n/	[t͡ʃ, t͡ʃ, ʃ, ʒ, ɲ]
15	English	Escure (1976); Zsiga (1995, 2000)	/j/	/t, d, s, z/	[t͡ʃ, d͡ʒ, ʃ, ʒ]
16	Fongbe[20]	Lefebvre & Brousseau (2002)	/i, ĩ/	/t, d/	[t͡ʃ, d͡ʒ]
17	French (Acadian)	Hume (1992)	/j/	/t, d/	[t͡ʃ, d͡ʒ]

[19] Coronal affrication can also occur, resulting [t͡s].

[20] Coronal affrication can also occur, resulting [t͡s, d͡z]

	Languages	*References*	*Triggers*	*Targets*	*Outcomes*
18	Greek (Cypriot)[21]	Newton (1972)	/j/	/s, z, n, l/	[ʃ, ʒ, ɲ, ʎ]
19	Greek (Kos)[22]	Kochetov (2016); Newton (1972)	/j/	/n, l/	[ɲ, ʎ]
20	Greek (Naousa)	Kappa & Sipitanos (2016)	/i, e/	/t͡s, s, z/	[t͡ʃ, ʃ, ʒ]
21	Harari	Ross (2004)	/i/	/t, d, t’, s, n, l/	[t͡ʃ, d͡ʒ, t͡ʃ’, ʃ, ɲ, j]
22	Hausa	Jaggar (2001)	/i, e/	/t, d, s, z/	[t͡ʃ, d͡ʒ, ʃ, ʒ]
23	Ikalanga[23]	Mathangwane (1999)	/j/	/t̪, n/	[t͡ʃ, ɲ]
24	Ilocano	Rubino (1997)	/j, i/	/t, d, s/	[t͡ʃ, d͡ʒ, ʃ]
25	Japanese	Kochetov & Alderete (2011)	/j, i/	/t, d, s, z, n/	[t͡ʃ, d͡ʒ, ʃ, ʒ, ɲ]
26	Kirundi[24]	Kochetov (2016)	/j/	/s, d͡z, n/	[ʃ, d͡ʒ, ɲ]
27	Korean[25]	H. Lee (1996); Yu Cho (2009)	/j, i/	/t, t^h, s, s’, n, l/	[t͡ɕ, $\widehat{tɕ}^h$, ɕ, ɕ’, ɲ, ʎ]

[21] /j/ is derived from /i, e/ by glide-formation.

[22] /j/ is derived from /i, e/ by glide-formation; /tj, sj, zj/ undergo glide-strengthening rather than palatalization.

[23] /j/ is derived from /i, e/ by glide-formation.

[24] /j/ is derived by glide-formation; /d/ undergoes coronal affrication; /t/ undergoes spirantization rather than coronal affrication, resulting [s].

[25] /t, t^h/ undergo morphophonemic palatalization.

	Languages	*References*	*Triggers*	*Targets*	*Outcomes*
28	Latvian[26]	Urek (2016)	/j/	/t, d, t͡s, d͡z, s, z, n, l/	[ʃ, ʒ, t͡ʃ, d͡ʒ, ʃ, ʒ, ɲ, ʎ]
29	Logoori[27]	Glewwe & Aly (2016); Leung (1991)	/j, i/	/s, n̪/	[ʃ, ɲ]
30	Luvale	Bateman (2007)	/j, i/	/t, ⁿd, s, z, n/	[t͡ʃ, ⁿʒ, ʃ. ʒ, ɲ]
31	Mandarin	Duanmu (2000); W. Lee & Zee (2003)	/i, y/	/t͡s, t͡sʰ, s, n/	[t͡ɕ, t͡ɕʰ, ɕ, ɲ]
32	Maori	Bauer (1993)	/i/	/t/	[t͡ç]
33	Marathi	Wali (2005)	/j, i, iː/	/t͡s, d͡z, d͡zʰ/	[t͡ʃ, d͡ʒ, d͡ʒʰ]
34	Mbahám	Cottet (2014, 2015)	/j, i, u (?), w (?)/	/t, d, ⁿd/	[t͡ʃ, d͡ʒ, nd͡ʒ]
35	Mina	Frajzyngier & Johnston (2005)	/i/	/t͡s, d͡z, s, z/	[t͡ʃ, d͡ʒ ʃ, ʒ]
36	Mongo[28]	de Rop (1958)	/j, i/	/n/	[ɲ]
37	Nanai	Ko & Yurn (2011)	/i, ɪ/	/s, n/	[ɕ, ɲ]
38	Nimboran	Anceaux (1965)	/i/	/t, d, s, n/	[t̠, d̠, ɕ, n̠]

[26] /j/ is derived from /i, e/ by glide-formation

[27] /j/ triggers palatalization of /s/ but /i/ triggers that of /n̪/.

[28] /t, d/ undergo coronal affrication rather than palatalization.

	Languages	*References*	*Triggers*	*Targets*	*Outcomes*
39	Nishnaabemwin	Valentine (2001)	/j, i/	/t, d, s/	[t͡ʃ, d͡ʒ, ʃ]
40	Nupe	Hyman (1970)	/i, e/	/t͡s, d͡z, s, z/	[t͡ʃ, d͡ʒ ʃ, ʒ]
41	Nyawaygi	Dixon (1981, 1983)	/i/	/d̪, n̪/	[d̠, n̠]
42	Oroqen	X. Zhang (1996)	/j/	/s/	[ɕ]
43	Polish	Ćavar (2004); Rubach (1984)	/i, e/	/t, d, s, z, n/	[t͡ɕ, d͡ʑ, ɕ, ʑ, ɲ]
44	Romanian[29]	Chitoran (2002)	/i/	/s, z/	[ʃʲ, ʒʲ]
45	Salar	Dwyer (2007)	/i, y/	/t, d/	[t͡ɕ, d͡ʑ]
46	Sanuma	Borgman (1990)	/i/	/t͡s, s/	[t͡ʃ, ʃ]
47	Shaoxing Wu	J. Zhang (2006)	/j, i, y/	/t͡s, t͡sʰ, d͡z, s, z, n/	[t͡ɕ, t͡ɕʰ, d͡ʑ, ɕ, ʑ, ɲ]
48	Slovak	Rubach (1993)	/j, i, iː, ɛ, ɛː, (æ)/	/t, d, t͡s, d͡z, s, z, n, l/	[c, ɟ, t͡ʃ, d͡ʒ, ʃ, ʒ, ɲ, ʎ]
49	Sonora Yaqui	Dedrik & Casad (1999)	/i/	/t/	[t͡ʃ]
50	Taiof[30]	Ross (2002)	/i/	/d, t͡s, n/	[t͡ʃ, d͡ʒ, ɲ]
51	Tera	Tench (2007)	/i, iː, e, eː/	/t, d/	[t͡ʃ, d͡ʒ]
52	Tiwi	J. Lee (1987)	/i/	/t̪, ⁿt̪, n̪/	[t̠, ⁿt̠, n̠]

[29] /d/ undergoes spirantization rather than coronal affrication.

[30] /t/ undergoes coronal affrication rather than palatalization.

	Languages	*References*	*Triggers*	*Targets*	*Outcomes*
53	Tota Logba	Dorvlo (2008)	/i/	/s, z/	[ʃ, ʒ]
54	Trentino Italian	Cordin (1997)	/i/	/t, n/	[t͡ʃ, ɲ]
55	Tswana[31]	University of Botswana (1999)	/j/	/t, n/	[t͡ʃ, ɲ]
56	Udmurt	Kochetov (2016)	/j/	/t, d, n, l/	[c, ɟ, ɲ, ʎ]
57	Upper Sorbian	Hawson (2017); Schaarschmidt (2004)	/i, e/	/t, d/	[t͡ʃ, d͡ʒ]
58	Wai Wai	Hawkins (1998)	/j, i, e/	/t, n/	[t͡ʃ, ɲ]
59	West Futuna-Aniwa	Dougherty (1983)	/i, e/	/t/	[t͡ʃ, d͡ʒ]
60	Yonaguni	Izuyama (2012); Yamada et al. (2015)	/j, i/	/t͡sˀ, s, z/	[t͡ɕˀ, ɕ, ʑ]
61	Zoque	Wonderly (1951)	/j/	/t, d, t͡s, s, n/	[t̠, d̠, t͡ʃ, ʃ, ɲ]

[31] /j/ is derived from /i, e, ɛ/ by glide-formation; /t/ can also be realized as [t͡s].

2. Coronal Affrication

	Languages	*References*	*Triggers*	*Targets*	*Outcomes*
1	Axininca Campa	Payne (1981); Spring (1992)	/i/	/t/	[t͡s]
2	Blackfoot	Frantz (1991)	/i/	/t/	[t͡s]
3	Cheyenne[32]	Davis (1962); Leman (1980)	/i/	/t/	[t͡s]
4	Dutch	Booij (1995)	/i/	/t/	[t͡s]
5	Fongbe	Lefebvre & Brousseau (2002)	/i, ĩ/	/t, d/	[t͡s, d͡z]
5	French (Quebec)	Kim (2001); Papen (1998)	/j, i, y, ɥ /	/t, d/	[t͡s, d͡z]
7	German[33]	Hall (2004)	/j/	/t/	[t͡s]
8	Japanese[34]	Kochetov & Alderete (2011)	/u/	/t, d/	[t͡s, d͡z]

32 Coronal palatalization can also occur, resulting [t͡ʃ].

33 /j/ is derived from /i/ by glide-formation.

34 /t, d, s, z, n/ undergo coronal palatalization before /j, i/.

	Languages	*References*	*Triggers*	*Targets*	*Outcomes*
9	Kirundi[35]	Kochetov (2016)	/j/	/d/	[d͡z]
10	Maori	Bauer (1993); Harlow (2006); Morrefield (2003)	/i, u/	/t/	[t͡s]
11	Mongo[36]	de Rop (1958)	/j, i, w/	/t, ⁿd/	[t͡s, ⁿd͡z]
12	Papago	Hale (1965); Hill & Zepeda (1992)	/i, ɨ, u/	/t, d/	[t͡s, d͡z]
13	Plains Cree	Wolfart (1973)	/j, i, ĩ/	/t/	[t͡s]
14	Romanian[37]	Chitoran (2002)	/i/	/t/	[t͡sʲ]

35 /t/ undergoes spirantization rather than coronal affrication, resulting [s]; /s, z, n/ undergo coronal palatalization.

36 /n/ undergoes coronal palatalization before /j, i/.

37 /d/ undergoes spirantization rather than coronal affrication.

	Languages	*References*	*Triggers*	*Targets*	*Outcomes*
15	Samoan[38]	Alderete & Bradshaw (2012)	/i/	/t/	[t͡s]
16	Slovak	Rubach (1993)	/j/	/t, d/	[t͡s, d͡z]
17	Taiof[39]	Ross (2002)	/i, u/	/t, d/	[t͡s, d͡z]
18	Tota Logba	Dorvlo (2008)	/i, u/	/t, d/	[t͡s, d͡z]
19	Tswana[40]	University of Botswana (1999)	/j/	/t/	[t͡s]
20	West Greenlandic	Fortescue (1984)	/i/	/t/	[t͡s]

[38] /s, z/ undergo coronal palatalization; /d/ undergoes spirantization.

[39] Before /i/, /t, d/ can be realized as [t͡ʃ, d͡ʒ]; /n/ undergoes coronal palatalization before /i/.

[40] /j/ is derived from /i, e, ɛ/ by glide-formation; /t/ can also be realized as [t͡ʃ].

APPENDIX II. The Typological Data

AINU

Family: Ainu Genera: Ainu

ISO 693-3: ain Geographical macroarea: Eurasia

Prior typological studies: none

phonemic inventory (Bugaeva 2004)	
coronals	anterior: t, s, n, r posterior: t͡ʃ
vocoids	glide: j vowel: i, e, a, u, o

In the Ainu language, among anterior consonants, it seems that only an anterior voiceless fricative /s/ undergoes allophonic coronal palatalization when it is followed or preceded by a high front vowel /i/, being realized as [ʃ]. For instance, /**s**ine/ → [**ʃ**ine] 'one', or /**s**inutapka/ → [**ʃ**inutapka] 'the name of a village in folktales' (Bugaeva 2004: 11). Although /t/ also undergoes coronal palatalization in this language, /t/-palatalization is morphophonemic rather than allophonic. When the morpheme final /t/ is followed by the high front /i/, coronal palatalization turns it into the posterior affricate [t͡ʃ]. For example, /e+sinri**t**-ihi/ → [esinri**t͡ʃ**hi] 'your ancestor' (Bugaeva 2004: 12). In addition, in Ainu, a word final nasal /n/ undergoes secondary palatalization, especially when it is followed by the palatal glide /j/. For instance, /a**n**+jak-ka/ → [a**nʲ**jak-ka] 'even if I went' (Bugaeva 2004: 14).

ACOMA

Family: Keresan   Genera: Keresan

ISO 693-3: kjq   Geographical macroarea: North America

Prior typological studies: Bhat (1978)

Alternative name: West Keresan

phonemic inventory (Miller 1965: 7)	
coronals	anterior: t, d, t͡s, d͡z, s, n, r laminal posterior: t̠, d̠, d͡ʒ, t͡ʃ, ʃ apical posterior: d͡ʐ, t͡ʂ, ʂ glottalized anterior: tˀ, t͡sˀ, sˀ, nˀ, rˀ glottalized laminal posterior: t̠ˀ, t͡ʃˀ, ʃˀ glottalized apical posterior: t͡ʂˀ, ʂˀ
vocoids	glide: j, w, jˀ, wˀ vowel: i, e, ɨ, a, o, u

In Acoma, anterior stops /t/ and /d/ are neutralized into palatal stops [t̠] and [d̠] respectively, before front vowels /i/ and /e/ (Miller 1965: 13). For example, /**d**ískamá/ → [**d̠**ískamá] 'corn husk', and /ziu**d**í/ → [ziu**d̠**í] 'he gave it to him' (Miller & Davis 1963: 321). According to Miller (1965: 13), "[t]he palatal stops are articulated with the flat of the tongue just behind the alveolar ridge, and are similar in position to 't' of 'tune' as pronounced in some Oklahoma dialects of English." Based on this description, I transcribed Acoma posterior stops as post-alveolar [t̠] and [d̠], rather than palatal [c] and [ɟ]. Although Miller's description implies that a glottalized anterior stop /tˀ/ also undergoes coronal palatalization before front vowels, I did not include it in my data since I was not able to find any supporting evidence for palatalization of this non-plain stop. In addition, in Acoma, an anterior nasal /n/ also undergoes (presumably allophonic) coronal palatalization before front vowels (and before posterior consonants /t̠/ and /t͡ʃ/). For example, /siu**n**í/ → [siu**ɲ**í] ‘I know him’ (Miller 1966: 14). Miller (1966) does not consider this palatal [ɲ] as a phoneme which makes a contrast with an anterior /n/.

AMHARIC

Family: Afro-Asiatic Genera: Semitic

ISO 693-3: amh Geographical macroarea: Africa

Prior typological studies: Bateman (2007), Bhat (1978)

phonemic inventory (Hayward & Hayward 1999; Leslau 1995)	
coronals	anterior: t, d, t’, s, z, s’, n, l, r posterior: t͡ʃ, d͡ʒ, t͡ʃ’, ʃ, ʒ, ɲ
vocoids	glide: j, w vowel: i, e, ɨ, ə, a, u, o

In Amharic, stem final anterior consonants undergo coronal palatalization when they are followed by suffixes with initial front vowels, such as a second person imperative marker /-i/ or a first person singular gerund marker /-e/ (Leslau 1995: 14ff). This process turns /t, d, s, z, t’, s’, n/ and /l/ into [t͡ʃ, d͡ʒ, ʃ, ʒ, t͡ʃ’, t͡ʃ’, ɲ] and [j] respectively. For example, /kəffə**t**-i/ → [kɨfə**t͡ʃ**i] ~ [kɨfə**t͡ʃ**] ‘open!’, /wəssə**d**-i/ → [wɨsə**d͡ʒ**i] ~ [wɨsə**d͡ʒ**] ‘take!’, /bɨlə**t’**-i/ → [bɨlə**t͡ʃ’**i] ~ [bɨlə**t͡ʃ’**] ‘exceed!’, /mələ**s**-i/ → [məllɨ**ʃ**i] ~ [məllɨ**ʃ**] ‘return!’, /mərrə**z**-i/ → [mərrɨ**ʒ**i] ~ [mərrɨ**ʒ**] ‘poison!’, /ləmmə**n**-i/ → [ləmmɨ**ɲɲ**i] ~ [ləmmɨ**ɲ**] ‘beg!’, /kəffə**l**-i/ → [kɨfa**j**i] ~ [kɨfa**j**] ‘pay!’, /kəffə**t**-e/ → [kɨfə**t͡ʃt͡ʃ**e] ‘(I) having opened’, and /məllə**s**-e/ → [məllɨ**ʃʃ**e] ‘(I) having returned’ (Leslau 1995: 14). According to Bateman (2007: 326), the Gonder and Menz dialects of Amharic present the same morphophonological palatalization patterns with the Addis Ababa dialect. In addition to this morphophonological palatalization commonly observed in Amharic dialects, in the Gojjam and Wello dialects, allophonic coronal palatalization is also observed. The triggers of this allophonic process are /i, e/ and /ɪ (ɨ)/. Since the phoneme /ɨ/ is realized as fronted [ɪ] in the palatalizing environment, it can be considered as one of the high-front vowels (see Hayward and Hayward 1999: 47). This phonological coronal palatalization turns /d/ and /t'/ into [d͡ʒ] and [t͡ʃ']. For instance, /a**t'**ege/ → [a**t͡ʃ'**ege] 'head of the Ethiopian monks' and /**d**ɨngula/ → [**d͡ʒ**ɪngula] 'stallion' (Leslau 1995: 16). Among these Amharic dialects, only the Addis Ababa dialect is included in the data as a representative. Note that the descriptions and examples are re-transcribed using IPA convention based on Hayward and Hayward (1999).

APALAI

Family: Cariban Genera: Cariban

ISO 693-3: apy Geographical macroarea: South America

Prior typological studies: Bateman (2007)

phonemic inventory (Koehn & Koehn 1986: 120ff.)	
coronals	anterior: t, s, z, n, ɾ posterior: ʃ
vocoids	glide: j, w oral vowel: i, e, ɨ, a, u, o nasal vowel: ĩ, ẽ, ɨ̃, ã, ũ, õ

According to Koehn & Koehn (1986: 120), in Apalai, allophonic coronal palatalization changes anterior /t/ and /n/ into [t͡ʃ] and [ɲ] before or after a high front vowel /i/. For instance, /pi**t**iko/ → [piˈ**t͡ʃ**iko] 'small' and /koko**n**ie/ → [kokoˈ**ɲ**ie] 'yesterday'. There is no given evidence which shows that alveolar fricatives, /s/ and /z/, can also undergo coronal palatalization in the same context where /t/ and /n/ undergo it.

ATAYAL

Family: Austronesian Genera: Atayalic

ISO 693-3: tay Geographical macroarea: Papunesia

Prior typological studies: none

phonemic inventory (Rau 1992)	
coronals	anterior: t, t͡s, s, n, l, r posterior: ʒ
vocoids	glide: j, w oral vowel: i, y, e, a, u, o

In Atayal, a high front vowel /i/ triggers allophonic coronal palatalization of sibilant consonants /s/ and /t͡s/, turning them into posterior [ʃ] and [t͡ʃ] respectively (Rau 1992: 19). In addition, in this language, an anterior stop /t/ is neutralized into the corresponding affricate /t͡s/ before /i/, being phonetically realized as [t͡ʃ]. For example, /ku**t**-i/ → [ku**t͡ʃ**i] 'cut' (Rau 1992: 30). Huang (2012: 2-3) also reports that /s/ and /t/ undergo coronal palatalization into [ʃ] and [t͡ʃ] in the Atayal language. For instance, /**t**ina/ → [**t͡ʃ**ina] 'some'. In addition, according to Huang (2012), /s/ automatically undergoes coronal palatalization in all Atayal dialects whereas /t/ undergoes it only in some dialects.

AXININCA CAMPA

Family: Arawakan Genera: Pre-Andine

ISO 693-3: cni Geographical macroarea: South America

Prior typological studies: Hall & Hamann (2006)

phonemic inventory (Payne 1981: 59)	
coronals	anterior: t, tʰ, t͡s, t͡sʰ, s, n, r posterior: t͡ʃ, t͡ʃʰ, ʃ, ɲ, rʲ
vocoids	glide: j, w, ɰ oral vowel: i, a, u

In Axininca Campa, coronal affrication applies only in the derived environment (Spring 1992: 339); when a stem final /t/ is followed by a non-future tense marker /-i/, morpho-phonological coronal palatalization turns this stem final /t/ into the alveolar affricate [t͡s]. For example, /no-kan**t**-i/ → [nokan**t͡s**i] 'I said', /no-an**t**-i/ → [nan**t͡s**i] 'I did', /no-misi**t**-i/ → [nomisi**t͡s**i] 'I dreamed', /no-ti**t**-i/ → [noti**t͡s**i] 'I inserted', and /no-pisi**t**-i/ → [nopisi**t͡s**i] 'I swept' (Spring 1992: 339; Payne 1981: 122ff). Note that this language does not have a voiced alveolar stop, such as /d/.

BLACKFOOT

Family: Algic Genera: Algonquian

ISO 693-3: bla Geographical macroarea: North America

Prior typological studies: Hall & Hamann 2006

phonemic inventory (Frantz 1991: 1ff.)	
coronals	t, s, n
vocoids	glide: j, w oral vowel: i, a, o

In Blackfoot, there are three alveolar consonants: /t, s/ and /n/. Among them, an anterior stop /t/ undergoes coronal affrication, e.g., [máátaakahkayiwa(a**t͡s**iksi)] ‘he’s not going home’, and [máá**t͡s**i**t͡s**inikiwa(at͡siksi)] ‘he didn't relate (a story)’ (Frantz 1991: 16). I was not able to find any evidence which shows the presence of coronal palatalization in this language.

BRAZILIAN PORTUGUESE

Family: Indo-European Genera: Romance

ISO 693-3: por Geographical macroarea: Eurasia (spoken in S.A.)

Prior typological studies: none

phonemic inventory (Barbosa & Albano 2004)	
coronals	dental: t, d, n alveolar: s, z, l, ɾ post-alveolar: ʃ, ʒ palatal: ɲ, ʎ
vocoids	vowel: i, e, ɛ, a, ɔ, o, u

In Brazilian Portuguese, underlying front vowels /i/ and /e/ trigger coronal palatalization of anterior stops: before /i/ and /e/, anterior /t/ and /d/ are realized as [t͡ʃ] and [d͡ʒ]. For example, /**t**ipo/ → [ˈ**t͡ʃ**ipʊ] ‘type’, /ar**t**e/ → [ˈah**t͡ʃ**ɪ] ‘art’, /**d**ito/ → [ˈ**d͡ʒ**itʊ] ‘said’, and /ar**d**e/ → [ˈaɦ**d͡ʒ**ɪ] ‘sting’. Also note that the underlying /e/ is phonetically realized as [ɪ] in the palatalizing environment (Cristófaro-Silva and Guimarães 2009: 142). According to Barbosa and Albano (2004: 228), coronal palatalization is especially widespread in the São Paulo dialect.

BRETON

Family: Indo-European Genera: Celtic

ISO 693-3: bre Geographical macroarea: Eurasia

Prior typological studies: Bateman (2007)

phonemic inventory (Iosad 2012: 321)	
coronals	anterior: t, d, s, z, n, n̊, l, l̊, r, r̊ posterior: t͡ʃ, d͡ʒ, ʃ, ʒ
vocoids	glide: j, j̊, ɥ, ɥ̊, w, ʍ short: i, e, ɛ, æ, y, ø, ə, a, u, o, ɔ, ɒ long: iː, eː, ɛː, æː, yː, øː, aː, uː, oː, ɔː, ɒː

* This inventory describes the phonemic contrasts found in the Bothoa dialect of the Breton language.

According to several studies on the Breton language (Bateman 2007; Iosad 2012; Press 1986), coronal palatalization is attested in the various dialects of this language. For example, across Breton dialects, sibilant palatalization is quite broadly attested in the context of the front vocoids (Bateman 2007: 336; Press 1986: 36), as in *izel* ['i**ʒ**ːɛl] 'low'. Furthermore, in the Vannaetais dialect, it seems that sonorant consonants /n/ and /l/ also undergo palatalization before a high front vocoid. Among all the dialects, the most notable dialect which shows coronal palatalization is the Bothoa dialect. In this dialect, suffixes with an initial /i/, such as plural markers /-iəw/ and /-iən/, trigger coronal palatalization of the preceding consonant (Iosad 2012). Almost all anterior consonants are targeted by this process, except only for a rhotic /r/. For example, /pon**t**-iəw/ → [põː**ʃ**əw] 'bridge, PL', /praː**d**-iəw/ →

[ˈpraːʒəw] 'player, PL', /lɒs**t**-iəw/ → [ˈlɒs**t͡ʃ**əw] 'tail, PL', /pla**s**-iəw/ → [ˈpla**ʃ**əw] 'place, PL', /miː**z**-iəw/ → [miː**ʒ**əw] 'month, PL', /kær**n**-iəw/ → [ˈt͡ʃær**ɲ**əw] 'horn, PL', and /paː**l**-iəw/ → [ˈpaː**j**əw] 'shovel, PL'. Coronal palatalization attested in the Bothoa dialect is included in my typological data as a representative of palatalization processes found in the Breton language.

BUNUN (Isbukun)

Family: Austronesian   Genera: Bunun

ISO 693-3: bnn   Geographical macroarea: Papunesia

Prior typological studies: none

phonemic inventory (Huang 2004, 2005)	
coronals	anterior: t, d, s, n, l posterior: -
vocoids	vocoid: - vowel: i, a, u

According to Huang (2004), in Isbukun Bunun, coronal palatalization turns anterior /t/ and /s/ into posterior [t͡ʃ] and [ʃ] before a high front vowel /i/. For example, /**t**ina/ → [**t͡ʃ**ina] 'mother', and /**s**iða/ → [**ʃ**iða] 'to take'. Although Isbukun Bunun has three other anterior phonemes, /d, n/ and /l/, it seems that they are not targeted by coronal palatalization. For instance, /min**d**ia/ → [min**d**já] 'pick up' (Huang 2008: 6).

BUNUN (Takituduh)

Family: Austronesian Genera: Bunun

ISO 693-3: bnn Geographical macroarea: Papunesia

Prior typological studies: none

phonemic inventory (Huang 2004, 2005)	
coronals	anterior: t, d, t͡s, s, n, l posterior: -
vocoids	vocoid: - vowel: i, a, u

In this language, among anterior consonants /t, d, t͡s, s, n/ and /l/, only sibilant consonants /t͡s/ and /s/ undergo coronal palatalization before /i/ (Huang 2004). For example, /**s**iðaʔ/→ [**ʃ**iðaʔ] 'to take'. In contrast, other consonants, such as /t/, do not undergo coronal palatalization at all. For instance, /**t**ina/ → [**t**ina] 'mother'.

CANTONESE

Family: Sino-Tibetan Genera: Chinese

ISO 693-3: yue Geographical macroarea: Eurasia

Prior typological studies: none

	phonemic inventory (Alderete et al. 2017)
coronals	anterior: t, tʰ, s, t͡s, t͡sʰ, n, l posterior: -
vocoids	glide: j, w vowel: i, y, ɛ, œ, ɐ, aː, u, ɔ

According to Alderete et al. (2017: 6), in the Hong Kong dialect, anterior sibilants /s, t͡s/ and /t͡sʰ/ undergo allophonic coronal palatalization before a high front rounded vowel /y/, being realized as their palato-alveolar counterparts [ʃ, t͡ʃ] and [t͡ʃʰ] respectively. For example, /**tsʰ**yn˩/ → [**tʃʰ**yn˩] 'whole', and /**s**y˥/ → [**ʃ**yː˥] 'book'. In the Guangzhou dialect, only a fricative /s/ becomes alveolopalatal [ɕ], before not only /y/ but also /i/. For instance, /**s**y˥/ → [**ɕ**yː˥] 'book'. It seems that anterior stops /t, tʰ/ do not undergo coronal palatalization in the Cantonese language in general. There is a possibility that the difference in place-of-articulation between anterior stops and sibilants plays a role in making this discrepancy. According to Alderete et al. (2017: 5), the anterior stops and nasal /n/ are dental consonants in which "tongue tip touches the back of the upper teeth," contrary to the sibilants which have alveolar articulations. Note that Alderete et al. (2017: 6) describe that /s, t͡s/ and /t͡sʰ/ are also 'partially' palatalized before /œ/.

CHEYENNE

Family: Algic　　　　Genera: Algonquian

ISO 693-3: chy　　　　Geographical macroarea: North America

Prior typological studies: Bhat (1978), Hall & Hamann (2006)

phonemic inventory (Leman 1980: 1ff.)	
coronals	anterior: t, s, n posterior: ʃ
vocoids	glide: - vowel: i*, a, o

* Although a front vowel /i/ is conventionally described as /e/, as Leman (1980: 1) describes, “the letter e is most often pronounced like the English i in the word pin.” Hall & Hamann (2006) also transcribe this sound as a high front /i/ rather than a mid front /e/.

Leman (1980: 214) illustrates coronal affrication in Cheyenne. According to Leman, in this language, /t/ is affricated before a high front /i/. For instance, /nó**t**i/ → [nǒ**t͡s**i] ‘alien’. Davis (1962: 32) also reports that Cheyenne /t/ can be realized not only as [t͡s] but also as [t͡ʃ], before /i/. Although this high front vowel /i/ conventionally has been transcribed as /e/ in many previous studies, it is mostly realized as a high front vowel rather than a mid front vowel (Leman 1980). For this reason, I transcribed this phoneme as a high-front /i/, as in Hall & Hamann (2006: 1207).

COATZOSPAN MIXTEC

Family: Oto-Manguean Genera: Mixtecan

ISO 693-3: miz Geographical macroarea: North America

Prior typological studies: Bateman (2007)

phonemic inventory (Gerfen 1999)	
coronals	anterior: t, ⁿd, t͡s, ⁿd͡z, s, n, l, r posterior: t͡ʃ, ⁿd͡ʒ
vocoids	plain vowel: i, e, a, ɨ, o, u nasal vowel: ĩ, ẽ, ã, ɨ̃, õ, ũ

In Coatzospan Mixtec, coronal palatalization which yields a change in place-of-articulation of a target consonant can only be observed in women's speech (Gerfen 1999: 40). This coronal palatalization in women's speech turns /t/ and /ⁿd/ into [t͡ʃ] and [ⁿd͡ʒ] respectively, before /i/ and /e/. For example, /**ⁿd**ii/ → [**ⁿd͡ʒ**ii] 'force', /**ⁿd**ee/ → [**ⁿd͡ʒ**ee] 'black', /**t**ii/ → [**t͡ʃ**ii] 'man', and /**t**ee/ → [**t͡ʃ**ee] 'leaf used for roofing' (Gerfen 1999: 41). In addition, in this language, both men and women speakers secondarily palatalize anterior stops before high vocoids /ɨ, u/. For instance, /**ⁿd**uʔu/ → [**ⁿdʲ**uʔu] 'tree trunk', /**ⁿd**ɨː/ → [**ⁿdʲ**ɨː] 'flat, smooth', /**t**uʔu/ → [**tʲ**uʔu] 'cutting off ot water', and /**t**ɨʔɨ/ → [**tʲ**ɨʔɨ] 'twiested' (Gerfen 1999: 41).

DHIVEHI

Family: Indo-European Genera: Indic

ISO 693-3: div Geographical macroarea: Eurasia

Prior typological studies: Bateman (2007)

phonemic inventory (Cain 2000)	
coronals	anterior: t, d, ^{n}d, s, z, n, l laminal posterior: t͡ʃ, d͡ʒ apical posterior: ʈ, ɖ, ^{n}ɖ, ʂ, ɭ, ɻ
vocoids	vocoid: j short vowel: i, e, a, o, u long vowel: iː, eː, aː, oː, uː

In this language, a stem final /i/ triggers coronal palatalization of a preceding anterior consonant, such as /t, d, ^{n}d, n/ and /l/, when this stem final /i/ is immediately followed by suffixes with initial vowels. When coronal palatalization occurs, the preceding consonant is geminated and the stem final /i/ is deleted (Cain 2000). For example, /e**t**i-ek/ → [e**tt͡ʃ**ek] ‘a thing’, /ro**d**i-ek/ → [ro**dd͡ʒ**ek] ‘a thread’, /fa**n**i-ek/ → [fa**ɲɲ**ek] ‘a worm’, /du**n**i-ek/ → [du**ɲɲ**ek] ‘a bow’, and /fa**l**i-ek/ → [fa**jj**ek] 'an oar’ (Cain 2008: 8).

DUTCH

Family: Indo-European Genera: Germanic

ISO 693-3: nld Geographical macroarea: Eurasia

Prior typological studies: Hall & Hamann (2006)

phonemic inventory (Booij 1995: 4ff.)	
*coronals**	anterior: t, d, s, z, n, l, r posterior: -
vocoids	glide: j, w vowel: i, y, ɪ, e, ʏ, ø, ɛ, ə, u, o, ɔ, a, ɑ

* Affricates are not regular phonemes in this language.

According to Collins and Mees (2003: 191-196), alveolar stops, except for a lateral /l/, undergo allophonic palatalization (with coalescence) under the influence of a following /j/: /**t**/ → [**t͡ʃ**], /**s**/ → [**ʃ**], /**z**/ → [**ʒ**], and /**n**/ → [**ɲ**]. A devoiced /d/ also shows the same pattern with /t/. For example, /ha**d** je/ → [ha**t͡ʃ**ə] (Collins & Mees 2003: 193; Booij 1995: 151). In addition, Dutch also shows morpho-phonological coronal affrication. Some Latinate suffixes with an initial /i/ trigger this process (e.g., -*i*, -*io*, -*iaan*, and -*ion*), turning a stem final /t/ into an affricate [t͡s]. For example, *rela**t**-ie* [rela**t͡s**i] 'relation', and *ra**t**-io* [ra**t͡s**ijo] 'ratio' (Booij 1995: 79ff). It seems that /d/ does not undergo coronal affrication in the same context. For instance, *kome[**d**]-ie* 'comedy' cf. *rela**t**-ie* [rela**t͡s**i] 'relation'.

ENGLISH

Family: Indo-European Genera: Germanic

ISO 693-3: eng Geographical macroarea: Eurasia

Prior typological studies: Bateman (2007), Bhat (1978), Hall & Hamann (2006)

phonemic inventory (Ladefoged 1999)	
coronals	anterior: t, d, s, z, n, l, ɹ posterior: t͡ʃ, d͡ʒ, ʃ, ʒ
vocoids	glide: j, w vowel: i, ɪ, e, ɛ, æ, ɚ, ʌ, u, ʊ, o, ɑ

The morphophonemic coronal palatalization in English is well-known (Escure 1976; Zsiga 1995, 2000). For example, perpe[**t͡ʃ**]ual (cf. perpe[**t**]uity), and resi[**d͡ʒ**]ual (cf. resi[**d**]ue) (examples are from Hall & Hamann 2006: 1223). English also has post-lexical coronal palatalization which targets alveolar obstruents. For instance, /hi**t** ju/ → [hɪt**t͡ʃ**ju] 'hit you', /di**d** ju/ → [dɪ**d͡ʒ**ju] 'did you', /mi**s** ju/ → [mi**ʃ**ju] 'miss you', /pli**z** ju/ → [pli**ʒ**ju] 'please you' (Bateman 2007: 360). In addition, Bruce Hayes (personal communication, June 2018) informed me that there is a palatalization-like process in English even before a high back vocoid /w/, as in *twin* [**t͡ʃ**wɪn]. There is a possible explanation to this process: it can be understood as a result of coronal affrication with labialization under the influence of the labilaity of the following /w/, given the fact that English [t͡ʃ] is inherently realized as labialized consonant (e.g., [t͡ʃʷ]).

FONGBE

Family: Niger-Congo   Genera: Kwa

ISO 693-3: fon   Geographical macroarea: Africa

Prior typological studies: Bateman (2007), Hall & Hamann (2006)

phonemic inventory (Lefebvre & Brousseau 2002)	
coronals	anterior: t, d, ɗ*, s, z, l* posterior: t͡ʃ, d͡ʒ
vocoids	glide: j, w plain vowel: i, e, ɛ, a, ɔ, o, u nasal vowel: ĩ, ɛ̃, ã, ɔ̃, ũ

* The implosive /ɗ/ contextually alternates with a nasal [n], and /l/ also has rhotic variation [r] especially after a coronal consonant.

In Fongbe (also known as the Fon dialect of the Gbe language), /t/ and /d/ undergo coronal affrication before high vowel /i/ and /ĩ/. For instance, /**t**i/ → [**t͡s**i] 'squeeze', /**d**ĩ/ → [**d͡z**ĩ] 'be very good'. In addition, in the same context where coronal affrication occurs, /t/ and /d/ can be optionally palatalized as [t͡ʃ] and [d͡ʒ] (Lefebvre & Brousseau 2002: 25).

FRENCH (Acadian)

Family: Indo-European Genera: Romance

ISO 693-3: fra Geographical macroarea: Eurasia (spoken in N.A.)

Prior typological studies: none

phonemic inventory (Cichocki 2012)	
coronals	dental: t, d, n, l alveolar: s, z alveolo-palatal: t͡ʃ, d͡ʒ, ʃ, ʒ, palatal: ɲ
vocoids	glide: j plain vowel: i, y, e, ɛ, ɛː, ø, œ, a, ɑ, u, o, ɔ nasal vowel: ɛ̃, ɑ̃, ɔ̃

According to Hume (1992: 163), in Acadian French, anterior stops /t/ and /d/ undergo coronal palatalization before an underlying non-syllabic palatal vocoid. Note that this process is optional. At the surface, underlying stops optionally realized as non-palatalized, secondarily palatalized, or primarily palatalized forms. For example, /kar**t**ie/ → [kar**t**je] ~ [kar**tʲ**e] ~ [kar**t͡ʃ**e] 'quartier', /kana**d**iɛ̃/ → [kana**d**jɛ̃] ~ [kana**dʲ**ɛ̃] ~ [kana**d͡ʒ**ɛ̃] 'Canadian'; cf. /**d**yp/ → [**d**yp] 'dupe' and /**t**ip/ → [**t**ip] 'type'.

FRENCH (Quebec)

Family: Indo-European Genera: Romance

ISO 693-3: fra Geographical macroarea: Eurasia (spoken in N.A.)

Prior typological studies: Hall & Hamann (2006)

phonemic inventory (Walker 1984)	
coronals	anterior: t, d, s, z, n, l posterior: ʃ, ʒ, ɲ
vocoids	glide: j, ɥ, w plain vowel: i, ɪ, y, ʏ, e, ɛ, ø, œ, a, u, ʊ, o, ɔ, ɒ nasal vowel: ẽ, œ̃, ɔ̃, ɒ̃

According to Kim (2001: 91-92) and Papen (1998: 165), in Quebec French, anterior stops /t/ and /d/ undergo coronal affrication before high front vocoids such as /j, i, y, ɥ/. Through this process, /t/ is realized as an affricate [t͡s], and /d/ is realized as [d͡z]. The following examples describe affrication in Quebec French (Kim 2001: 91):

Standard French	Quebec French	
pe[**t**i]t	pe[**t͡s**i]t	'little'
[**t**i]pe	[**t͡s**i]pe	'type'
[**t**j]ens	[**t͡s**j]ens	'(I) hold'
[**t**y]rc	[**t͡s**y]rc	'Turk'
[**t**ɥ]er	[**t͡s**ɥ]er	'to kill'
[**d**i]x	[**d͡z**i]x	'ten'
[**d**j]eu	[**d͡z**j]eu	'God'
[**d**yː]rer	[**d͡z**yː]rer	'to continue'

GERMAN

Family: Indo-European   Genera: German

ISO 693-3: deu   Geographical macroarea: Eurasia

Prior typological studies: Hall & Hamann (2006)

phonemic inventory (Kohler 1999)	
coronals	anterior: t, d, s, z, n, l post-alveolar: ʃ, ʒ palatal: ç
vocoids	glide: j vowel: i, ɪ, y, ʏ, e, ø, ɛ, ɛː, œ, a, aː, ə, u, ʊ, o, ɔ

In German, coronal affrication turns /t/ into [t͡s] before the palatal glide /j/ (which is derived from /i/ by glide-formation), as in /nega**t**io:n/ → /nega**t**jo:n/ → [nega**t͡s**jo:n] 'negation' (Hall 2004: 1035, 1052). However, in the same vocalic environment (before /j/), /d/ does not undergo coronal affrication. Note that other anterior consonants, such as /s, z, n/ and /l/, also do not undergo coronal palatalization in the environment where /t/ undergoes coronal affrication (Hall 2004: 1042). In addition, this coronal affrication can be considered as an allophonic process, since there are no affricate phonemes (e.g., /t͡s/) in German (Kohler 1999).

GREEK (Cypriot)

Family: Indo-European Genera: Greek

ISO 693-3: ell Geographical macroarea: Eurasia

Prior typological studies: Bateman (2007)

phonemic inventory (Arvaniti 1999b)	
coronals	anterior: t, s, z, n, l, ɾ posterior: t͡ʃ, ʃ, ʒ
vocoids	glide: - vowel: i, e [ɛ], a [ɐ], o [ɔ], u

According to Newton (1972), in the Cypriot dialect of the Greek language, the sibilants /s, z/ undergo coronal palatalization, especially before a palatal glide /j/ formed by the glide-formation process (e.g., /iV/ → /jV/). For example, /kra**s**ia/ → /kra**s**ja/ → [krɐ**ʃ**ɐ] 'wines', and /vi**z**ia/ → /vi**z**ja/ → [vi**ʒ**ɐ] 'breasts' (Newton 1972: 142). In addition, Arvaniti (1999) reports that, in this dialect, sonorant consonants /n, l/ also undergo coronal palatalization in the same context where sibilants undergo it. For instance, /tia**n**ia/ → [tiɐ**ɲ**ɐ] 'frying fans', /fi**l**ia/ → [fi**ʎ**ɐ] 'kisses', /i**l**ios/ → [i**ʎ**ɔs] 'sun' (Arvaniti 1999: 175). Note that the high front vowel /i/ which is not followed by another vowel does not trigger coronal palatalization at all. For example, [krɐ**s**i] 'wine', [vi**z**i] 'breast', [tiɐ**n**in] 'frying fan', and [fi**l**in] 'kiss' (Newton 1972: 142; Arvaniti 1999: 175).

GREEK (Kos)

Family: Indo-European Genera: Greek

ISO 693-3: ell Geographical macroarea: Eurasia

Prior typological studies: none

*phonemic inventory (Arvaniti 1999a; Newton 1972)**	
coronals	anterior: t, s, z, n, l, ɾ posterior: -
vocoids	glide: - vowel: i, e [ɛ], a [ɐ], o [ɔ], u

* This phonemic inventory describes that of (Standard) Modern Greek, based on the Arvaniti (1999a: 167-169) and Newton (1972: 13).

In Kos Greek, as in Cypriot Greek, sonorants /n, l/ undergo coronal palatalization before /j/ which is derived from the prevocalic /i/. For example, /ɣo**n**ia/ → /ɣo**n**ja/ → [ɣɔ**ɲɲ**ɐ] 'corner' and /ski**l**ia/ → /ski**l**ja/ → [ski**ʎʎ**ɐ] 'dogs' (Kochetov 2016: 14). However, in this dialect, when the obstruents precede the glide, a palatal glide /j/ undergoes glide strengthening after /t, s, z/ (e.g., /kra**sj**a/ → [kra**sc**a] 'wines'), leaving the preceding consonant unchanged (Kochetov 2016: 22; Newton 1972: 167).

GREEK (Naousa)

Family: Indo-European Genera: Greek

ISO 693-3: ell Geographical macroarea: Eurasia

Prior typological studies: none

*phonemic inventory (Arvaniti 1999a; Newton 1972)**	
coronals	anterior: t, s, z, n, l, ɾ posterior: -
vocoids	glide: - vowel: i, e [ɛ], a [ɐ], o [ɔ], u

* This phonemic inventory describes that of (Standard) Modern Greek, based on the Arvaniti (1999a: 167-169) and Newton (1972: 13).

According to Kappa & Sipitanos (2016: 64), in the Naousa dialect of the Greek language, anterior sibilants undergo coronal palatalization before front vowels /i/ and /e/. For example, /xri**s**í/ → [xri**ʃ**í] 'Chrisi (*proper name*)', /k**s**érete/ → [k**ʃ**ériti] 'you know', /e**s**í/ → [i**ʃ**í] 'you 2SG', /korí**t͡s**i/ → [kurí**t͡ʃ**o] 'girl NOM SG', and /i**s**e/ → [í**ʃ**i] 'you are'. Naousa Greek also shows remote coronal palatalzation which targets a sibilant that is not immediately adjacent to the trigger. For example, /**s**kilí/ → [**ʃ**cilí] 'dog NOM SG', /ko**s**tí/ → [ku**ʃ**tí] 'Kosti (*proper name*)', and /ni**s**tía/ → [ni**ʃ**tía] 'fasting NOM SG'. These examples also show that non-sibilant anterior consonants are not targeted by the same process, coronal palatalization. For instance, /**n**istía/ → [**n**iʃtía] 'fasting NOM SG' or /ski**l**í/ → [ʃci**l**í] 'dog NOM SG'.

HARARI

Family: Afro-Asiatic Genera: Semitic

ISO 693-3: har Geographical macroarea: Africa

Prior typological studies: Bhat (1978)

phonemic inventory (Wagner 1997: 487-488)	
coronals	anterior: t, d, t’, s, z, n, l, ɾ posterior: t͡ʃ, d͡ʒ, t͡ʃ’, ʃ, ɲ
vocoids	glide: j, w short vowel: i, e, a, o, u long vowel: iː, eː, aː, oː, uː

In Harari, anterior consonants such as /t, d, t’, s, n/ and /l/ undergo morphologically conditioned coronal palatalization before the 2nd person singular feminine subject suffix /-i/ (Ross 2004: 42ff.). For instance, /kifa**t**-i/ → [kifa**t͡ʃ**i] ‘open, 2nd FEM IMPR’, /zima**d**-i/ → [zima**d͡ʒ**i] ‘drag, 2nd FEM IMPR’, /riga**t’**-i/ → [riga**t͡ʃ’**i] ‘kick, 2nd FEM IMPR’, /liba**s**-i/ → [liba**ʃ**i] ‘dress, 2nd FEM IMPR’, /difa**n**-i/ → [difa**ɲ**i] ‘block container, 2nd FEM IMPR’, and /kifa**l**-i/ → [kifa**j**] ‘pay, 2nd FEM IMPR’. Note that the outcome of palatalization of /l/ is a palatal gilde [j], rather than a palatal lateral [ʎ]. According to Ross (2004: 45), when /l/ is palatalized into [j], the following /i/ cannot be phonetically realized in order to avoid an illegal *[ji] sequence.

HAUSA

Family: Afro-Asiatic Genera: West Chadic

ISO 693-3: hau Geographical macroarea: Africa

Prior typological studies: Bhat (1978), Bateman (2007)

phonemic inventory (Jaggar 2001)	
coronals	anterior: t, d, d' [ɗ], s, s', z, n, l, r, ɽ posterior: t͡ʃ, d͡ʒ, t͡ʃ', ʃ, ɲ
vocoids	glide: j, 'j*, w short vowel: i, e, a, o, u long vowel: iː, eː, aː, oː, uː

* /'j/ denotes a laryngealized palatal glide.

In Hausa, anterior consonants /t, d, s/ and /z/ are palatalized before /i/ and /e/, being realized as posterior [t͡ʃ, d͡ʒ, ʃ] and [ʒ] respectively. For example, [mōtō**t͡ʃ**ī] 'car PL' cf. [mō**t**à̄] 'car', [fàn**ʃ**ī] 'redeem PRENOM' cf. [fàn**s**ā] 'redeem', [sà̄ta**t͡ʃt͡ʃ**ē] 'stolen' cf. [sà̄**t**ā] 'steal', [fàsa**ʃʃ**ē] 'broken' cf. [fa**s**à̄] 'break'. The palatalization process generally results in morphophonemic changes, and it is, synchronically, partially productive (Jaggar 2001: 25-26; see also Bateman 2007: 369ff.).

IKALANGA

Family: Niger-Congo   Genera: Bantoid

ISO 693-3: kck   Geographical macroarea: Africa

Prior typological studies: Bateman (2007), Hall & Hamann (2006)

Alternative name: Kalanga

phonemic inventory (Mathangwane 1999: 55ff.)	
coronals	anterior - dentals: t̪, t̪ʰ, d̪, t͡s, d͡z, t͡sʰʷ, d͡zʷ - alveoalrs: tʰ, d, ⁿd, dʷ, s, z, sʷ, zʷ, n, l, r posterior - palato-alveolar: t͡ʃ, d͡ʒ, ⁿd͡ʒ, ʃ, ʒ, ʃʷ - palatal: ɲ
vocoids	glide: ʋ, j, w vowel: i, e, a, u, o

In Ikalanga, a nasal /n/ that precedes noun final front vowels such as /i/ and /e/ usually undergoes morphophonemic coronal palatalization, especially when the diminutive suffix '-ana' is affixed to the noun. Since these noun final front vowels undergo glide formation when it followed by a low vowel /a/ (Matangwane 1999: 132), the input form of coronal palatalization is assumed here as the derived palatal glide /j/, rather than underlying front vowels. For example, /d̪u**n**i-ana/ → /d̪u**n**jana/ → [d̪u**ɲ**áná] 'small mortar' (Matangwane 1999: 126). In addition, although it is quite rare, an apical dental stop /t̪/ can also undergo coronal palatalization in the context where /n/-palatalization occurs. Only one example of this morphologically conditioned stop palatalization is given in Matangwane (1986: 102): /gʷa**t̪í**-ana/ → /gʷa**t̪j**-ana/ → [gʷa**t͡ʃ**áná] 'small piece of tree bark'. Note that a lateral /l/ also undergoes a similar process in the same context, the /l/-to-[d͡ʒ] change. For instance, /m-bi**l**i/ → /m-bi**l**j-ana/ → [mbi**d͡ʒ**áná] 'small body' (Mathangwane 1999: 122). However, it seems that this change is an obvious reflex of diachronic change. According to Mathangwane (1999: 123), a lateral /l/ undergoes the /l/-to-[d͡ʒ] change because this lateral was a voiced stop **d* in Proto-Bantu. Diachronically, Proto-Bantu **d* underwent coronal palatalization before **j*, as in **-**d**i-a* > ****d**j-a* > ***d͡ʒ**-a* 'eat', and in turn it developed into a lateral **l* at the later stages (Mathangwane 1999: 124). Because this /l/-to-[d͡ʒ] change shown in the contemporary Ikalanga language involves a change in sonorancy and shows evident diachronic influences, I did not include this change in my data as a case of coronal palatalization.

ILOCANO

Family: Austronesian Genera: Nothern Luzon

ISO 693-3: ilo Geographical macroarea: Papunesia

Prior typological studies: none

phonemic inventory (Rubino 1997)	
coronals	dental: t, d, n alveolar: s, l, r posterior: -
vocoids	glide: j, w vowel: i, e, a, o, u

According to Rubino (1997: 10ff.), in Ilocano, a palatal glide /j/, and a high vowel /i/ that precedes another vowel trigger coronal palatalization of preceding anterior obstruents /t, d/ and /s/. For example, /i**d**iaj/ → [ʔi.**d͡ʒ**áj] 'there', /**d**iak/ → [**d͡ʒ**ák] 'I don't', /but**t**iog/ → [but.**t͡ʃ**óg] 'large abdomen', and /**s**iák/ → [**ʃ**ak] 'I'. According to (Rubino 1997: 13), there are no phonemically contrastive affricate consonants in this language. Since not only affricates but also other posterior consonants do not phonemically contrast with their anterior counterparts in general, Ilocano coronal palatalization can be considered as an allophonic process. In addition, although Ilocano has anterior nasal, lateral, and rhotic consonants, it seems that they do not undergo coronal palatalization (Rubino 1997: 15).

JAPANESE

Family: Japonic Genera: Japanese

ISO 693-3: jpn Geographical macroarea: Eurasia

Prior typological studies: Bateman (2007), Bhat (1978); Hall & Hamann (2006)

phonemic inventory (Labrune 2012)	
coronals	anterior: t, d, s, z, r [ɾ] posterior: -
vocoids	glide: j, w vowel: i, e, a, o, u [ɯ]

In Japanese, /t, d, s, z/ and /n/ undergo coronal palatalization before /i/ and /j/, and /t/ and /d/ undergo coronal affrication before /u/ (Itô & Mester 1995; Labrune 2012; Kochetov & Alderete 2011). First, a voiceless stop /t/ is realized as a posterior affricate [t͡ʃ] before high front vocoids /i/ and /j/ and as an anterior affricate [t͡s] before a high back vowel /u/. Second, a voiced stop /d/ is realized as a posterior affricate [d͡ʒ] or fricative [ʒ] in the high front vocoid context and as an anterior affricate [d͡z] in the high back vocoid context. Third, before /i/ and /j/, anterior sibilants /s/ and /z/ and a nasal /n/ are realized as their posterior counterparts [ʃ, ʒ] and [ɲ] respectively. Labrune (2012: 66) argues that Japanese posterior sibilants which have been described as [t͡ʃ, d͡ʒ, ʃ] and [ʒ] should be described as [t͡ɕ, d͡ʑ, ɕ] and [ʑ] respectively, since they are "actually alveolo-palatals or pre-dorso-palatals." In addition, it is worth here noting that, in recent loanwords, non-palatalized and non-affricated [t] and [d] can occur even before the high vocoids. For example, /**t**iːbaggu/ → [**t**iːbaggɯ]/*[**t͡ɕ**iːbaggɯ] 'tea bag', /**d**inaː/ → [**d**inaː]/*[**d͡ʑ**inaː] 'dinner' (Labrune 2012: 62-63).

KIRUNDI

Family: Niger-Congo Genera: Bantoid

ISO 693-3: run Geographical macroarea: Africa

Prior typological studies: none

Alternative name: Rundi

phonemic inventory (Kochetov 2016: 7)	
coronals	anterior: t, d, t͡s, d͡z ~ z, s, n, r posterior: t͡ʃ, d͡ʒ ~ ʒ, ʃ, ɲ
vocoids	glide: j, w short vowel: i, e, a, o, u long vowel: iː, eː, aː, oː, uː

In Kirundi, this /j/ is derived from front vowels /i/ and /e/ which precede another vowel by glide-formation (e.g., /iV/ → /jV/ → [jV]). This derived /j/ in turn triggers coronal palatalization of the preceding anterior consonant. The following examples illustrate Kirundi coronal palatalization triggered by /j/ (from Kochetov 2016: 8): /ja-do**d**-je/ → [jado**d͡z**e] 'bang 3 SG PAST', /ja-sa**s**-je/ → [jaʃa**ʃ**e] 'spread 3 SG PAST', /ja-too**d͡z**-je/ → [jatoː**d͡ʒ**e] 'pick up with 3 SG PAST', and /ja-so**n**-je/ → [jaʃo**ɲ**e] 'sew 3 SG PAST'. Note that /t/ undergoes spirantization rather than coronal affrication in the same environment. For example, /ja-roo**t**-je/ → [jaɾoː**s**e] 'dream 3 SG PAST'. /r/ also undergoes a kind of affricating process, as in /ja-ko**r**-je/ → [jako**d͡z**e] 'work 3 SG PAST', or a deletion, as in /ja-koo**r**-je/ [jakoːje] 'peel 3 SG PAST'. This language does not have an anterior lateral consonant (e.g., /l/) (Kochetov 2012: 7).

KOREAN

Family: Korean　　Genera: Korean

ISO 693-3: kor　　Geographical macroarea: Eurasian

Prior typological studies: Bateman (2007), Bhat (1978), Hall & Hamann (2006)

phonemic inventory (H. Lee 1996)	
coronals	anterior: t [d̥], t’ [t͈], tʰ, s, s’ [s͈], n, l posterior: t͡ɕ, t͡ɕ’ [t͡ɕ͈], t͡ɕʰ
vocoids	glide: j, w vowel: i, (y), e, (ø), (ɛ), a, u, ɯ, o, ʌ

In Korean, several types of palatalization processes that target anterior consonants are attested. First, morphophonemic palatalization turns /t/ and /tʰ/ into [t͡ɕ] and [t͡ɕʰ] respectively, before a derivational or inflexional suffix which has an initial front vowel /i/. For examples, /ma**t**-i/ → [ma**t͡ɕ**i] ‘eldest one (= eldest, NML)’, /ka**tʰ**-i/ → [ka**t͡ɕʰ**i] ‘together (be like, NML)’, /pa**tʰ**-i/ → [pa**t͡ɕʰ**i] ‘field, NOM’, and /pa**tʰ**-ita/ → [pa**t͡ɕʰ**ita] ‘field, COP’ (Yu Cho 2009: 466). Second, anterior fricatives, /s/ and /s’/, undergo allophonic coronal palatalization before /i/ and /j/. For examples, /**s**in/ → [**ɕ**in] ‘god’, and /mul**s’**in/ → [mul**ɕ’**in] ‘be nicely scanted’ (H. Lee 1996: 86). Third, before /i/ and /j/, sonorant consonants, /n/ and /l/, undergo allophonic secondary palatalization or coronal palatalization, being realized as [nʲ] ~ [ɲ] and [lʲ] ~ [ʎ] respectively. For example, /a**nn**jʌŋ/ → [a**nʲnʲ**jʌŋ] ~ [a**ɲɲ**ʌŋ] ‘hello’, /sa**ll**im/ → [sa**lʲlʲ**im] ~ [sa**ʎʎ**im] ‘housekeeping’, and /tʰan**lj**ʌk/ → [tʰaːlʲ**lʲj**ʌk] ~ [tʰaːʎ**ʎ**ʌk] 'elasticity' (H. Lee 1996: 93, 97). Fourth, anterior stops, /t, t'/ and /t^h/, also undergo allophonic secondary palatalization before /i/ and /j/. For example, /ma**t**i/ → [ma**d^j**i] 'joint', /**t'**i/ → [**t'^j**i] 'band, sash', and /**t^h**inun/ → [**t^{hj}**inun] 'corn' (H. Lee 1996: 78).

LATVIAN

Family: Indo-European Genera: Baltic

ISO 693-3: lav Geographical macroarea: Eurasia

Prior typological studies: Hall & Hamann (2006)

phonemic inventory (Urek 2016: 54)	
coronals	anterior: t, d, t͡s, d͡z, s, z, n, l, r posterior: c, ɟ, t͡ʃ, d͡ʒ, ʃ, ʒ, ɲ, ʎ
vocoids	glide: j short vowel: i, e, æ, ɑ, ɔ, u long vowel: iː, eː, æː, ɑː, ɔː, uː

In Latvian, anterior consonants /t, d, t͡s, d͡z, s, z, n/ and /l/ undergo coronal palatalization before an underlying thematic vowel /-i-/ or /-e-/ which precedes vowel initial suffixes. According to Urek (2016: 60-64), these underlying thematic vowels fail to surface when they are followed by vowel initial suffixes, whereas they can surface when consonant initial suffixes follow them. For instance, /ez-**i**-m/ → [ez**i**m] 'hedgehog, DAT SG'. Note also that these underlying /-i-/ and /-e-/ undergo gilde-formation when they are followed by another vowel (Urek 2016: 60ff). The following examples describe coronal palatalization in Latvian: /zu**t**-i-u/ → /zu**t**-j-u/ → [zu.**ʃ**u] 'eel GEN PL', /briː**d**-i-u/ → /briː**d**-j-u/ → [briː.ʒu] 'moment GEN PL', /ta**s**-e-u/ → /ta**s**-j-u/ → [ta.**ʃ**u] 'cup GEN PL', /e**z**-i-u/ → /e**z**-j-u/ → [e.**ʒ**u] 'hedgehog GEN PL', /laː**t͡s**-i-u/ → /laː**t͡s**-j-u/ → [laː.**t͡ʃ**u] 'beer GEN PL', /da**d͡z**-i-u/ → /da**d͡z**-j-u/ → [da.d͡ʒu] 'thistle GEN PL', /zilu͜o**n**-i-u/ → /zilu͜o**n**-j-u/ → [zilu͜o.**ɲ**u] 'elephant GEN

PL', and /pe**l**-e-u/ → /pe**l**-j-u/ → [pe.ʎu] 'mouse GEN PL'; cf. /buː**r**-i-u/ → /buː**r**-j-u/ → [buː.**r**-u] ~ [buː.**r**ʲu] 'cage GEN PL' (Urek 2016: 60-61). In addition, Hall & Hamann (2006: 1209) suggest a diachronic change which turned **tj*, **dj* into *t͡ʃ*, *d͡ʒ* (in the 17th century) as an example of Latvian assibilation conditioned by /j/.

LOGOORI

Family: Niger-Congo Genera: Bantoid

ISO 693-3: rag Geographical macroarea: Africa

Prior typological studies: none

Alternative name: Lulogooli

phemic inventory (Leung 1991: 84ff.)	
*coronals**	anterior - dental: n̪ - alveolar: t, d, s, z, n, (l), r posterior: t͡ʃ, d͡ʒ, (ʃ)*, ɲ
vocoids	glide: j*, (w)* vowel: i, ɪ, e, a, u, ʊ, o

* Leung (1991) describes an underlying form of /j/ as a dental /j̪/, arguing that a palatal [j] only occurs when it precedes high vowels or in the [C_V] context whereas a dental [j̪] occurs elsewhere. She also considers [l, ʃ] and [w] which are derived from /r, h/ and back vowels respectively, do not have phonemic status in this language. However, contrary to this assumption, Glewwe & Aly (2016) argue that at least [ʃ] has phonemic status in this language.

In Logoori, a dental nasal /n̪/ undergoes coronal palatalization before a high front vowel /i/. For example, /kʊ-ki-je**n̪**-i/ → [kʊt͡ʃeː**ɲ**i] 'we have just wanted it', and /jɪ-je**n̪**-i/ → [j̪ej̪e**ɲ**i] 'want yourselves' (Leung 1991: 45). However, although Leung describes that this /n̪/ undergoes coronal palatalization also before a high back vowel /u/, it is quite suspicious since there is no example which can support the presence of /n̪/-palatalization before a back vowel. About this problem, Leung

(1991: 46) argues that "while no examples in my data show any productive alternation between [n̪] and [ɲ] in front of the upper high back vowel [u] in the SR, [ɲ] in all surface [ɲu] sequences may still be analyzed as underlyingly a dental nasal based on the fact that [n̪] is never found in front of [u] in the SR." However, lack of [n̪u] sequences in the surface itself cannot be evidence of the presence of productive coronal palatalization triggered by a high back vowel (see also discussion in section 2.4). For this reason, I only included /n̪/-palatalization triggered by /i/ in my data. In addition, it seems that there is /s/-palatalization in this language. Contrary to Leung (1991) who proposes that a surface [ʃ] is not a phoneme and only an allophone of an underlying /h/, Glewwe & Aly (2016) argues that this [ʃ] is derived from coronal palatalization of /s/ before /j/, as shown in the following surface variations: [**sj**ɔːmaː] ~ [**ʃ**ɔːmaː] 'wail, 1st SING PRES'. I included this /s/-palatalization, rather than /h/-palatalization, in my data, following Glewwe & Aly's (2016) description and analysis.

LUVALE

Family: Niger-Congo Genera: Bantoid

ISO 693-3: lue Geographical macroarea: Africa

Prior typological studies: Bateman (2007)

	phonemic inventory (Bateman 2007: 402)
*coronals**	anterior: t, (^{n}d), n, s, z, l posterior: t͡ʃ, d͡ʒ, ʃ, ʒ, ɲ
vocoids	glide: j, w vowel: i, e, ɛ, a, u, o, ɔ

According to Bateman (2007: 403), in Luvale, before /i/, anterior consonants /t, ^{n}d, s, z/ and /n/ undergo coronal palatalization, being realized as [t͡ʃ, ^{n}ʒ, ʃ, ʒ] and [ɲ] respectively. For example, [hi**t͡ʃ**isa] 'pass CAUS' (cf. [hi**t**a] 'pass'), [ɲi**ɲ**isa] 'climb CAUS' (cf. [**ɲ**ina] 'climb'), [la**^{n}ʒ**isa] 'by CAUS' (cf. [la**^{n}d**a] 'buy'), [ʃi**ʃ**isa] 'substitute CAUS' (cf. [ʃi**s**a] 'substitute'), and [fwi**ʒ**isa] 'spit CAUS' (cf. [fwi**z**a] 'spit'). An alveolar lateral /l/ does not undergo coronal palatalization in this language. In addition, a palatal glide /j/ is derived from front vowels, such as /i/ and /e/, at word boundaries by glide-formation. This derived glide can cause coronal palatalization, also. For instance, /olo**z**e etu/ → /olo**z**jetu/ → [olo**ʒ**etu] 'but we'. Since I was not able to access to the primary sources cited in Bateman (2007) or any alternative sources, regarding this language, I entirely rely on the descriptions provided by Bateman (2007).

MANDARIN

Family: Sino-Tibetan   Genera: Chinese

ISO 693-3: cmn   Geographical macroarea: Eurasia

Prior typological studies: Bateman (2007), Bhat (1978)

Alternative name: Standard Chinese

phonemic inventory (Lee & Zee 2003: 109-112)	
coronals	anterior: t, tʰ, t͡s, t͡sʰ, s, n, l posterior: t͡ʂ [t͡ʃ̻], t͡ʂʰ [t͡ʃ̻ʰ], ʂ [ʃ̻], ɻ [ɹ̻], (t͡ɕ), (t͡ɕʰ), (ɕ)
vocoids	glide: j, w vowel: i, y, ə, a, u, ɤ

* Phonemic statuses of palatal sibilants, such as /t͡ɕ, t͡ɕʰ/ and /ɕ/, are controversial (cf. Duanmu 2000).

In Mandarin, /s, t͡s/ and /t͡sʰ/ are realized as [ɕ, t͡ɕ] and [t͡ɕʰ] in high front contexts (before /i/ and /y/). For example, /**t͡s**ian/ → [**t͡ɕ**ian] 'sharp', /**t͡sʰ**ian/ → [**t͡ɕʰ**ian] 'owe', and /**s**ian/ → [**ɕ**an] 'thread' (Duanmu 2000: 27; W. Lee & Zee 2003: 111). In addition, /n/ is secondarily palatalized in the high front contexts in general, but it can also be realized as a palatal [ɲ]. For instance, /**n**ian/ → [**nʲ**an] ~ [**ɲ**an] (Duanmu 2000: 27). Other anterior consonants, such as /t, tʰ/ and /l/, only undergo secondary palatalization in the same contexts, being realized as [tʲ, tʰʲ] and [lʲ], respectively.

MAORI

Family: Austronesian Genera: Oceanic

ISO 693-3: mri Geographical macroarea: Papunesia

Prior typological studies: Bateman (2007), Hall & Hamann (2006)

phonemic inventory (Harlow 2006: 63)	
coronals	anterior: t, n, r posterior: -
vocoids	glide: w vowel: i, e, a, o, u

In Maori, /t/ is usually affricated before unstressed and devoiced high vowels such as /i, u/, being realized as [t͡s] (Bauer 1993: 521; Harlow 2006: 76). Also, Moorefield's (2003) online dictionary of Maori language which provides recorded pronunciations shows clear coronal affrication of /t/ in the high vocoid contexts. Although Bauer (1993) additionally reports that they can be palatalized, as in *iti* [i**t͡s**i] ~ [i**t͡ç**i] 'small' refferring to Biggs (1969), I was not able to find any comments about optional palatalization in the [_u] context from the recent edition of Biggs's (1998) book or any other sources. It is highly doubtful whether the optional coronal palatalization really targets /t/ in the high back context.

MARATHI

Family: Indo-European Genera: Indic

ISO 693-3: mar Geographical macroarea: Papunesia

Prior typological studies: Bateman (2007)

phonemic inventory (Wali 2005: 3-4)	
coronals	anterior - dental: t, tʰ, d, dʰ, n - alveolar: t͡s, d͡z, d͡zʰ, s, l, r posterior - retroflex: ʈ, ʈʰ, ɖ, ɖʰ, ɳ, ɭ - alveolo-palatal: t͡ʃ, t͡ʃʰ, d͡ʒ, d͡ʒʰ, ʃ
vocoids	glide: j, w short vowel: i, e, æ, ə, a, u, o, ɔ long vowel: iː uː

Marathi has several anterior consonants: /t, tʰ, d, dʰ, t͡s, d͡z, d͡zʰ, s, n, l/ and /r/ (Wali 2005: 4). Among them, only affricates /t͡s, d͡z/ and /d͡zʰ/ undergo coronal palatalization before high front vocoids /j, iː/ and /i/. For example, /**t͡s**imɳi/ → [**t͡ʃ**imɳi] 'sparrow', /**ts**jut/ → [**tʃ**jut] 'become cross', /**d͡z**ja/ → [**d͡ʒ**ja] 'which', and /**d͡zʰ**iːj/ → [**d͡ʒʰ**iːj] 'loss'. In some dialects, /e/ also triggers coronal palatalization. For example, /**t͡s**enɖu/ → [**t͡ʃ**enɖu] 'ball' (Wali 2005: 7). I did not include this palatalization triggered by /e/ in my typological data.

MBAHÁM

Family: West Bomberai Genera: West Bomberai

ISO 693-3: bdw Geographical macroarea: Papunesia

Prior typological studies: none

Alternative name: Baham

	phonemic inventory (Cottet 2015: 51, 72)
coronals	anterior: t, d, ^{n}d, s, n, l, r posterior: -
vocoids	glide: j, w vowel: i, e, a, o, u

According to Cottet (2015: 213), in Mbahám, anterior stops /t, d/ and /^{n}d/ allophonically alternate with [t͡ʃ, d͡ʒ] and [^{n}d͡ʒ] before high vocoids /i, j, u/ and /w/ which precede other vowels. For example, /**t**jári/ → [**t͡ʃ**já.ri] 'rain', /ki**^{n}d**ján/ → [kin.**d͡ʒ**ján] 'person', /**t**úon/ → [**t͡ʃ**ú.on] 'thigh', and /**^{n}d**úoŋ/ → [n**d͡ʒ**ú.oŋ] 'to cut' (Cottet 2015: 213). However, according to Cottet (2014), at least /t/ can optionally be realized as non-palatalized [t͡s] in the same contexts. Since Cottet (2014) does not give a clear example which shows the variation between the anterior and posterior affricates, I did not include this non-palatalized variant in my typological data. In addition, according to Flassy (1987: 25ff.), Mbahám coronal stops have palato-alveolar stop allophones, such as [t̠, d̠] (which he describes as [t^{j}, d^{j}]), rather than affricates, only before a high front vocoid. For instance, /wa'**t**jaːkop/ →

[wa’**t̲**akop^h] ‘turtle’. For those occurring before high back vocoids, he does not report such a palatalizing process, for example, /**t**we**t**we/ → [**t**wɛ**t**wɛ] ~ [**d**wɛ**d**wɛ] ‘vegetable’ (Flassy 1987: 28).

MINA

Family: Afro-Asiatic Genera: Biu-Mandara

ISO 693-3: hna Geographical macroarea: Africa

Prior typological studies: Bateman (2007)

Alternative name: Baham

phonemic inventory (Frajzyngier & Zygmunt 2005: 8)	
coronals	anterior: t, tʰ, ⁿd, ɗ, t͡s, d͡z, s, z, n, l, ɬ, ɮ, r posterior: -
vocoids	glide: j, w vowel: i, (y), e, ɨ, u, o, a

According to (Frajzyngier & Johnston 2005: 12), in Mina, alveolar sibilants, such as /t͡s, d͡z, s/ and /z/, undergo coronal palatalization when they are adjacent to a front high vowel /i/, producing [t͡ʃ, d͡ʒ, ʃ] and [ʒ] respectively. For examples, /**z**ìn/ → [**ʒ**ìn] ‘return’, and /bí**t͡s**ì/ → [bí**t͡ʃ**ì] ‘proper name for a first-born child’. In addition, a voiced fricative /z/ can undergo morphologically conditioned palatalization, especially when it is preceded by a nasal /n/ and followed by a stative marker ‘-ji’, as in /n**z**-jí/ → [n**ʒ**í] ‘sit, STAT’. Interestingly, however, it seems that a palatal glide /j/ can be a barrier to palatalization when the target consonant is not preceded by /n/. For example, /hà**z**-jìì/ → [hà**z**íjì] ‘dog, PL’. Other anterior consonants, such as /t/, do not undergo coronal palatalization in the context where sibilants undergo it, as in [tí] ‘see’ (Frajzyngier & Johnston 2005: 14).

MONGO

Family: Niger-Congo   Genera: Bantoid

ISO 693-3: lol   Geographical macroarea: Africa

Prior typological studies: Hall & Hamann (2006)

Alternative name: Lomongo

phonemic inventory (de Rop 1958: 9ff.)	
coronals	anterior: t, d, t͡s, d͡z, s, n, l posterior: ɲ
vocoids	glide: j, w vowel: i, e, ɛ, a, ɔ, o, u

In the Mongo language (also known as Lomongo), coronal affrication turns anterior stops /t/ and /^{n}d/ into corresponding affricates [t͡s] and [^{n}d͡z] respectively, before high vocoids /i, j/ and /w/. In addition, in this language, a nasal /n/ undergoes coronal palatalization before high front vocoids /i/ and /j/, being realized as [ɲ]. For example, /-lo**t**-/ ‘flee’ *vs*. [bo-lo**t͡s**-i] ‘fugitive’, /-kɛ$^{\mathbf{n}}$**d**-/ ‘go’ *vs*. [bɔ-kɛ$^{\mathbf{n}}$**d͡z**-i] ‘traveler’, [bɔ-kɛ$^{\mathbf{n}}$**d͡z**-wá] ‘inconstant’, and /-té**n**-/ ‘cut’ *vs*. [bo-té**ɲ**-i] ‘cutter’ (de Rop 1958: 9-10). Kenstowicz & Kisseberth (1979: 156) also clearly state that “there is a rule whereby *t*, *d* and *l* are affricated to *ts*, *j* (= *dz*), and *j* (= *dz*), respectively, when followed by a glide, *w* or *y*.” I did not include a change from /l/ into [d͡z] because it involves a change in sonorancy.

NANAI

Family: Tungusic Genera: Southern

ISO 693-3: gld Graphical macroarea: Eurasia

Prior typological studies: none

phonemic inventory (Ko & Yurn 2011: 9ff.)	
coronals	anterior: t, d, s, n, l, r posterior: t͡ʃ, d͡ʒ
vocoids	glide: j, w vowel: i, ɪ, ə, a, u, o

According to Ko & Yurn (2011: 14), in (Najkhin) Nanai, a fricative /s/ is realized as a lamino-prepalatal [ɕ] before front vowels /i/ and /ɪ/, but [s] elsewhere. For example, /a**s**i/ → [a**ɕ**i] 'wife' and /**s**ɪŋakta/ → [**ɕ**ɪŋaktaː] 'fur'. In addition, a lamino-alveolar nasal /n/ is also realized as a lamino-prepalatal [ɲ] before /i/ and /ɪ/. For instance, /**n**iməkən/ → [**ɲ**iməkə̃ː] 'neighborhood', and /**n**ɪmokta/ → [**ɲ**ɪmɔktaː] 'tear' (Ko & Yurn 2011: 16).

NIMBORAN

Family: Nimboran Genera: Nimboran

ISO 693-3: nir Geographical macroarea: Papunesia

Prior typological studies: Bhat (1978)

phonemic inventory (Anceaux 1965: 8)	
coronals	anterior: t, d, s, n, r posterior: -
vocoids	glide: j vowel: i, e, a, u, o

According to Anceaux (1968: 18), a voiceless apico-dental stop /t/ is realized as a ‘lamino-alveolar’ [t̻] when it precedes an accented high front vowel /i/. If this /i/ is not accented and /t/ precedes it, /t/ has a palatalized variation, [t̠], which Anceaux calls a voiceless ‘lamino-domal’ stop. For example, /pei**t**iua/ → [pei**t̠**iuá] ‘old man’. Similarly, /d, s, n/ may also have palatal allophones [d̠, ɕ] and [n̠] respectively, before a non-accented /i/. For example, /**d**io/ → [**d̠**ió] ‘gathering’, /i**s**iu/ → [i**ɕ**iú] ‘shake’, and /mi**n**ie/ → [mí**n̠**ie] ‘before’.

NISHNAABEMWIN

Family: Algic Genera: Algonquian

ISO 693-3: ciw Geographical macroarea: North America

Prior typological studies: Bateman (2007), Hall & Hamann (2006)

Alternative name: Eastern Ojibwe

phonemic inventory (Valentine 2001: Chapter 2)	
coronals	anterior: t, d, s, z, n posterior: t͡ʃ, d͡ʒ, ʃ, ʒ
vocoids	glide: j, w short vowel: i, e, a, o long vowel: iː aː oː

Nishnaabemwin has five alveolar phomenes: /t, d, s, z/ and /n/, and there are no anterior liquids. In this language, high front vocoids /j/ and /i/ condition coronal palatalization of /t, d/ and /s/. For example, /apiː**t**+i+gi/ → [piː**t͡ʃ**gi] ‘grow to such extent’, /biː**d**+i+bizo/ → [biː**d͡ʒ**bizo] ‘come driving’, and /da**s**+i/ → [da**ʃ**i] ‘be a certain amount’ (Valentine 2001: 86ff.). In addition, only a nasal /n/ which is historically derived from *θ turns into [ʒ] before high front vocoids. I did not include this [n] ~ [ʒ] alternation since it involves a change in sonorancy and has an evident diachronic influence.

NUPE

Family: Niger-Congo Genera: Nupoid

ISO 693-3: nup Geographical macroarea: Africa

Prior typological studies: Bateman (2007), Bhat (1978)

phonemic inventory (Hyman 1970: 59)	
coronals	anterior: t, d, t͡s, d͡z, s, z, n, l, r posterior: t͡ʃ, d͡ʒ, ʃ, ʒ
vocoids	glide: j, w short vowel: i, e, a, o, u long vowel: aː nasal vowel: ĩ, ã, ũ

In Nupe, /t͡s, d͡z, s/ and /z/ are neutralized as [t͡ʃ, d͡ʒ, ʃ] and [ʒ] before /i/ amd /e/ (Hyman 1970: 60). E.g., /**s**i/ → [**ʃ**i] 'to buy', and /**z**i/ → [**ʒ**i] 'to confuse' (examples are from Bateman 2007: 438). Other consonants, such as /p/, undergo secondary palatalization in the same context. I was not able to find any evidence which shows primary palatalization of /t, d, n/ and /l/ in this language.

NYAWAYGI

Family: Pama-Nyungan Genera: Northern Pama-Nyungan

ISO 693-3: nyt Georaphical macroarea: Australia

Prior typological studies: none

phonemic inventory (Dixon 1983: 438-441)	
coronals	apical: n, l laminal: d̻, n̻
vocoids	vocoids: j, w vowel: i, a, u

According to Dixon (1983: 440-441), a laminal stop /d̻/ and nasal /n̻/ are usually realized as interdental consonants, such as [d̪] and [n̪], except before /i/ where these laminal consonants have posterior articulations, such as [d̠] and [n̠] (which are described as *ɖ* and *ɲ* by Dixon). Note that Dixon (1983) denotes representative forms of these laminal sounds with symbols for posterior consonants, such as /ɖ/ and /ɲ/ due to diachronic reasons; however, major allophones of these laminal consonants in this language are interdental consonants rather than posterior ones. Therefore, it can be concluded that (interdental) laminal consonants undergo allophonic coronal palatalization before a high front vowel /i/ in this language.

OROQEN

Family: Tungusic   Genera: Northern Tungusic

ISO 693-3: orh   Geographical macroarea: Eurasia

Prior typological studies: none

phonemic inventory (X. Zhang 1996: 153ff.)	
coronals	anterior: t, d, s, n, l, r posterior: t͡ɕ, d͡ʑ, ɲ
vocoids	glide: j, w vowel: i, eː, ɛː, ə, a, u, ʊ, o, ɔ

According to X. Zhang (1996: 168), before front vowels, such as /eː/ or /ɛː/, a palatal glide /j/ is formed, as in /eːlu/ → [**j**eːlu] 'charcoal', and /ɛːsa/ → [**j**ɛːsa] 'eye'. This palatal glide, in turn, triggers allophonic coronal palatalization of the preceding anterior fricative /s/. For instance, /**s**ɛːn/ → /**s**jɛːn/ → [**ɕ**ɛːn] 'ear'. It seems that other anterior consonants do not undergo coronal palatalization in this language. For example, /ʊk**t**ɛːn/ → /ʊk**t**jɛːn/ → [ʊk**t**jɛːn] 'cover (nom.)', /a**n**ɛː/ → /a**n**jɛː/ → [a**n**jɛː] 'New Year', and /mɔː**l**ɛːn/ → /mɔː**l**jɛːn/ → [mɔː**l**jɛːn] 'bullet'.

PAPAGO

Family: Uto-Aztecan   Genera: Tepiman

ISO 693-3: ood   Geographical macroarea: North America

Prior typological studies: Bateman (2007), Bhat (1978), Hall & Hamann (2006)

Alternative name: Tohono O'Odham

phonemic inventory (Hale 1965: 296)	
coronals	apico-dental: t, d, n, l apico-alveolar: s lamino-alveolar: t͡s, d͡z, n̻ retroflex: ɖ, ʂ
vocoids	glide: j, w vowel: i, ɨ, a, o, u

The Papago language, also known as Tohono O'Odham, has three high vowels: /i/, /ɨ/, and /u/ (Saxton 1963: 30; Hale 1965). According to the studies on Papago phonetics and phonology (Dart 1993; Hale 1965; Saxton 1963), Papago /t, d/ and /n/ are neutralized into laminal alveolar consonants /t͡s, d͡z/ and /n̻/, before these high vowels. For instance, /tatad̪a**d**i/ → [tátd̪a**d͡z**] 'his feet' (Hale 1965: 300). Although Bateman (2007) describes that not only high vowels /i, u/ but also a front vowel /e/ trigger palatalization processes in this language, in fact, there is no front /e/ in Papago language (Dart 1993; Hale 1965). According to Dart (1993: 29), the average F1 and F2 values of Papago /ɨ/ were 465 and 1,360 respectively. These F2 values clearly show that /ɨ/ is high central (see also section 2.4 for detailed discussion).

PLAINS CREE

Family: Algic　　Genera: Algonquian

ISO 693-3: crk　　Geographical macroarea: North America

Prior typological studies: Hall & Hamann (2006)

phonemic inventory (Russell 1992)	
coronals	anterior: t, t͡s, s, n posterior: -
vocoids	glide: j, w plain vowel: i, (e), a, u nasal vowel: ĩ, ẽ, ã, õ

In Plains Cree, there are four anterior stops /t, t͡s, s/ and /n/. Among them, a stop /t/ undergoes coronal affrication before high front vocoids /j, i/ and /ĩ/. This change is morphologically conditioned (Wolfart 1973: 79; Russell 1992). For instance, /oh**t**-i/ → [oh**t͡s**i] 'from PARTICLE' (Russell 1992). Note that a voicing contrast does not exist in this language.

POLISH

Family: Indo-European Genera: Slavic

ISO 693-3: pol Geographical macroarea: Eurasia

Prior typological studies: Bateman (2007), Bhat (1978), Hall & Hamann (2006)

phonemic inventory (Jassem 2003)	
coronals	anterior: t, d, t͡s, d͡z, s, z, n, l posterior: - apical (post-)alveolar: t̺͡ʃ, d̺͡ʒ, ʃ̺, ʒ̺, r - laminal alveolo-palatal: ɕ, d͡ʑ, ɕ, ʑ, ɲ - laminal palatal: c, ɟ
vocoids	glide: j, w vowel: i, e, ɨ, a, o, u

According to Jassem (2003), Polish has abundant coronal sounds in its inventory: (denti-)alveolar /t, d, t͡s, d͡z, s, z, n, l/, post-alveolar /t̺͡ʃ, d̺͡ʒ, ʃ̺, ʒ̺, r/, alveolo-palatal (prepalatal) /t͡ɕ, d͡ʑ, ɕ, ʑ, ɲ/, and palatal /c, ɟ/. Among these coronal consonants, Polish coronal palatalization turns /t, d, s, z/ and /n/ into prepalatal [t͡ɕ, d͡ʑ, ɕ, ʑ] and [ɲ] respectively, in the front vowel contexts (e.g., [_i] or [_e]) (Ćavar 2004: 5, 138; Rubach 1984: 243). For example (Bateman 2007: 443, from Szpyra-Kozłowska 1995), zło[**t͡ɕ**]it͡ɕ ‘to gild’ (cf. zło[**t**]o ‘gold’), wo[**ʑ**]it͡ɕ ‘to car’ (cf. wo[**z**]y ‘carts’), o[**ɕ**]e ‘wasp DAT SG’ (cf. o[**s**]a ‘wasp’), and ra[**ɲ**]it͡ɕ ‘to wound’ (cf. ra[**n**]a).

ROMANIAN

Family: Indo-European Genera: Romance

ISO 693-3: ron Geographical macroarea: Eurasia

Prior typological studies: Bateman (2007), Bhat (1978), Hall & Hamann (2006)

	phonemic inventory (Chitoran 2002: 7ff.)
coronals	anterior: t, d, t͡s, s, z, n, l, r posterior: t͡ʃ, d͡ʒ, ʃ, ʒ
vocoids	glide: j, w vowel: i, e, ɨ, ə, a, u, o

In Romanian, before a suffix initial /-i/, a stem final alveolar /t/ undergoes coronal affrication, /d/ undergoes spirantization, and /s, z/ undergo coronal palatalization. The following examples illustrate these processes (from Chitoran 2002: 187ff): /mun**t**-i/ → [mun**t͡sʲ**] 'mountain PL', /solda**t**-i/ → [solda**t͡sʲ**] 'soldier PL', /bra**d**-i/ → [bra**zʲ**] 'fir tree PL', /pa**s**-i/ → [pa**ʃʲ**] 'step PL', and /obra**z**-i/ → [obra**ʒʲ**] 'cheek PL'. Also note that sonorant consonants, /n, l/ and /r/, undergo only secondary palatalization in the same context. For example, /a**n**-i/ → [a**nʲ**] 'year PL', /sko**l**-i/ → [sko**lʲ**] 'wake up, 2nd', and /kla**r**-i/ → [kla**rʲ**] 'clear PL'. In addition, a lateral /l/ can be deleted in this context, as in /ka**l**-i/ → [kaj] 'horse PL'. Because this [j] is a realization of the underlying /i/ rather than /l/, it cannot be considered as a case of /l/-to-[j] palatalization.

SALAR

Family: Turkic Genera: Oghuz

ISO 693-3: slr Geographical macroarea: Eurasia

Prior typological studies: none

phonemic inventory (Dywer 2007: 94ff.)	
coronals	anterior: t, d, s, z, n, l, r posterior: ʂ, t͡ʂ, d͡ʐ, ɕ, t͡ɕ, d͡ʑ
vocoids	glide: j vowel: i, y, e, ø, a, u, ɯ, o

According to Dwyer (2007: 186), anterior stops /t, d/ undergo optional, but commonly attested, coronal palatalization before high front vowels, producing posterior affricates [t͡ɕ, d͡ʑ] respectively. For example, je(t)[**t͡ɕ**]i ~ je(t)[**t**]i 'seven', and xa[**d͡ʑ**]i ~ xa[**d**]i 'Chinese'.

SAMOAN

Family: Austronesian Genera: Oceanic

ISO 693-3: smo Geographical macroarea: Papunesia

Prior typological studies: Hall & Hamann (2006)

phonemic inventory (Alderete & Bradshaw 2012)	
coronals	anterior: t, n, s, l, (r) posterior: -
vocoids	glide: - short vowel: i, e, a, o, u long vowel: iː, eː, aː, oː, uː

According to Alderete & Bradshaw (2012: 3), in Samoan, /t/ undergoes coronal affrication before /i/, being realized as [t͡s]. This language does not have voiced obstruents in its phonemic inventory. Although Alderete & Bradshow (2012: 3) also notes that "[t]his shows similarities to other Polynesian languages (e.g., Tongan, Niuean)," I did not include Tongan and Niuean in my data since I was not able to find detailed descriptions on coronal palatalization/affrication in these languages.

SANUMA

Family: Yanomam Genera: Yanomam

ISO 693-3: xsu Geographical macroarea: South America

Prior typological studies: Bateman (2007)

phonemic inventory (Borgman 1990: 220ff.)	
coronals	anterior: t, t^h, t͡s, s, n, l posterior: -
vocoids	glide: w plain vowel: i, e, ɨ, ə, a, o, u nasal vowel: ĩ, ẽ, ɨ̃, ã, õ, ũ

According to Borgman (1990: 220ff.), in Sanuma, coronal sibilants /t͡s/ and /s/ undergo coronal palatalization before a high vowel /i/, being realized as [t͡ʃ] and [ʃ] respectively. For instance, /**s**ilaka/ → [**ʃ**ilaka] 'arrow'. Note that non-sibilant anterior consonants, /t, t^h, n/ and /l/, do not undergo coronal palatalization in the same context.

SHAOXING WU

Family: Sino-Tibetan Genera: Chinese

ISO 693-3: wuu Geographical macroarea: Eurasia

Prior typological studies: none

Alternative name: Shaoxing Chinese

phonemic inventory (J. Zhang 2006: 35, 109)	
coronals	anterior: t, tʰ, d, t͡s, t͡sʰ, d͡z, s, z, n, l posterior: (t͡ɕ), (t͡ɕʰ), (d͡ʑ), (ɕ), (ʑ), (ɲ)
vocoids	glide: (j), (ɥ), (w) vowel: i, (y), e, ɤ, a, u, o

In Shaoxing Wu (a variant of Wu Chinese spoken in Shaoxing), posterior (alveolo-palatal) consonants such as [t͡ɕ, t͡ɕʰ, d͡ʑ, ɕ, ʑ] and [ɲ] only occur before high front /i, y/ or /j/ (J. Zhang 2006: 165). These posterior consonants are generally in complementary distribution with anterior consonants [t͡s, t͡sʰ, d͡z, s, z] and [n] respectively (J. Zhang 2006: 166); however, J. Zhang (2006: 168) considers posterior sibilants /t͡ɕ, t͡ɕʰ, d͡ʑ, ɕ/ and /ʑ/ independent phonemes, based on the fact that the anterior sibilants and posterior sibilants are in fact not in complementary distribution in a specific context. J. Zhang argues that both anterior and posterior consonants can occur (only) before a surface sequence [ɪʔ]. However, since the contrasts between anterior sibilants and posterior sibilants only marginally exist in this specific context, it can be argued that at least the contrasts between anterior and posterior sibilants are neutralized in the high front vocoid contexts, except for the [_ɪʔ] context. In addition, although J. Zhang (2006) analyzes that [ʅ] (an apical vowel), [i] and [ɪ] are surface allophones of the underlying /i/, these three variants can also be considered as independent phonemes, depending on the analysis. Note that anterior consonants can occur before [ʅ] whereas posterior consonants cannot do so. In addition, in this language, /l/ does not undergo coronal palatalization in the same context, as in [ljaŋ^{22}] 'two' and [ljaʔ^{3}] 'omit' (J. Zhang 2006: 174).

SLOVAK

Family: Indo-European Genera: Slavic

ISO 693-3: slk Geographical macroarea: Eurasia

Prior typological studies: none

phonemic inventory (Hanulíková & Hamann 2010)	
coronals	anterior: t, d, t͡s, d͡z, s, z, n, l, r post-alveolar: t͡ʃ, d͡ʒ, ʃ, ʒ palatal: c, ɟ, ɲ, ʎ
vocoids	glide: j, w short vowel: i, ɛ, (æ), a, ɔ, u long vowel: iː, ɛː, aː, ɔː, uː

Slovak has nine anterior consonants /t, d, t͡s, d͡z, s, z, n, l, r/, eight palatal consonants /c, ɟ, t͡ʃ, d͡ʒ, ʃ, ʒ, ɲ, ʎ/, and six front vocoids /j, i, iː, ɛ, ɛː, æ/ (Hanulíková & Hamann 2010: 374; Rubach 1993: 30-31). According to Rubach (1993: 99-133), there are at least three processes which target anterior consonants. First, alveolar affricates /t͡s/ and /d͡z/ undergo coronal palatalization before front vocoids. For instance, /zaja**t͡s**-ik/ → [zaja**t͡ʃ**ik] 'hare DIM'. Second, four alveolar consonants, /t, d, n/ and /l/, undergo coronal palatalization either, before all suffix initial front vowels. For example, /mies**t**-ɛ/ → [mies**c**ɛ] 'place LOC SG', /hra**d**-ɛ/ → [hra**ɟ**ɛ] 'castle LOC SG', /bah**n**-ɛ/ → [bah**ɲ**ɛ] 'ram LOC SG', and /soko**l**-ɛ/ → [soko**ʎ**ɛ] 'falcon LOC SG'. Finally, in certain morphological conditions, an inserted /j/ triggers coronal palatalization of /s/ and /z/, turning them into posterior [ʃ] and [ʒ]. This inserted /j/ also triggers coronal affrication of /t/ and /d/, resulting in anterior affricates [t͡s] and [d͡z] (Rubach 1993: 121).

SONORA YAQUI

Family: Uto-Aztecan Genera: Cahita

ISO 693-3: yaq Geographical macroarea: North America

Prior typological studies: Hall & Hamann (2006)

phonemic inventory (Dedrik & Casad 1999: 21)	
coronals	anterior: t, s, n, l, r posterior: t͡ʃ
vocoids	glide: j, w vowel: i, e, a, o, u

According to Dedrik & Casad (1999: 30), in Sonora Yaqui, an anterior stop /t/ becomes [t͡ʃ], before a high vowel /i/. This process is morphophonemic. Although this language has four other anterior consonants, /s, n, l/ and /r/, there is no evidence which shows that these consonants undergo coronal palatalization.

TAIOF

Family: Austronesian Genera: Oceanic

ISO 693-3: sps Geographical macroarea: Papunesia

Prior typological studies: Hall & Hamann (2006)

phonemic inventory (Ross 2002: 426-427)	
coronals	anterior: t, d, t͡s, s, n, r posterior: ɲ
vocoids	glide: j, w vowel: i, e, a, o, u

According to Ross (2002: 426), in Taiof, anterior consonants /t/ and /n/ are neutralized as an anterior affricate [t͡s] and a posterior nasal [ɲ] respectively, before a high front vowel /i/. In contrast, in this language, coronal affrication turns /d/ into an allophonic [d͡z] before /i/ and /u/. In addition, before /i/, /t͡s/ and /d/ can undergo optional coronal palatalization, being realized as [t͡ʃ] and [d͡ʒ] respectively.

TERA

Family: Afro-Asiatic Genera: Biu-Mandara

ISO 693-3: ttr Geographical macroarea: Africa

Prior typological studies: none

phonemic inventory (Tench 2007)	
coronals	anterior: t, d, ɗ, ^{n}d, n, s, z, n, l, ɬ, ɮ, r posterior: t͡ʃ, d͡ʒ, $^{\text{ɲ}}$d͡ʒ, ʃ, ʒ, ɲ
vocoids	glide: j, w short vowel: i, e, ɨ, a, u, o long vowel: iː, eː, aː, uː, oː

In Tera, anterior stops /t/ and /d/ undergo coronal palatalization before front vowels, such as /i, iː, e/ and /eː/, being neutralized as [t͡ʃ] and [d͡ʒ]. For example, /xà**t**in/ → [xa**t͡ʃ**in] 'his brother', /**t**i/ → [**t͡ʃ**i] 'to stir', /**d**ere/ → [**d͡ʒ**ere] 'cap', and /ku**d**i/ → [ku**d͡ʒ**i] 'chief' (Tench 2007: 227, 229). Although there are other anterior consonants, i.e. /ɗ, ^{n}d, n, r, s, z, ɬ, ɮ/ and /l/, in this language, Tench (2007) does not report any coronal palatalization or affrication process which targets these consonants.

TIWI

Family: Tiwian Genera: Tiwian

ISO 693-3: tiw Geographical macroarea: Australia

Prior typological studies: none

phonemic inventory (J. Lee 1987: 23; Maddieson 1984)	
coronals	apical anterior: t, $^{\text{n}}$t, n, l, r apical posterior: ʈ, $^{\text{n}}$ʈ, ɳ, ɭ, ɽ laminal dental: t̪, $^{\text{n}}$t̪, n̪
vocoids	glide: j, w vowel: i, a, o, u

According to J. Lee (1987), in Tiwi, an apical anterior and apical posterior consonant are phonemically distinguished from each other, whereas a laminal consonant does not have the anteriority contrast. Among these coronal consonants, the laminal consonants, phonemically /t̻, $^{\text{n}}$t̻/ and /n̻/, “have dental and palatal allophones,” and “[n]ormally the palatal variant occurs before the high front vowel /i/ and the dental variant before the other vowels” (J. Lee 1987: 25). Note that /t̻, $^{\text{n}}$t̻/ and /n̻/ are considered as basically dental /t̪, $^{\text{n}}$t̪/ and /n̪/ in other works (Anderson & Maddieson 1994; Maddieson 1984) since these laminal phonemes are dominantly realized as dentals across conditions. Thus, allophonic realizations of laminal phonemes before a front vowel, such as [t̠, $^{\text{n}}$t̠] and [n̠], can be interpreted as results of coronal palatalization of dental consonants in the front context.

TOTA LOGBA

Family: Niger-Congo Genera: Bantoid

ISO 693-3: loq Geographical macroarea: Africa

Prior typological studies: none

Alternative name: the Tota dialect of the Ikpana language

	phonemic inventory (Dorvolo 2008: 12ff.)
coronals	anterior: t, d, t͡s, d͡z, s, z, n, l, r posterior: ɖ, ʃ, ʒ, t͡ʃ*, d͡ʒ*, ɲ
vocoids	glide: j, w vowel: i, e, ɛ, a, u, o, ɔ

* Ladefoged (1968: 54) only includes alveolar affricates /t͡s/ and /d͡z/ in the inventory of this language, excluding posterior /t͡ʃ/ and /d͡ʒ/ from it.

In the Tota dialect of the Logba language, coronal palatalization and coronal affrication occur. Note that Dorvolo (2008) calls both processes 'palatalization'. First, in this language, anterior fricatives, /s/ and /z/, turn into [ʃ] and [ʒ] respectively, when they precede a high front vowel /i/. For example, /i**s**íkpe/ → [i**ʃ**íkpe] 'ring', /ina**s**ína/ → [ina**ʃ**ína] 'everybody', /on**z**iɛ/ → [on**ʒ**iɛ] 'owl', and /**z**í/ → [**ʒ**í] 'good' (Dorvolo 2008: 17ff). Second, an anterior nasal /n/ also undergoes coronal palatalization before /i/, but more restrictively. According to Dorvolo (2008: 34, Note 14), this nasal palatalization is only found in Vuinta town. Because this /n/-palatalization only rarely occurs, I did not include it in my data. For instance, /a**n**i/ → [a**ɲ**i] '2nd PL SUBJ'. Third, there is also coronal affrication which turns /t/ into [t͡s] before a high vowel /i/ or /u/. For example, /a**t**í/ → [a**t͡s**í] 'night', and /o**t**ú/ → [o**t͡s**ú] 'hill' (Dorvolo 2008: 18, 34). Dorvolo (2008: 34) also suggests evidence of /d/-affrication, as in /o**d**ú/ → [o**d͡z**ú] 'river'.

TRENTINO ITALIAN

Family: Indo-European Genera: Romance

ISO 693-3: ita Geographical macroarea: Eurasia

Prior typological studies: Hall & Hamann (2006)

*phonemic inventory (Bertoldi 1989: 262)**	
coronals	anterior: t, d, t͡s, d͡z, s, z, n, l, r posterior: t͡ʃ, d͡ʒ, ʃ, ɲ
vocoids	glide: j, w vowel: i, e, ɛ, a, u, o, ɔ

* This inventory describes the phonemic contrasts found in so-called 'the Rovereto dialect', which is a variant of Trentino Italian.

According to Cordin (1997: 261), in Trentino Italian, a plural marker /-i/ triggers coronal palatalization of /t/ and /n/. E.g., *gatti* 'cats' [ga**t͡ʃ**], *anni* 'years' [a**ɲ**i]. I was not able to find any evidence which shows coronal palatalization targeting other anterior consonants in this context (see also Hall & Hamann 2006: 2011). Note that this language lacks a posterior lateral /ʎ/ in its phonemic inventory. This absence of /ʎ/ makes contrast with Standard Italian language. According to Bertoldi (1989: 233), "Questa consonante manca totalmente nei dialetti trentini, cosi pure in roveretano (This consonant is completely absent in the Trentino dialects, as well as in the Rovereto dialect)." In addition, on behalf of this vanished /ʎ/, "[a]l suo posto rimane la /j/ semivocalica (In this place, the semivowel /j/ remains)." (translations by the author of this thesis are given inside the parentheses.)

TSWANA

Family: Niger-Congo Genera: Bantoid

ISO 693-3: tsn Geographical macroarea: Africa

Prior typological studies: Bateman (2007), Bhat (1978)

Alternative name: Setswana

phonemic inventory (University of Botswana 1999: 10, 16)	
coronals	anterior: t, tʰ, t͡s, t͡sʰ, t͡ɬ, t͡ɬʰ, s, n, l, r posterior - palato-alveolar: t͡ʃ, t͡ʃʰ, d͡ʒ, ʃ - palatal: ɲ
vocoids	glide: j, w vowel: i, e [ɪ], ɛ, a, ɔ, o [ʊ], u

According to University of Botswana (1999: 28), in Tswana, sequences such as /tj/, /t͡sj/, /t͡sʰj/, /t͡ɬj/, /t͡ɬʰj/, /nj/, and /lj/ are not permitted. Thus, to avoid these sequences, an anterior consonant that precedes /j/ (which is derived from a front vowel by glide-formation, when it is followed by another vowel) turns into a different consonant, with the deletion of the following /j/. For example, /t/ undergoes coronal affrication before /j/, as in /pʰo**t**i-ana/ → /pʰo**tj**-ana/ → [pʰʊ̀**t͡s**àːnà] 'a small duiker'. Bateman (2007) provide several examples of such changes based on the descriptions of Cole (1955) and LaCharité (1993). First, causative suffix *-ja* can trigger coronal palatalization of /n/ and assibilation of /l/, as shown in *-leka**n**a* 'be equal' *vs*. *-leka**ɲ**a* 'make equal', and *-xaka**l**a* 'become indignant' vs. *-xaka**t͡s**a* 'cause to be indignant' (Bateman 2007: 136). Second, diminutive suffix -*ana* changes a stem final front vowel into a palatal gilde /j/ which in turn conditions alternation of the preceding consonant. In this context, /t/ is changed into [t͡s] or [t͡ʃ], and /n/ is turned into [ɲ]. For example, /loba**t**i-ana/ → /loba**t**j-ana/ → [loba**t͡s**ana] ~ [loba**t͡ʃ**ana] 'a small board/flank', and /namane-ana/ → /nama**n**j-ana/ → [nama**ɲ**ane] 'small calf'. Note that liquid consonants, /l/ and /r/, also undergo alternations in this morphological context. However, they are targeted by assibilating processes rather than coronal palatalization or affrication, resulting in [d͡ʒ] and [t͡sʰ] respectively (Bateman 2007: 142ff.).

UDMURT

Family: Uralic Genera: Permic

ISO 693-3: udm Geographical macroarea: Eurasia

Prior typological studies: none

phonemic inventory (Winkler 2001: 9; Kochetov 2016: 21)	
coronals	anterior: t, d, s, z, n, l, r posterior - palato-alveolar: t͡ʂ, d͡ʐ, ʂ, ʐ - palatal: c, ɟ, t͡ɕ, d͡ʑ, ɕ, ʑ, ɲ, ʎ
vocoids	glide: j vowel: i, e, a, u, ɯ*, o, ɤ*

* The classification of back unrounded vowels, such as /ɯ/ and /ɤ/, is controversial: these back vowels are sometimes described as central vowels, such as /ɨ/ and /ə/ respectively, rather than back vowels.

According to Kochetov (2016: 21), Udmurt /t, d, n/ and /l/ undergo coronal palatalization before /j/. For example, /pur**t**-jos/ → [pur**c**ːos] 'knife, PL', /ku**d**-jos/ → [ku**ɟ**ːos] 'swamp, PL', /puko**n**-jos/ → [puko**ɲ**ːos] 'chair, PL', and /sɯka**l**-jos/ → [sɯka**ʎ**ːos] 'cow, PL'. Note that anterior sibilants and /r/ undergo no changes before /j/, in standard Udmurt. In Southwest Udmurt, the glide /j/ is deleted when it follows sibilants, leaving the preceding sibilant unchanged. For instance, /pi**s-j**anɤ/ → [pi**s**ːanɤ] 'to thread a needle'. Also, in Southwest Udmurt, this palatal /j/ is strengthened when it is preceded by /r/. For example, /ʂu**r-j**os/ → [ʂu**rʎ**os] ~ [ʂu**rd͡ʑ**os] 'river, PL'.

UPPER SORBIAN

Family: Indo-European Genera: Slavic

ISO 693-3: hsb Geographical macroarea: Eurasia

Prior typological studies: Hall & Hamann (2006)

phonemic inventory (Hawson 2017)	
coronals	anterior: t, d, t͡s, s, z, n, nʲ, l, r posterior: t͡ʃ, d͡ʒ, ʃ, ɲ
vocoids	vocoids: j, w, wʲ vowel: i, e [ɪ], ɛ [e]

In Upper Sorbian, a close-mid /e/ and high front /i/ trigger morphologically conditioned coronal palatalization of anterior stops, /t/ and /d/. For example, when a locative singular masculine marker /-e/ follows /t/ and /d/, coronal palatalization occurs, turning /t/ and /d/ into [t͡ʃ] and [d͡ʒ] respectively: *w haće* [ha**t͡ʃ**e], cf. *hat* 'lake', and *sudźe* [su**d͡ʒ**e], cf. *su**d*** 'barrel' (Schaarschmidt 2004: 14-15). In addition, in this language, many consonants including /n/ and /l/ undergo secondary palatalization before /i, e/ and /ɛ/, rather than coronal palatalization. For instance, ***l**ičak* [**lʲ**it͡ʃakʰ] 'calculator' (Schaarschmidt 2004: 14; Hawson 2017: 7). Note that Hawson (2017) describes phoneme /e/ as /ɪ/, and /ɛ/ as /e/.

WAI WAI

Family: Cariban   Genera: Cariban

ISO 693-3: waw   Geographical macroarea: South America

Prior typological studies: Hall & Hamann (2006)

phonemic inventory (Hawkins 1998: 148-149)	
coronals	anterior: t, s, n, r posterior: t͡ʃ, ʃ, ɲ, r̲*
vocoids	glide: j, w vowel: i, e, ɨ, a, u, o

*The rhotic /r̲/ is formed with the blade of the tongue in the alveolo-palatal region.

In Wai Wai, anterior consonants /t/ and /n/ are neutralized into [t͡ʃ] and [ɲ] respectively, before front vocoids /j, i/ and /e/. For example, /**tɨ-i**rko/ → [**t͡ʃi**rko] 'fix', /**t**ɨ**t**ɨ**-i**r̲a/ → [**t͡ʃ**i**t͡ʃ**ir̲a], and /**n**ɨ-e**n**ɨ-**j**e/ → [**ɲ**ee**ɲ**e] 'he saw it.' (Hawkins 1998: 160-161). Note that this is morphologically conditioned coronal palatalization: when suffixes with initial front vocoids are attached to the stem, these initial front vocoids trigger both fronting of mid vowel /ɨ/ and palatalization of /t, n/ (Hawkins 1998: 160). For instance, as in /n**ɨ**-enɨ-je/ → [ɲ**e**eɲe] 'he saw it.', the underlying /ɨ/ is realized as a front vowel [e]. Sometimes this underlying /ɨ/ is deleted at the surface, especially when it is directly followed by /i/, as you can see in the following example: /t**ɨ-i**rko/ → [t͡ʃ**i**rko] 'fix'.

WEST FUTUNA-ANIWA

Family: Austronesian Genera: Oceanic

ISO 693-3: fut Geographical macroarea: Papunesia

Prior typological studies: Hall & Hamann (2006)

phonemic inventory (Dougherty 1983: 2-3)	
coronals	anterior: t, s, n, l, r posterior: ʃ*
vocoids	vocoids: - vowel: i, e, a, u, o

* Dougherty (1983: 3) transcribes this phoneme as /j/, however, as Dougherty notes, "/j/ is used here to represent the palatal fricative often indicated by /š/."

According to Dougherty (1983: 7), in West Futuna-Aniwa, /t/ undergoes coronal palatalization before /i/ in general and sometimes before /e/. For example, /**t**i/ → [**t͡ʃ**i] *definite article*, and /**t**ia/ → [**d͡ʒ**ia] 'to hit'. In addition, Dougherty (1983) also notes that /n/ also undergoes secondary palatalization before /i/. For instance, /ka**n**ieni/ → [ka**nʲ**ieni] 'want'.

WEST GREENLANDIC

Family: Eskimo-Aleut Genera: Eskimo

ISO 693-3: kal Geographical macroarea: Eurasia

Prior typological studies: Hall & Hamann (2006)

phonemic inventory (Fortescue 1983)	
coronals	anterior: t, s, n, l apical posterior: ʂ, ɻ
vocoids	vocoids: - vowel: i, a, u

In West Greenlandic, /t/ undergoes allophonic coronal affrication before /i/, being realized as [t͡s]. For instance, /naalag + **t**it + vaa/ → [nala**t͡s**ippaa] 'he made him obey' (Fortescue 1983: 344). According to Fortescue (1983: 333ff), anterior consonants /s, n/ and /l/ also "slightly palatalized in the environment of /i/." However, since this description, 'slightly palatalized,' is so vague, I did not include palatalization of /s, n/ and /l/ in my data. Note that there is no voiced alveolar stop /d/ in this language.

YONAGUNI

Family: Japonic   Genera: Ryukyuan

ISO 693-3: yoi   Geographical macroarea: Eurasia

Prior typological studies: none

Alternative name: Dunan

phonemic inventory (Izuyama 2012: 413-414)	
coronals	anterior: tʰ, tˀ, d, t͡sˀ, s, (z), n, ɾ posterior: -
vocoids	glide: j, w vowel: i, a, u

In Yonaguni (also known as Dunan), high front vocoids, /j/ and /i/, trigger allophonic coronal palatalization of the preceding sibilants, /t͡sˀ/ and /s/ (Izuyama 414; Yamada et al. 2015: 451). First, a glottalized alveolar affricate /t͡sˀ/ is realized as a palatal [t͡ɕˀ] in this context. For instance, /**t͡sˀ**i/ → [**t͡ɕˀ**i] 'blood' (cf. [t͡sˀa] 'grass' and [t͡sˀuɴ] 'wear'). Second, in the same context where the affricate undergoes palatalization, fricative consonants, /s/ and /z/, are also palatalized into [ɕ, ʑ] respectively. For example, /**s**i/ → [**ɕ**i], /**s**ja/ → [**ɕ**a], and /**z**ja/ → [**ʑ**a] (no gloss is given in Izuyama 2012: 414). Note that the voiced fricative /z/ is marginal phoneme in this language. This sound is only found in a limited number of words. For examples, *zjahi* [ʑahi] 'snake skin, shamisen' and *zjaku* [ʑaku] 'a small fish eaten by bonitos'.

ZOQUE

Family: Mix-Zoque Genera: Mix-Zoque

ISO 693-3: zoc Geographical macroarea: North America

Prior typological studies: Bateman (2007)

phonemic inventory (Wonderly 1951: 105)	
coronals	anterior: t, d, t͡s, s, n, l, ɾ, r posterior: t̠, d̠, t͡ʃ, d͡ʒ, ʃ, ɲ
vocoids	glide: j, w vowel: i, e, a, u, ɯ*, o

* This vowel is unrounded, varying from mid back to high back positions. Wonderly (1951) transcribes this vowel as /ʌ/.

According to Wonderly (1951: 117), when a palatal glide /j/ follows anterior consonants, /t, d, t͡s, s/ and /n/, these anterior consonants are realized as their alveolopalatal counterparts, [t̠, d̠, t͡ʃ, ʃ] and [ɲ] respectively. For example, /wih**t**-jah-u/ → [wih**t̠**ahu] 'they walked', /mjeʔ**t͡s**-jah-u/ → [mjeʔ**t͡ʃ**ahu] 'they sought it', /soh**s**-jah-u/ → [ʃoh**ʃ**ahu] 'they cooked it', /ke**n**-jah-u/ → [ke**ɲ**ahu] 'they looked'. In addition, in Zoque, it seems that the preceding /j/ can trigger coronal palatalization also, by metathesis. For example, /nɯ **j-d**urat͡sɯhk-u/ → /nɯ **dj**urat͡sɯhk-u/ → [nɯ **d̠**urat͡sɯhku] 'it is lasting'.

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국문초록

설정구개음화 및 파찰음화의 음운유형론

본 논문은 설정 자음의 구개음화 및 파찰음화의 횡언어적 양상에 대해서 탐구한다. Hume(1992)의 모음-위치 모형은 설정구개음화와 파찰음화가 서로 다른 음운 현상임을 예측하고 있으나, 선행 유형론 연구(Bateman 2007; Bhat 1978; Hall & Hamann 2006; Kochetov 2011 등)의 결과는 이 두 음운과정이 서로 유사한 속성을 다수 공유함을 제시하고 있다. 그러나 설정구개음화와 설정 파찰음화의 두 현상이 체계적으로 비교된 바가 없기 때문에, 이 둘이 서로 다른 음운현상인지 아닌지 판별하기가 쉽지 않다. 이러한 문제에 대답하기 위해서, 본 연구는 두 음운과정을 그 유형론 및 음성학적 측면에서 별도로 조사하였다. 그 결과는 두 과정이 서로 다른 유형론적 패턴과 음성학적 배경을 가진 별개의 음운과정임을 제시한다.

다음과 같은 네 종류의 언어보편적 함의관계가 총 69개 언어를 대상으로 한 유형론적 조사의 결과로서 도출되었다. 이 가운데 둘은 구개음화와 관련된 것이며, 나머지 둘은 파찰음화와 관련된다. 첫째로, 전설 비고모음류는 전설 고모음류가 구개음화를 일으키지 않는 경우 역시 구개음화를 일으키지 않는다

(촉발모음류의 높이에서의 비대칭). 둘째로, 설측음은 비음이 구개음화를 겪지 않는 경우 역시 구개음화를 겪지 않으며, 비음은 저해음이 구개음화를 겪지 않는 경우 역시 구개음화를 겪지 않는다(대상자음의 조음방식에서의 비대칭). 셋째로, 중설 또는 후설 고모음은 전설 고모음류가 파찰음화를 일으키지 않는 경우 역시 파찰음화를 일으키지 않는다(촉발모음류의 전방성에서의 비대칭). 넷째로, 유성 파열음은 무성 파열음이 파찰음화를 겪지 않는 경우 역시 파찰음화를 겪지 않는다(대상파열음의 유성성에서의 비대칭). 더불어, 본 조사의 결과는 설정구개음화가 전설모음류에 의해서 배타적으로 일어나는 반면, 설정파찰음화는 오로지 고모음류에 의해서 일어남을 보여준다. 설정구개음화와 설정파찰음화가 그 촉발음과 대상음에 있어서 서로 다른 제약들을 가진다는 사실과 이 두 음운과정이 서로 다른 부류의 촉발음을 가진다는 점으로부터, 두 음운과정의 분리는 유형론적으로 지지된다.

설정자음 구개음화 및 파찰음화의 음성학적 배경에 대한 탐구 결과는, 위에서 언급한 유형론적 언어보편성이 청취적 비대칭성과 대응관계를 가진다는 사실을 보여준다. 이 음성학적 탐구에서 이루어진 핵심적인 관찰은 다음과 같다. 먼저, 대상자음은 유관한 대비에 있어서 촉발음일 가능성이 낮은 모음류 앞에서보다 촉발음일 가능성이 높은 모음류 앞에서 청취적으로 분명하지 않다. 다음으로, 대상음일 가능성이 낮은 자음에 비해서 대상음일 가능성이 높은 자음이 역시 관련된 대비에 있어서 청취적으로 보다 분명하지 않다. 특히, 본 연구에서는 구개음화와 관련하여 [전방성] 자질, 그리고 파찰음화와 관련해서는 [치찰성] 자질의 청취도에 관하여 탐색했다. 먼저, [전방성] 자질의 청취도는 주로 전방음과 후방음의 F2 전이가 유사한 정도에 의해 결정된다. 두 자

음은 전설 고모음류 앞에서 전설 비고모음류 앞에서에 비해 보다 유사한 F2 전이를 보인다. 더불어, 전방 저해음과 후방 저해음사이에는 전방 비음과 후방 비음사이에 비해서 F2 전이에서 보다 큰 유사성이 보이며, 전방 비음과 후방 비음사이에는 전방 설측음과 후방 설측음사이에 비해서 역시 F2 전이에서 보다 큰 유사성이 관찰된다. 이러한 음성학적 관찰결과는 전방성에 있어서의 대비가 전설 비고모음류 앞에 비해서 전설 고모음류 앞에서 청취적으로 덜 분명하다는 사실과, 또한 전방성에 있어서의 대비가 저해음 사이에서 비음 사이에 비해 청취적으로 덜 분명하며, 비음 사이에서 설측음 사이에 비해 청취적으로 덜 분명하다는 사실을 제시한다. 이러한 관찰 결과는 앞서 언급한 설정구개음화에서의 언어보편적 함의관계와 상호대응된다. 다음으로, [치찰성] 자질의 청취도는 설정 파열음과 파찰음 사이의 마찰소음 강도 및 길이에서의 유사성에 따라 결정된다. 파열음 파열소음의 강도와 길이는 전설 고모음류 앞에서 중설 혹은 후설 고모음류 앞에서보다 더욱 높고 길며, 따라서 전설 고모음류 앞에서 파열음의 소음구간은 파찰음의 그것과 더욱 유사하다. 또한, 무성 파열음의 소음 강도와 길이는 본질적으로 유성음의 소음 강도와 길이에 견주어서 더욱 높고 길기 때문에, 무성 파열음이 파찰음과 더욱 유사한 소음 강도와 길이를 가진다고 할 수 있다. 이러한 음향적인 속성 때문에, 설정 파열음과 파찰음 사이의 치찰성 대비는 후설 고모음류에 비해서 전설 고모음류 앞에서 청취적으로 덜 분명하며, 또한 무성음 사이에서 유성음 사이에 비해 청취적으로 덜 분명하다. 이러한 관찰결과는 앞서 언급한 설정파찰음화의 언어보편적 함의관계와 대응된다.

본 연구에서는, 관찰된 언어보편적 함의관계와 청취적 비대칭성 사이의 관

편성을 최적성이론(Prince & Smolensky 2004)의 틀 안에서 포착하고자 하는 목적으로, 청취적으로 보다 도드라지는 분절음 및 위치에 대한 충실성제약이 청취적으로 덜 도드라지는 분절음 및 위치에 대한 충실성제약에 비해서 보다 높은 위계를 갖는다는 청취적 사상 가설(P-Map hypothesis; Steriade 2009)에 기반한 분석을 시도한다. 이 분석은 두 음운과정의 유형론적 보편성이 음운론에 대한 음성학 기반의 접근(Hayes, Kichner & Steriade 2004) 아래에서 가장 잘 설명됨을 보여주며, 특히 음운문법의 형성에 있어서 음성 인지의 역할에 대한 추가적인 지지근거를 제시한다(Boersma 1998; Jun 1995, 2004; Steriade 2001, 2009 등).

주요어 설정구개음화, 설정파찰음화, 음운유형론, 음성학기반 음운론, 청취적 사상, 언어보편성

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