CHAPTER 1

CLUSTER PHONOTACTICS AND THE SONORITY SEQUENCING PRINCIPLE

1.1 Introduction

Languages of the world differ in their syllable phonotactics. Some languages are extremely restrictive and only allow CV sequences; others allow more complex structures both in the margins and nuclei. Across languages, segments are organized into well-formed sequences according to universal principles of segment sequencing. The organization of segments within the syllable, and across syllables, is traditionally assumed to be driven by principles of sonority, a property that ranks segments along a hierarchy from most sonorous to least sonorous. A number of strong cross-linguistic tendencies on the distribution and sequencing of segments is explained with reference to the *Sonority Hierarchy*. Principles such as the *Sonority Sequencing Principle*, introduced as early as the 19th century by Sievers (1881), and later by Jespersen (1904), explains, for instance, the tendency, within a syllable, of more sonorous segments to stand closer to the syllable peak than less sonorous ones. *The Minimum Sonority Distance Principle*, introduced by Harris (1983), explains language-specific patterns of consonant clustering by proposing that segments combine on the basis of their relative distance on the sonority scale. Sonority-based principles are not limited to intrasyllabic sequences, the *Syllable Contact Law* (Murray and

Vennemann, 1983), applies to intersyllabic segment sequences. It holds that the preferred contact between two adjacent syllables is when the segment ending the first syllable is higher in sonority than the segment beginning the second syllable.

Although sonority-based principles of segment organization capture the most common patterns found across languages, they, however, are not without exceptions. Clusters that are not predicted by sonority-based generalizations are relatively frequent across languages. As an example, initial s+stop clusters are commonly found across a number of unrelated languages, despite the fact that they constitute violations of the Sonority Sequencing Principle. The main tendency in the phonological tradition has been to account for the occurrence of such violations by means of special syllabification rules or representations, which would make these sequences immune to sonority. The attempt to reconcile the occurrence of sonority violations with sonority-based principles was the main motivation behind these approaches. In this dissertation, I argue that, at least in the case of obstruent clusters, there is no need to stipulate any special rule or representation to justify their immunity to the principles of sonority. I defend the hypothesis that obstruent clusters are not constrained by sonority principles. I show that the generalizations observed can only be explained in sonority-independent terms, which I formalize under Optimality Theory (Prince and Smolensky 1993). Moreover, I argue against the view that the asymmetric behavior shown by certain obstruent clusters in a number of languages is evidence for the special status of such clusters. On the contrary, I show that their different behavior results from the interaction of basic syllable structure constraints as well as independent markedness considerations.

This dissertation has two main goals. One goal is purely empirical and its main purpose is to contribute to the understanding of universal principles of syllable phonotactics and segment patterning. A number of facts about the distribution and co-occurrence restrictions of obstruent clusters that result from a cross-linguistic study are presented and analyzed. The other goal is instead theoretical. From this point of view, the dissertation contributes to the understanding and implementation of the tools available in Optimality Theory by providing an explicit formalization of a technique of analysis, referred to as *The Subset Strategy*. This technique will be used repeatedly to capture the markedness relationships that I argue exist among the different types of obstruent clusters, as well as the implicational universals that follow from the systems of constraints. The dissertation also provides a detailed discussion and implementation of the *Harmonic Bounding Argument*, and addresses other current theoretical issues within Optimality Theory. In particular, I discuss the property of *Strong Harmonic Completeness.* I show how different dimensions of markedness can give rise to *harmonically incomplete* languages in a typology that is itself *strongly harmonically complete*. Finally, the dissertation contributes to the understanding of how phonetics and phonology may interact in the characterization of phonological grammars by showing how a number of constraints which explicitly refer to phonetic facts can contribute to the understanding of phonotactic patterns.

In the rest of this chapter, I will briefly review some of the literature on sonority and sonority-based accounts of segment clustering. I will consider whether certain conclusions reached in previous literature still hold in view of the current framework of Optimality Theory. I will, moreover, provide arguments for why a satisfactory explanation of the well-formedness of the clusters that violate sonority cannot be formulated in sonority-dependent terms.

1.2 Sonority and the Sonority Sequencing Principle

1.2.1 Sonority

Although the notion that segments are ranked along a scale on the basis of their sonority is broadly accepted, the question of what sonority is and how it could be defined still remains a highly controversial issue, both in the phonetic and in the phonological literature. From a phonetic point of view, researchers disagree on whether a single phonetic parameter should be used to define sonority, i.e. perceptual salience or loudness of a particular sound (Ladefoged 1982, 1993); or the amount of airflow in the resonance chamber (Bloch and Trager 1942, Goldsmith 1995); or whether it should be interpreted in terms of multiple phonetic parameters (Ohala and Kawasaki 1984; Ohala 1990; Butt 1992). In the phonological literature the issue revolves, instead, upon whether sonority should be a phonological primitive in the form of a multi-valued feature (Foley 1972;

Hankamer and Aissen 1974; Selkirk 1984), or whether it should be derivable from the more basic binary features of phonological theory (Clements 1990). Another strategy, instead, is not to deal with the nature of sonority itself, but rather derive the relative sonority of each segment on the basis of their occurrence within a syllable. In other words scales are constructed on the basis of the observed patterns of syllable organization in a language specific way (Steriade 1982; Davis 1990).

1.2.2 Sonority Scales

The many different approaches proposed to derive sonority have led to the proposal of a number of competing scales in the literature. The main issue is whether sonority scales are universal, i.e. there is only a single universal scale common to all languages (Selkirk 1984; Clements 1990; Butt 1992); or whether sonority scales are language-specific and languages have a certain degree of freedom in the assignment of sonority values to their segments (Steriade 1982). Sonority scales with fixed universal values mostly refer to the major natural classes of sounds. Finer distinctions among segments are derived by means of sonority-independent parameters, i.e. voicing, coronality etc.. Clements' universal sonority scale, for example, for nonsyllabic segments only consists of the four major natural classes of sounds (obstruents, nasals, liquids and glides) ranked from least sonorous to most sonorous, as in (1) below:

(1) O < N < L < G

Butt's sonority scale differs slightly from Clements' in that he assigns a different value to voiceless and voiced obstruents. His universal sonority scale consists of the following ranking:

(2) Voiceless O < Voiced O < N < L < G < V.

Selkirk (1984) assumes even further distinctions among the obstruents and the liquids and proposes the following universal sonority scale for non-syllabic segments:

(3) p, t, k < b, d, g < f, θ < v, z, ð < s < m, n < l < r

As noted by Steriade (1982), the problem with Selkirk's proposal is that different languages seem to assign contradictory values to the same entries on the scale. Steriade proposes, instead, that languages enjoy a certain level of freedom in the assignment of sonority values to their segments. Clements argues, however, that allowing the sonority scale to vary across languages seriously undermines its explanatory power. Clements writes: "… increasing the number of ways in which the sonority hierarchy can accommodate potential exceptions, will reduce the number of cross-linguistic generalizations that it accounts for". As a matter of fact, both Clements and Butt argue that most of the apparent evidence for language particular variation in the sonority scale comes from observations that can be explained in ways which are sonority independent and should not count in the formulation of the scale (Clements 1990; Butt 1992).

For the purpose of this study, it is crucial that fricatives and stops constitute a single class with respect to sonority. In particular, in Section 2.3, I argue that splitting the obstruents into separate classes with respect to sonority not only does not solve the problem, but actually makes the wrong typological predictions. I moreover argue that the generalizations for obstruent clusters and their patterning across languages must be stated in sonority-independent terms. Sonority not only does not explain the facts observed but makes also the wrong predictions.

1.2.3 The Sonority Sequencing Principle

Despite the lack of agreement on the nature of sonority itself, and the way sonority scales are constructed, its role in deriving some of the most common restrictions on segment sequencing is uncontroversial. One of the most general cross-linguistic patterns of syllable phonotactics is the generalization that in any syllable the segment ranking highest on the sonority scale constitutes the peak of the syllable. All the other segments are organized around the nucleus in such a way that the more sonorous segments are closer to the peak and the less sonorous ones are further away from it. This generalization, known in the literature as the *Sonority Sequencing Principle* (henceforth SSP), was noticed early on by Sievers (1881), Jespersen (1904), Sausurre (1914) and Grammont (1933). More recently, researchers such as Hooper (1976), Kiparsky (1979), Steriade (1982), Selkirk (1982), Clements (1990) have attempted to provide formal characterizations of the SSP.

Although the validity of the SSP in phonological theory is uncontroversial, the existence of clusters that do not conform to the pattern prescribed by the principle undermines its universality within theories in which constraints are not violable. As a matter of fact, given the occurrence of clusters that do not conform to this generalization, the SSP is best characterized as a universal tendency rather than an absolute universal. Within the framework of lexical phonology (Pesetsky 1979; Kiparsky 1982; Mohanan 1982), in which different levels of representations are allowed, the question arises at what linguistic level the SSP holds. Steriade (1982) and Clements (1990), for example, argue that the SSP only holds at the level of core syllabification, i.e. the level where the cyclic or lexical syllabification rules apply. Post-cyclic syllabification rules, in their proposal, are not constrained by relative sonority. More complex clusters are created by later adjunction rules applying at the periphery of the syllabification domain. By restricting the domain of application of the SSP to the level of core syllabification, both authors attempt, in one way or another, to preserve the universality of the SSP at the level where the principle applies.

Within Optimality Theory, the issue of the universality of the SSP does not arise due to the architecture of the framework, as I will show in Section 1.3. Before turning to such a discussion, I will introduce the basic architecture of Optimality Theory with particular attention to some evaluation procedures that will be used in the rest of the dissertation. In particular, I will focus on markedness within OT and introduce a strategy of analysis, that I call the *Subset*

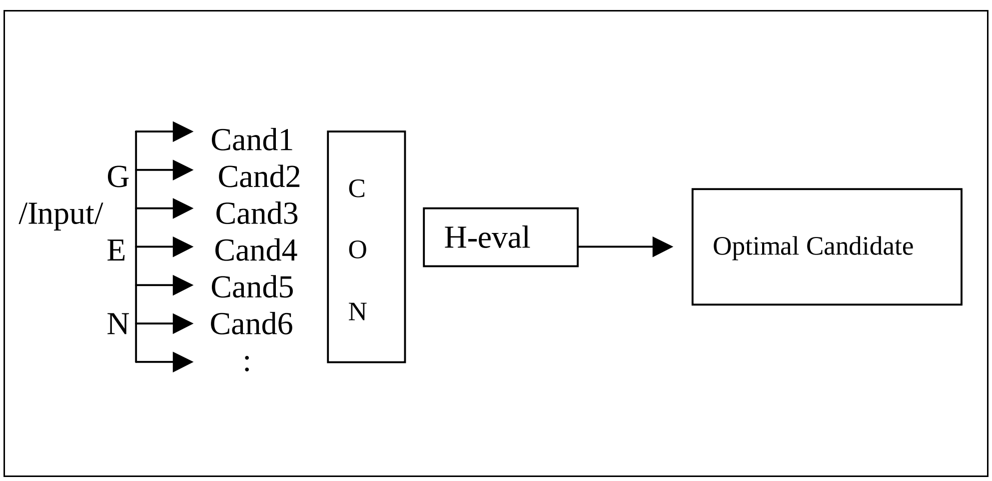
Strategy. This strategy allows to derive markedness relations in the case in which no universal rankings can be determined. Moreover, in Section 1.4 I will provide a discussion of the Sonority Sequencing Principle and its role within a theory such as OT. This section does not contain the core of the proposal, but is rather intended to provide the background for the idea that obstruent clusters are different from other types of clusters and represent a unique phenomenon.

1.3 Optimality Theory

1.3.1 Basic Architecture

Optimality Theory (Prince and Smolensky 1993) is a theory of violable, universal constraints and their interaction. The basic architecture of OT can be represented in the following diagram adapted from Smolensky (1995):

(4) Architecture of Optimality Theory



Given an input, **Gen** produces an infinite number of possible output candidates, which are evaluated for harmony against **Con**, i.e. the set of violable universal constraints ranked on a language particular basis. The candidate that best satisfies the constraint system of the language in question is selected as the optimal surface form by **H-eval**. **H-eval** is a function that evaluates the violations incurred by the candidates and selects the most harmonic candidate on the basis of constraint violations. The most harmonic candidate corresponds to the candidate that best satisfies the constraint hierarchy. Best satisfaction of a constraint system is determined on the basis of satisfaction of higher ranked constraints at the expenses of violations of lower ranked constraints.

1.3.2 Markedness as Harmony

Built within the basic architecture of OT is a formal theory of markedness. Markedness corresponds to dis-harmony, and markedness relations among forms are expressed in terms of harmonic orderings of forms. Determining harmonic orderings consists in establishing the relative harmony of each output candidate on the basis of its constraint violations. In the case of single binary constraints, harmony evaluation of candidates consists in determining whether a candidate violates a given constraint or not. Since marks are by definition anti-harmonic, it follows that a candidate α that satisfies a constraint C is more harmonic (or unmarked with respect to C), than a candidate β that violates it (which is therefore marked with respect to C). The harmonic ordering, or markedness relationship between candidates α and β is expressed as $\alpha \succ \beta$, where "$\succ$" means "more harmonic than". Harmonic ordering evaluation by a single binary constraint is shown in the tableau below:

(5) $\alpha \succ \beta$ with respect to C

	C
a. α	
b. β	*

Prince and Smolensky (1993) show that more complex cases of candidate evaluation by single non-binary constraints or entire constraint systems in domination hierarchies are reducible to the simple case of single binary constraints. This is because of the evaluation strategy that cancels common marks and evaluates candidates on the basis of the unshared marks. This strategy is called the *Cancellation Lemma* and is defined in Prince and Smolensky (1993) as follows:

(6) *Cancellation Lemma*

Suppose two structures S_1 and S_2 both incur the same mark *m. Then to determine whether $S_1 \succ S_2$, we can omit *m from the list of marks of both S_1 and S_2 ('cancel the common mark') and compare S_1 and S_2 solely on the basis of the remaining marks. Applied iteratively, this means we can cancel *all* common marks and assess S_1 and S_2 by comparing only their unshared marks.

The procedure is illustrated in tableau (7), where C' stands for a gradient constraint, i.e. a constraint that assigns multiple violations to candidates. Shared violations are included in square brackets:

(7) $\alpha \succ \beta$ with respect to C'

	C'
a. α	[**]
b. β	[**] *

In this case, $\alpha \succ \beta$ with respect to the non-binary constraint C' because after deleting all the common marks, β contains a mark than α does not contain. In other words, β contains a proper superset of the marks of α.

In the case of constraints in a strict dominance hierarchy, harmonic orderings are established on the basis of minimal violation of constraints. This means that violation of less dominant constraints is more harmonic than violation of more dominant constraints. In a constraint hierarchy where C >> B (A dominates B), and the marks assigned to candidates α and β are not identical, i.e. not shared, then the candidate with the violation of the lowest ranked constraint is the most harmonic in the ordering. A simple case of constraint dominance is illustrated in tableau (8) below:

(8) $\alpha \succ \beta$ with respect to C >> B

	C	B
a. α		*
b. β	*	

Candidate α is more harmonic, i.e. less marked, than β because it best satisfies the hierarchy C >> B due to its minimal violation of a lower ranked constraint. If, however, α also violates constraint C, then α and β incur identical marks with respect to C. Thus, by the *Cancellation Lemma*, harmony evaluation is determined solely on the basis of the marks of the lower ranked constraint B, as the following tableau shows:

(9) $\alpha \prec \beta$ with respect to C >> B

	C	B
a. α	[*]	*
b. β	[*]	

In (9) α is less harmonic (we use the symbol "$\prec$") than β, because α contains a violation of B that β does not contain. By canceling the common marks assigned by C, candidates α and β are evaluated by the single binary constraint B, which is only violated by α. Note, however, that if the constraints are ranked in such a way that B >> C, β is still more harmonic than α, since α violates the dominant constraint B. The violations assigned by C are no longer relevant in assessing the relative harmonies of α and β due to the principle of constraint dominance by which constraints higher in the hierarchy have absolute priority over constraints lower in the hierarchy. This situation is illustrated in tableau (10) below:

(10) $\alpha \prec \beta$ with respect to B >> C

	B	C
a. α	*	*
b. β		*

The fact that in (9) and (10), the ranking of the constraints does not matter in evaluating the relative harmony of these two candidates, is because constraints B and C stand in a *stringency relationship* (Prince 1997). Two constraints are in a stringency relationship when they are in a special to general relationship and they disagree on some candidate set, but not conflict, with the general assigning a proper superset of the marks assigned by the specific constraint. In tableaux (9) and (10), candidate β contains a proper subset of the violations of α, which results in β being more harmonic than α by the basic evaluation procedure of Optimality Theory, i.e. the *Cancellation/Domination Lemma*, which includes both the *Cancellation Lemma* and the principle of constraint dominance (Prince and Smolensky, 1993). The lemma is formulated as follows:

(11) *Cancellation/Domination Lemma*

In order to show that one parse B is more harmonic than a competitor A which does not incur an identical set of marks, it suffices to show that every mark incurred by B is either (i) cancelled by an identical mark incurred by A, or (ii) dominated by a higher-ranking mark incurred by A. That is, for every constraint violated by the more harmonic form B, the losing competitor A either (i) matches the violations exactly, or (ii) violates a constraint ranked higher.

Implicit in the *Cancellation Lemma* is a strategy to formalize universal markedness relationships among forms. This strategy does not derive universal markedness relations through fixed universal rankings, as in the case of the place hierarchy in Prince and Smolensky (1993), where the unmarkedness of the place coronal follows from the fixed ranking in (12):

(12) *PL/Lab, *PL/Dor >> *PL/Cor.

On the contrary, candidates are evaluated against sets of constraints that are in a stringency relationship. Harmonic orderings of forms are hence established only on the basis of the *Cancellation Lemma,* which involves elimination of the shared marks and evaluation on the basis of the unshared ones. I will call this strategy of analysis to determine universal harmonic orderings the *Subset Strategy*[1] and give it the following formal definition:

(13) $S_1 \prec_{UG} S_2$ iff the marks of $S_2 \subset$ marks of S_1.
A Structure S_1 is universally less harmonic, and hence more marked, than a Structure S_2 if and only if the list of marks assigned to S_2 is a proper subset of the list of marks assigned to S_1.

In other words, the set of marks assigned to S_1 contains all of the marks assigned to S_2 plus one extra mark, which is not assigned to S_2. A simple example of this strategy can be constructed to evaluate and determine the markedness relationship between a VC structure and a VCC structure. A VCC structure is assumed to be

[1] See the Method of Universal Tableau in Prince and Smolensky (1993) for an illustration of universal rather than language-particular constraint interactions.

more marked than a VC structure. In OT terms, this relationship is expressed as the following harmonic ordering:

(14) VC $\succ$ VCC

The ordering in (14) can be easily characterized by evaluating the two structures against the relevant constraints on syllable structure, i.e. NOCODA, which bans syllable codas, and *COMPLEX, which bans complex structures. Tableau (15) below demonstrates the harmonic ordering between the two structures.

(15)

	NOCODA	*COMPLEX
a. VC	*	
b. VCC	*	*

As (15) shows, candidate (a), i.e. the VC structure, is universally less marked, and hence more harmonic than a structure VCC, because it contains a proper subset of the marks that VCC contains. Thus the universal markedness relationship between these two syllable structures follows directly from simple comparison of shared and unshared marks, rather than priority of marks derived via fixed rankings.

1.3.3 Implicational Universals

A theory of markedness constructed in this way, together with the basic architecture of Optimality Theory, that centers around constraint interaction as an explanatory method of analysis, makes it possible to provide a formal characterization of Implicational Universals.

Implicational universals are involved in many typological generalizations and specify that the presence of one structure in a language's inventory implies the presence of another structure but not vice-versa. Implicational universals of this type are often explained in terms of markedness, in the sense that a marked structure is found in a language only if its unmarked counterpart also occurs. However, markedness relations are established on the basis of the implicational universal observed, thus giving rise to a problem of circularity.

In Optimality Theory implicational universals follow directly from the architecture of the theory. Prince and Smolensky (1993) characterize implicational universals as follows:

(16) An *implicational universal* of the form 'ψ in an inventory implies φ in the inventory' holds if, for every possible grammar in which there is some input whose optimal parse includes ψ, there is an input whose optimal parse in that same grammar includes φ.

They further formulate the following general strategy to establish implicational universals:

(17) General Strategy for Establishing Implicational Universals $\psi \Rightarrow \varphi$

> If a configuration ψ is in the inventory of a grammar G, then there must be some input I_{ψ} such that ψ appears in the corresponding output, which, being the optimal parse, must be more harmonic than all competitors. Consideration of some

competitors shows that this can only happen if the constraint hierarchy defining the grammar G meets certain domination conditions. These conditions entail - typically by dint of universal dominations - that an output parse containing φ (for some input I_φ) is also optimal.

To clarify how implicational universals are derived in OT, consider the two forms VC and VCC. A syllable of the type VCC violates both NOCODA and *COMPLEX. Admitting VCC into the syllable's inventory of the language implies that Faithfulness dominates both NOCODA and *COMPLEX, as shown in tableau (18)

(18)

/VCC/	Faithfulness	*COMPLEX	NOCODA
a. ☞ VCC		*	*
b. VC	*!		*

However, the sub-ranking Faithfulness >> NOCODA implies that also VC structures are part of the language's inventory, as shown in tableau (19) below:

(19)

/VC/	Faithfulness	NOCODA
a. ☞ VC		*
b. V	*!	
c. V.CV	*!	

As a matter of fact, if NOCODA dominated Faithfulness, codas would not be possible in the language at all as the following tableau shows:

(20)

/VCC/	NOCODA	Faithfulness	*COMPLEX
a. VC	*!		
b. VCC	*!		*
c. ☞ V		*	

Admitting complex codas, therefore, implies admitting simple codas as well. Given these entailment considerations, no ranking of these constraints will ever give a language in which complex codas, but not simple codas, are admitted. The technique illustrated above is called the *Technique of Necessary and Sufficient Conditions*[2] and will be used in the rest of the dissertation to derive the implicational universals holding for clusters.

After having laid out the theory of markedness in OT and the procedures of analysis used in the rest of this dissertation, I turn to a discussion of the Sonority Sequencing Principle within Optimality Theory. The next section is intended as a background to the phenomenon that I will focus on in the rest of the dissertation, i.e. obstruent clusters. Although this dissertation is not about the Sonority Sequencing Principle, a discussion of the basic assumptions that I make about cluster phonotactics in general is necessary in order to understand why obstruent clusters are a unique phenomenon.

[2] This technique is discussed in footnote 72 of Prince and Smolensky (1993) and is also used in Legendre, Raymond & Smolensky (1993).

1.4 Background Assumptions

For reasons that will be discussed in Chapter 2, I assume a universal sonority scale such as the one in Clements (1990), which only refers to the major classes of segments (O < N < L < G). Under this scale, two-member clusters are classified as in diagram (21). For each column, the sequence on the left of the comma indicates an onset cluster, whereas the one on the right indicates a coda cluster.

(21)

a. Core Clusters	*b. Sonority Reversals*	*c. Sonority Plateaus*
OG, GO	GO, OG	GG
OL, LO	LO, OL	LL
ON, NO	NO, ON	NN
LG, GL	GL, LG	OO
NG, GN	GN, NG	
NL, LN	LN, LN	

All the clusters in (21a) are classified as core clusters because they show a decrease in sonority towards the syllable margins and thus follow the SSP. The clusters in (21b) are, instead, classified as reversals because the most sonorous segment occurs closer to the syllable margin than to the syllable peak. The clusters in (21c) instead constitute plateaus since there is no difference in sonority between the members of the clusters.

Clements (1990) proposes to evaluate the relative complexity of the clusters listed in (21a), i.e. the core clusters or unmarked clusters, in terms of the *Dispersion Principle*. The Dispersion Principle is an evaluation metric that determines the relative complexity of syllable types on the basis of their degree of distance from the optimal syllable, i.e. a syllable with the maximal and most evenly-distributed rise in sonority at the beginning and the minimal drop in sonority at the end. He also suggests that the relative complexity of reversals and plateaus may be calculated proportionally to their distance from the unmarked syllables. In his view, sonority reversals are more complex than sonority plateaus and the complexity of sonority reversals increases in proportion to the extent of the reversal.

Whereas Clements' formalism represents one of the most insightful approaches to the more unmarked phonotactics, it leaves some of the marked phonotactics unexplained. Due to the fact that both core clusters and sonority reversals involve a difference in sonority among the members of the clusters, it seems reasonable to assume that Clements' complexity metric, or an extension of it, could be an adequate method of evaluation for both core clusters as well as reversals[3]. However, in the case of plateaus, which do not involve a rise or fall in sonority between the members of the cluster, the distance in sonority between the two members is equal to zero. In Clements' complexity metric, a zero sonority distance means that these clusters are infinitely bad with respect to sonority, but it does not shed any light on the relative complexity within the set of obstruent clusters themselves. I propose, therefore, that whereas the relative well-

[3] For an OT derivation of Clements' complexity metric for unmarked syllable types see Smolensky (1995) and Hironymous (1999)

formedness of core clusters and sonority reversals may be evaluated in terms of sonority by means of the same evaluation procedure, sonority plateaus are different. They need to be explained in sonority-independent terms, because there is no sonority difference between the members of the clusters. The difference must therefore be derived by means of some other parameter. Part of this dissertation is, therefore, devoted to try to fill the gap in the theoretical machinery and provide a formalism to evaluate the relative well-formedness of sonority plateaus.

In this dissertation I focus on obstruent clusters. Obstruent clusters constitute an intriguing phenomenon because of their complex phonotactics. Moreover, the fact that, in a number of languages, obstruent clusters behave differently than core clusters with respect to phonological processes such as syllabification or reduplication, raises the question of what it is that drives such a phenomenon.

1.5 The Sonority Sequencing Principle and Optimality Theory

I formulate the Sonority Sequencing Principle as a positive markedness constraint defining the preferred order of segments within the syllable in the following way:

(22) Sonority Sequencing Principle (SSP)

Sonority increases towards the syllable peak and decreases towards the syllable margins

Within Optimality Theory, the universality of the SSP and its violability is resolved given the premise that in OT all constraints are in principle violable. OT grammars are constructed in terms of violable constraints and surface patterns are derived via constraint interaction between two basic types of constraints, markedness and faithfulness constraints. Violations of the SSP result from the fact that the SSP, a markedness constraint, is dominated by a faithfulness constraint that requires preservation of input clusters, as I show later. The SSP is therefore not an absolute universal. Absolute universals correspond formally to constraints that are never dominated and therefore never violated.

Moreover, in Optimality Theory, there is only one possible level at which the SSP holds, the level of the output. Unlike lexical phonology which recognized multiple levels of derivation, there are only two levels of representation in OT, the input and the output level, and constraints are stated over output forms only, never on inputs.

Candidates are evaluated for harmony with respect to the SSP following the procedures outlined in the previous section. Evaluation of possible clusters with respect to the single constraint SSP is given in tableau (23) below:

(23)

	SSP
a. trV	
b. rtV	*
c. stV	*

Candidate (a) is an example of an onset cluster obeying sonority generalizations. Both (b) and (c) are examples of clusters that violate sonority generalizations. In particular, in candidate (b), the least sonorous segment in the cluster occurs closer to the syllable peak than the most sonorous one. This is an example of a sonority reversal. Candidate (c) is, instead, an example of a sonority plateau, i.e. a cluster in which there is no difference in sonority between the members of the cluster, under the assumption that fricatives and stops form a single class with respect to sonority. Basically, the SSP constraint in an OT grammar has the same role as Clements' version of the SSP, i.e. the Core Syllabification Principle. It classifies clusters into two types, those that conform to the SSP and those that violate it. Formally, candidate (a) is the most harmonic with respect to the SSP constraint because it does not contain the mark that both candidates (b) and (c) contain. In markedness terms, this means that core clusters are the unmarked cluster types, i.e. they satisfy the SSP, and both sonority plateaus and reversals are instead marked with respect to the SSP constraint because they violate it.

The cross-linguistic fact that implicational universals[4] hold between core clusters and clusters that violate the SSP is captured directly from the interaction of Faithfulness with the SSP. If the SSP dominates Faithfulness, only core

[4] Steriade (1994) argues that clusters of the form s+stop, which are analyzed as plateaus in this dissertation, can actually occur in languages independently of core clusters. In the languages that I surveyed, languages that allow s+stop clusters also allow s+sonorant as in the case of Misantla Totonac (MacKay 1994) or Chiquihuitlan Mazateco (Jamieson 1977; Steriade 1994). I will therefore assume that the occurrence of plateaus and reversals is, in fact, dependent on the occurrence of core clusters.

clusters are allowed to surface because they are the only ones that satisfy the dominant SSP. This is shown in the following tableaux:

(24)

/trV/	SSP	Faithfulness
a. ☞ trV		
b. rtV	*!	*

In tableau (24), an input containing a core cluster surfaces, despite low ranking faithfulness, because it satisfies the dominant SSP. This ranking only allows core clusters to surface in a grammar. An input of the form /rtV/, which is not a core cluster, will never be able to surface faithfully because of the violation of higher ranked SSP, as illustrated in (25) below.

(25)

/rtV/	SSP	Faithfulness
a. ☞ trV		*
b. rtV	*!	

For an input of the form /rtV/ to surface it is necessary that Faithfulness dominate the SSP, as shown in (26):

(26)

/rtV/	Faithfulness	SSP
a. trV	*!	
b. ☞ rtV		*

In the same grammar, an input with a core cluster /trV/ surfaces faithfully as well as well, as in (27)

(27)

/trV/	Faithfulness	SSP
a. rtV	*!	*
b. ☞ trV		

The implicational universal of the type formulated in Greenberg (1978) which states that clusters violating the SSP always imply the presence of core clusters follows directly from the constraint rankings. If Faithfulness dominates the SSP then both types of clusters are allowed to surface. If the SSP dominates Faithfulness only core clusters are allowed to surface because they are the only harmonic clusters with respect to the markedness constraint SSP.

The SSP constraint, as stated, can only evaluate whether a cluster is well-formed or ill-formed with respect to the sonority generalization expressed by the constraint. The constraint, however, does not say anything about the relative harmony of the various core clusters, nor can it distinguish between the two types of violations that candidates (b) and (c) represent in tableau (23). A system that only consisted of the SSP constraint would not be able to distinguish plateau violations from reversal violations. Moreover, such a system would imply that grammars either disallow or admit any type of sonority violations. This is not a good result, because certain violations are more common than others, and the presence of one type of violation does not necessarily imply the presence of the other type. For this reason, I believe that the SSP can be best understood as a portmanteau constraint for a whole family of phonotactic constraints. As a first attempt, I will assume that the SSP is actually two separate constraints, which are most likely portmanteau constraints themselves. The two constraints are formulated as negative markedness constraints and, in their simplest form, they ban plateaus and reversals as follows:

(28) ***Plateau**

Sonority plateaus are disallowed

(29) ***Reversal**

Sonority reversals are disallowed

This system of constraints can now formally distinguish the three types of clusters on the basis of their constraint violations, as shown in the following tableau:

(30)

	*Reversal	*Plateau
a. trV		
b. rtV	*	
c. stV		*

Tableau (30) demonstrates the unmarkedness of core clusters, as opposed to the markedness of sonority violations. Sonority plateaus and reversals are less harmonic than core clusters due to their violations of the sonority constraints. Candidate (b), a sonority reversal and candidate (c), a sonority plateau, both contain marks that are not included in the set of the marks assigned to candidate (a), a core cluster. This latter has no marks at all.

The system of constraints proposed for the characterization of cluster phonotactics, claims no markedness relationship between plateaus and reversals. This is captured in the fact that the two candidates violate different constraints. The cluster representing a sonority reversal violates *Reversal, whereas the candidate representing sonority plateaus violates *Plateau. Since the two candidates do not share violations with respect to these two constraints, no universal harmonic orderings are established for the two types of clusters. Consequently, no markedness relationships are established between the two types. Implications exist between core clusters and either plateaus or reversals. These implicational universals follow from the fact that admitting either cluster type in a language will always involve also admitting the more harmonic clusters. Since the candidate containing a core cluster is unmarked with respect to all of the markedness constraints in this system, no matter where faithfulness is ranked, an input containing such a cluster will always surface, regardless of the ranking. For either sonority plateaus or reversals to be admitted in a language, it is necessary that Faithfulness dominates *Plateau or *Reversal, respectively. The rankings Faith >> *Plateau and Faith >> *Reversal do not imply each other and, therefore, no implications between the two types of clusters exist.

1.6 Summary of the chapter.

In this chapter, I have presented an overview of the main issues related to the theory of sonority. I have addressed one of the most basic problems in syllable phonotactics, i.e. the problem of obstruent clusters and their relation to sonority-based generalizations. I have argued that, given the fact that sonority does not distinguish among these clusters, an insightful understanding of the relevant phonotactics can only be gained by searching for an explanation of their behavior outside of sonority.

In this chapter, I have also presented a discussion of some of the tools that will be used in the analysis, and in particular I have provided a formal characterization of a strategy of analysis that will be used extensively in the rest of the dissertation, i.e. the *Subset Strategy*.

Finally, this chapter has provided an extensive discussion of the Sonority Sequencing Principle and addressed some of the problems that such a principle raises in phonological theories in which constraints are not violable.