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Markedness Relations and Implicational Universals in the Typology of Onset Obstruent Clusters[1]

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0. Introduction

Languages of the world differ in the structure of their onsets. Some languages only allow simple onsets, whereas others allow consonants clusters in onsets with different degrees of complexity. Among the languages which show complex onsets, some strictly obey the Sonority Sequencing Principle (SSP), (Hooper 1976; Kiparsky 1979; Steriade 1982; Selkirk 1984; Clements 1990 and Zec 1995 among others), and allow only core clusters, i.e. clusters that rise in sonority toward the syllable peak; others, instead, also allow clusters that do not conform to the SSP generalizations. Clusters containing two adjacent tautosyllabic consonants with the same sonority rank (sonority plateaus) or clusters in which the least sonorous segment is closer to the peak than the more sonorous one (sonority reversals) are considered violators of the SSP. Among the violators, clusters of the type "s+Stop" are quite common across languages, regardless of the fact that the SSP does not recognize them among the preferred sequences.

In this paper I will focus on onset clusters consisting of two obstruents and argue that clusters that contain a fricative followed by a stop (FS)[2], of which "s+Stop" clusters are a subset, are to be considered the unmarked case for obstruent clusters. I show that implicational universals and consequently markedness relations exist among the different types of obstruent clusters. I farther show that Optimality Theory (Prince and

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[2] Note that the account provided in this paper abstracts away from place issues and is only based on manner considerations. Such a level of abstraction seems necessary in order to capture the fundamental universal generalizations about obstruent clusters at the level where the distinction between stops and fricatives is relevant.

Smolensky, 1993, henceforth P&S) provides the tools for a correct analysis of the facts. I propose that the shape of these clusters in the individual grammars as well as their cross-linguistic generalizations are regulated by a set of structural constraints stated over the feature [continuant] which interact with Faithfulness.

The paper is organized as follows. In section 1 I present the generalizations which emerge from a cross-linguistic study of the patterns of occurrence of obstruent clusters in onsets. In section 2 I argue that the SSP is not responsible for the construction of these clusters because it fails to account for the facts observed in the typology. In section 3 I provide an optimality theoretical account of the markedness relations among the different clusters by evaluating the latter against a set of structural constraints. In section 4 I provide the different constraint rankings that will define the different typological grammars and show that the implicational universals observed in the typology follow directly from entailment considerations on the rankings established to admit the relevant clusters in the inventories of the typological grammars.

1. The Typology of Onset Obstruent Clusters

In what follows, a universal typology of onset obstruent clusters is given. The typology is limited to sequences of length two in monomorphemic words, given the fact that sequences of more than two obstruents are extremely rare and it is unclear whether implicational universals similar to the ones formulated for sequences of length two could be formulated (Greenberg 1978). The universal typology is based on a survey of about 25 languages. The languages belong to different language families and have mostly been selected according to the implicational universals of fricative and stop combinations in initial position formulated in Greenberg (1978). Greenberg includes also affricates in his universals. He counts them as sequences of a stop and a fricative, thus on a par with the other obstruent clusters. Unlike Greenberg, and following Sagey (1986) and Lombardi (1990), I consider affricates as a single unit with two value specifications for the feature [continuant], rather than as a combination of two distinct segments that form a sequence of a stop and a fricative. Under this view, affricates do not form clusters of their own, but can be one of the members of an obstruent cluster. The generalizations presented here are based on true clusters only and will therefore slightly differ from the ones proposed in Greenberg.

There are four possible logical ways in which fricatives (F) and stops (S) can cluster in the world's languages. Two-obstruent clusters can either consist of a fricative and a stop in either order, or of a sequence of two fricative segments or two stops. Some representative examples are given below:

- FS (e.g. English /στ/, Havasupai /θπ/, Haida /ℜκ/, German /Στ/)
- SF (e.g. Wichita /κσ/, Paipai /πξ/)
- FF (e.g. Italian /σφ/ , Nisqually /σχ/)
- SS (e.g. Khasi /pt/, Georgian /τэπH/)

All four possible clusters are attested, meaning that none of them is absent from the universal inventory. However, there is only a limited number of ways in which these clusters can either occur in isolation or co-occur in the world's languages. Out of the 15 possible ways in which inventories of onset obstruent clusters of length two can be constructed, only six ways are attested to occur across languages. The following table shows the six different language types and the clusters allowed for each type.

(1)

	FS	SF	SS	FF
Type 1	✓			
Type 2	✓			✓
Type 3	✓	✓		
Type 4	✓	✓		✓
Type 5	✓	✓	✓	
Type 6	✓	✓	✓	✓

Languages of *Type 1* only allow fricatives in initial position and only stops as the second member of the cluster. *Type 1* languages are English (Kenstowicz 1994), Haida (Swanton 1910; Sapir 1922), Havasupai (Seiden 1963; Hinton 1984), Hindi (Nagamma Reddy 1987), Isthmus Zapotec (Marlett and Pickett 1987), Mazateco (Pike and Pike 1947; Steriade 1994), Mislanta Totonac (MacKay 1994), Telugu (Nagamma Reddy 1987) and Yuchi (Wolff 1948; Crawford 1973). *Type 2* languages allow both stops and fricatives to follow an initial fricative. Dutch (De Schutter 1994) and Italian (Nespor 1993) belong to this class of languages. The languages of *Type 3* allow both fricative and stop combinations in either order. No combinations of two fricatives or two stops are allowed. *Type 3* languages are Modern Demotic Greek (Joseph and Philippaki-Warburton 1987) and Wichita (Rood 1975). *Type 4* languages allow combinations of fricatives and stops in either order, and sequences of two fricatives as well. There are no clusters containing two adjacent stops. Nisqually (Hoard 1978), Paipai (Joel 1966; Wares 1968) and Pashto (Penzl 1955) belong to this group of languages. Unlike languages of *Type 4*, *Type 5* languages only disallow a sequence of two adjacent fricatives. Fricatives and stops can combine freely without any restriction on the order of occurrence. *Type 5* languages are Aguatec Mayan (McArthur 1956), Attic Greek (Steriade 1982), Dakota (Boas and Deloria 1976) and Khasi (Henderson 1976). Finally languages of *Type 6* allow all four logical possibilities. There are no restrictions on the relative order of combinations of fricatives and stops as well as on sequences of segments belonging to the same natural class. Georgian (Vogt 1971; Deprez 1988; Chitoran 1994), Seri (Marlett 1981, 1988), Serbo-Croatian (Hodge 1946), Tsou (Wright 1996) and Yateé Zapotec (Jaeger and Van Valin 1982) belong to this group of languages.

The typology presented above shows that languages which only allow one type of combination always allow a sequence containing a fricative and a stop. For most of the languages of this type, such a sequence is restricted to the segment "s" followed by a stop. A cluster of the form FS is the only cluster that can occur in isolation, it is always present and the presence of other types of combinations always implies its presence. The presence of a sequence of two fricatives always implies the presence of FS sequences, but it seems to be independent of the other two types of clusters, i.e. SF and SS. However, the presence of SF clusters does imply the presence of FS, but does not imply the presence of either FF or SS. SS sequences imply the presence of SF sequences, and consequently the presence of FS clusters. There seems to be no implicational relation between FF and SS clusters, as well as between FF and SF clusters. The implications observed are schematized in diagram (2):

(2)
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          SS
          ⇓
          SF
          ⇓
    FF ⇒ FS
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In figure (2), implications are shown to exist between SS and SF, SF and FS and by transitivity SS and FS. Assuming implications as a means to determine markedness, the following markedness relations are established

(3)
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FS → FF
↓
SF
↓
SS
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Diagram (3) shows the markedness relations among the four types of clusters, with FS being the least marked and SS being the most marked given the fact that its presence not only implies the presence of FS clusters but also the presence of SF clusters. The diagram also shows no relations between FF clusters and SF or SS clusters. The existence of markedness relations as well as implicational universals suggests that any analysis of this kind of clusters must be able to provide a principled account of both issues.

In the following section I will provide a brief discussion of the Sonority Sequencing Principle and argue that such principle is not relevant to obstruent clusters since it fails to account for both the markedness relations and the implicational universals observed for onset obstruent clusters. Other researchers (Kiparsky 1979, 1981; Fujimura and Lovins 1978; Halle and Vergnaud 1980; Selkirk 1982; Steriade 1982; Clements and Keyser 1983; Borowsky 1986; Michelson 1988; Milliken 1988; Clements 1988, 1990 among others) have implicitly or explicitly recognized the fact that an account of such clusters must be found outside sonority. However, most analyses have attempted to explain only language specific phenomena, without recognizing that the whole phenomenon of obstruent clusters makes up a universal of its own.

2. The Sonority Sequencing Principle and the typology

The *Sonority Sequencing Principle* (Whitney 1865; Sievers 1881; Jespersen 1904; Saussure 1914; Grammont 1933; Hooper 1976; Kiparsky 1979; Steriade 1982; Selkirk 1984; Clements 1988, 1990 and references cited there) governs the preferred order of segments within the syllable. The principle states that segments can be ranked along a sonority scale. Segments with a higher sonority rank stand closer to the syllable peak, whereas segments with a lower sonority rank stand closer to the syllable margin. Although there is widespread agreement on the validity of the principle in phonological theory, there is much less agreement on which phonological features should be used to define sonority. Researchers disagree on whether only the 4 major natural classes of sounds (obstruents, nasals, liquids and glides) should be ranked along the scale or whether finer distinctions should be made when constructing a scale. Most controversial, among others, is whether obstruents should constitute a single class with respect to sonority (Greenberg 1978; Clements 1988, 1990; Zec 1995) or whether they should be divided into stops and fricatives (Selkirk 1984 and Steriade 1982 among others), and be assigned different sonority ranks. In what follows I will argue that sonority cannot explain the facts observed in the typology, thus suggesting that sonority is not responsible for the construction of obstruent clusters. A scale which does not distinguish between fricatives and stops is therefore to be preferred over one which does, because it recognizes that the locus of explanation for obstruent clusters must lie somewhere else.

Let us first consider a scale in which obstruents are broken down into stops and fricatives, with stops being less sonorous than fricatives as commonly assumed:

(4) F > S

Given this scale, the SSP would predict the well-formedness of SF clusters and the ill-formedness of FS clusters with respect to sonority. This basically means that clusters such as s+Stop should not be the most common type of obstruent clusters. Stop+s should instead be the preferred obstruent cluster type. According to this scale, SF clusters would be unmarked with respect to sonority, since they rise in sonority towards the syllable peak and do not violate the SSP. Thus we would expect to find both languages with only SF clusters, as well as languages where the following implication holds:

(5) FS ⇒ SF
If a language has FS clusters, then it has SF clusters.

However, as the typology shows, there are no languages which behave in this way. On the contrary, FS clusters, but not SF clusters, can be found in isolation, and SF always implies the presence of FS, thus making (5) false. FS and not SF is the unmarked cluster type, which is to be expected given the fact that FS clusters, and in particular s+Stop clusters, are extremely common across languages, more common than SF clusters. A scale which assigns a higher sonority rank to fricatives is, therefore, highly problematic for an account of the typology of onset obstruent clusters and its implicational universals.

Let us explore now the possibility of a scale opposite to (5), i.e. a scale in which stops are more sonorous than fricatives:

(6) S > F

The typology presented in this paper would motivate such a scale, since it would allow us to predict some of the generalizations observed. In other words, under this scale the existence of languages with only FS clusters, but not SF, as well as the implication SF ⇒ FS, would be completely predictable. However, such a scale would still be unable to explain other facts about obstruent clusters. In particular, this scale would be unable to explain the implications FF ⇒ FS and SS ⇒ SF.

Sonority cannot therefore be invoked to exhaustively account for the generalizations which emerge from the typology of obstruent clusters. In what follows, I will show how the interleaving of structural constraints stated over the feature [continuant] with Faithfulness within the framework of Optimality Theory (P&S) makes possible a principled account of both the markedness relations as well as the implicational universals that emerge from the typology.

3. Markedness relations or Relative Harmony

In OT markedness equals "harmony" and must be understood in a precise and formal sense. A form is marked with respect to some constraint C if it violates it, and hence receives a mark. The form is unmarked with respect to that constraint if it does not violate it, and therefore does not receive any marks. Establishing markedness relations among forms means comparing the relative harmony of forms with respect to some constraint or constraint system. Universally more marked structures are structures that are less harmonic than less marked ones. In this paper, markedness relations among the different clusters are established by comparing the sets of marks assigned to each form on the basis of the following strategy for relative harmony evaluation:

(7) $S_1 \succ S_2$ iff the marks of $S_2 \subset$ marks of S_1.
A Structure S_1 is 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 list 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.

The markedness relations schematized in (4) therefore directly translate to the following harmonic orderings:

(8) a. FS $\succ$ FF
b. FS $\succ$SF $\succ$SS

To establish the orderings in (8), I propose the following set of structural constraints:

(9) OCP[-cont]
Tautosyllabic [-continuant] segments are disallowed.

(10) OCP[+cont]
Tautosyllabic [+continuant] segments are disallowed

Constraints (9) and (10) are two separate OCP constraints (Leben 1973; Goldsmith 1979; McCarthy 1986; Yip 1988; Odden 1988). They are formulated over each value of the feature [continuant] and state, respectively, that SS or FF sequences are disallowed.

(11) *SO
A tautosyllabic sequence containing a stop followed by any obstruent is disallowed.

This is a negative constraint, which disallows tautosyllabic sequences of a stop and any obstruent, either a fricative or a stop. It is justified both phonetically and phonologically. Phonetically it reflects the preference for stops to be released into more sonorous segments. Phonologically it allows to assign SS clusters a proper superset of the marks assigned to SF clusters and thus derive the ordering SF $\succ$ SS.

The relative harmony of the four different types of obstruent clusters is obtained by evaluating them against the three structural constraints given above. Evaluation of the different obstruent clusters is given in tableau (12). The three structural constraints are universally unranked with respect to each other and the relative harmony of the different clusters is obtained via the strategy for harmony evaluation given in (6).

(12)

	OCP[+cont]	*SO	OCP[-cont]
a. FS			
b. FF	*		
c. SF		*	
d. SS		*	*

Along the dimension of onset obstruent combinations, FS is the most harmonic of all the cluster types with respect to this constraint system because it receives no marks at all. FS is provably the unmarked cluster type along the dimension of obstruent clusters. FF and SF are less harmonic, and hence more marked, than FS clusters because both clusters are assigned a mark that FS does not receive. In particular, FF is marked with respect to OCP[+cont] and SF is marked with respect to *SO. The marks that FF and SF receive are not identical, therefore there is no harmonic ordering between the two clusters. In this respect, harmony differs from markedness. Whereas the two clusters, FF and SF, can be said to be equally marked because they both imply the least marked cluster FS, they however cannot be said to be equally harmonic because they do not receive identical marks. No relative harmony can therefore be established between FF and SF. Harmonic ordering, on the contrary, exists between SF and SS. SS is less harmonic than SF because the list of marks of SS includes all of the marks assigned to SF plus one, i.e. the mark assigned by OCP[-cont]. Note that, since the list of marks of FS is empty, than FS is obviously more harmonic than SS, as well as SF.

4. The factorial typology

Interaction of the three structural constraints proposed above with Faithfulness will account for the relative well/ill-formedness of each cluster in the different typological grammars. Specifically, a cluster will be admitted in a language, and will be therefore well-formed in that language, if the structural constraint that penalizes it is ranked below Faithfulness. This domination relation assures that such a cluster in the input will correspond to an optimal output. A representative example of a cluster that will surface as a result of constraint ranking is given in (13):

(13)

/FF/	Faith	OCP[+cont]
a. ☞ FF		*
b. F↔F	*!	
c. F	*!	
d. FS	*!	

Tableau (13) shows that any candidate that contains a change in the shape of the input cluster loses in the competition with the faithful one. Any change to the input cluster, be it the insertion of an epenthetic vowel between the members of the cluster (candidate b), or the deletion of one of the segments of the cluster (candidate c) or even a change in the value of the feature [continuant] to one of the segments (candidate d), would result in a worst violation than the one incurred by the faithful parse. The faithful candidate is therefore the optimal one and hence the one that will surface given an input of the form FF.

On the other hand, a cluster will be ill-formed in a language, and hence disallowed as a surface form, if the constraint that penalizes it outranks Faithfulness. Note that for the sole purpose of the factorial typology, it is not necessary to split Faithfulness into separate constraints, since this paper is not about alternations but about well-formedness. However, in a grammar that has to deal with cluster ill-formedness, the actual surface form for an input containing an ill-formed cluster will depend on which of the faithfulness constraints regulating Input/Output correspondence[3] (McCarthy and Prince 1995) is ranked lowest in the hierarchy. The relative rankings of these constraints will determine the optimal output form for an input containing an ill-formed cluster. This will basically correspond to the strategy a language adopts to repair an ill-formed cluster. In particular, the ranking Ident(cont), MAX-IO >> DEP-IO defines a grammar where ill-formed obstruent clusters are repaired by epenthesis; the ranking Ident(cont), DEP-IO >> MAX-IO defines instead a grammar which repairs ill-formed clusters by deleting one of the segments; and finally the ranking MAX-IO, DEP-IO >> Ident(con) defines a grammar that neither deletes nor epenthesizes, but rather turns an ill-formed cluster into the unmarked FS. Tableau (14) provides a representative example of the relative ill-formedness of FF clusters in a given language. The tableau also shows the interaction of the faithfulness constraints in the selection of the output form in a language that repairs ill-formed clusters with epenthesis.

(14)

/FF/	OCP[+cont]	Ident(cont)	MAX-IO	DEP-IO
a. FF	*!			
b.☞ F↔F				*
c. F			*!	
d. FS		*!		

Due to the ranking OCP[+cont] >> Faithfulness, a cluster FF is ill-formed in this language. Candidate (b), i.e. the candidate in which the cluster is repaired by means of an epenthetic vowel, is the optimal one, given the fact that it violates only the faithfulness constraint that is ranked lowest in the hierarchy.

The above argument, however, does not hold for FS clusters. FS clusters are unmarked with respect to all of the structural constraints. There is no constraint in the system proposed here that penalizes such cluster and that could be ranked with respect to Faithfulness. As a consequence FS clusters are unmarked and therefore always well-formed, i.e. they will always surface in the languages that allow obstruent clusters regardless of the rankings established to admit the other cluster types. Such an analysis directly explains the fact that if a language allows obstruent clusters it will always allow clusters of the form FS.

The different rankings of the constraints that need to be established to admit the different clusters types in the relevant typological languages are given in table (15)[4]. Note that the table only gives the necessary and sufficient conditions under which a certain cluster type will either be admitted or disallowed in a language. Other rankings of these constraints are possible, but are irrelevant for the purposes of this paper because they do not give rise to a new language type.

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[3] The constraints involved are MAX-IO (no deletion), DEP-IO (no insertion) and Ident(cont) (correspondent segments must have the same value for the feature [continuant]).

[4] For a full analysis of the different typological grammars the reader is referred to Morelli (1997).

(15)

LANGUAGE TYPES	CONSTRAINT RANKINGS
a. *Type 1*: FS	OCP[+] OCP[-] *SO >> Faith
b. *Type 2*: FS-FF	_____ OCP[-] *SO >> Faith >> **OCP[+]**
c. *Type 3*: FS-SF	OCP[+] OCP[-] ___ >> Faith >> ***SO**
d. *Type 4*: FS-SF-FF	_____ OCP[-] ___ >> Faith >> **OCP[+] *SO**
e. *Type 5*: FS-SF-SS	OCP[+] ____ ___ >> Faith >> **OCP[-] *SO**
f. *Type 6*: FS-SF-FF-SS	**Faith** >> OCP[+] OCP[-] *SO

a) The ranking for *Type 1*, where Faithfulness is dominated by the three structural constraints, allows only FS clusters to surface. FS is the unmarked cluster with respect to all structural constraints, therefore whatever ranking is established it will always surface. However, in order to prevent inputs containing ill-formed clusters to surface it is necessary that the structural constraints dominate Faithfulness.

b) *Type 2* languages allow FS as well as FF clusters. FS will surface regardless of the ranking, given its unmarked status. However, in order to allow FF clusters in a language it is necessary that OCP[+cont] be ranked below Faithfulness. OCP[-cont] and *SO must dominate Faithfulness to assure that inputs of the form SF and SS do not surface.

c) *Type 3* languages allow FS and SF sequences. Once again, FS will surface regardless of the ranking. For SF to surface it is necessary that *SO be ranked below Faithfulness. OCP[-cont] and OCP[+cont] must be ranked above Faithfulness to avoid that inputs of the form SS and FF can surface.

d) For FS, SF and FF to surface in languages of *Type 4*, *SO as well as OCP[+cont] must be ranked below Faithfulness. OCP[-cont] must dominated Faithfulness to prevent an input of the form SS to surface in the language.

e) In *Type 5* languages, *SO and OCP[-cont] must both be ranked below Faithfulness in order to admit SF and SS clusters together with the unmarked cluster FS. In this languages, FF clusters do not surface given that OCP[+cont] dominates Faithfulness.

f) Finally, for all four cluster types to surface in a grammar it is necessary that Faithfulness be ranked above the three structural constraints. This ranking assures that all four cluster types can surface faithfully in the grammar and thus form well-formed clusters

Using the "Technique of Necessary and Sufficient Conditions"[5] (P&S), the implicational universals observed in the typology follow directly from entailment considerations on the rankings established to admit the relevant clusters in the inventories of the typological languages. First consider the cluster FS, this is unmarked with respect to all constraints in the hierarchy, therefore whatever ranking is established it will always have an optimal output parse. As for the cluster FF, the necessary and sufficient condition that allows it to surface in a grammar is that Faith >> OCP[+cont]. This ranking, however, also entails that FS will surface given its unmarked status. To allow SF in a grammar, instead, it is necessary that Faith >> *SO. This ranking entails that FS will also surface, but does not entail that FF will surface, as expected given the fact that there is no implication holding between SF and FF. Finally, for SS to be admitted in a grammar it is necessary that Faith >> OCP[-cont], *SO. However this ranking entails that SF will also be admitted in the same grammar, since the ranking Faith >> OCP[-cont], *SO entails the ranking Faith >> *SO. The ranking established for SS therefore assures that the same grammar admits SS as well as SF. In other words, given these logical entailments, there is no grammar that allows SS but not SF or FS, or FF but not FS. The system proposed in this paper will never give rise to a language that is not attested.

5. Conclusion

A cross-linguistic study of obstruent clusters shows that implicational universals, and consequently markedness relations, exist among the four possible types of obstruent clusters. I claim that sonority cannot account for the generalizations observed. I show that Optimality Theory gives us the tools to provide a principled and formal account of the markedness relations observed. The implicational universals are shown to follow directly from entailment considerations on the rankings established to admit the different clusters in the individual grammars.

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

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