Chapter X
Markedness, faithfulness, positions, and contexts: Lenition and fortition in Optimality Theory

Jennifer L. Smith

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1. Introduction

This paper investigates some of the phonological processes traditionally classified as *lenition* and *fortition* from the perspective of Optimality Theory (OT). It is a given that no phenomenon can be examined in a completely theory-neutral way. The very selection of a particular theoretical or analytical framework imposes a structure on the phenomenon to be examined, affecting the kinds of patterns that can be recognized and the kinds of questions that can be posed. Doing phonology in the OT framework therefore changes the way we look at lenition and fortition processes, especially because in this framework, the concept of a *phonological process* has no formal status.

An OT grammar does not apply phonological rules or processes to derive surface forms from underlying forms; instead, it maps an input form to one of a set of candidate outputs. If a particular language maps the input /lut+a/ to the output [luda], it does so not because the phonological grammar includes a rule of intervocalic voicing (a classic example of a lenition process), but because the constraint hierarchy of the language assigns the least significant violation marks when /lut+a/ is mapped to [luda], versus [luta] or other possible outputs. Therefore, a study of lenition and fortition "processes" in OT is actually a study of what constraints, in what rankings, act to choose the output forms that are "stronger" or "weaker" as compared to their corresponding inputs. In this paper, the terms *lenition process* and *fortition process* will be used as a convenient informal description for what are, from a formal perspective, input-output mappings of these types.

Thus, this paper has two main goals. The first is to demonstrate how lenition and fortition processes can be modeled in OT as the result of inter-

acting constraints. The second is to consider what contributions this examination of lenition and fortition phenomena can make to our understanding of the OT constraint set.

A primary focus of discussion is the distinction between two general types of lenition (Szigetvári, this volume; see also related discussion in Lavoie 2001, Ségéral and Scheer 2001, this volume, and Cser 2003). One type involves neutralization to a typologically *unmarked* feature value, and generally affects syllable codas. Another type involves an increase in sonority, and is more likely to affect intervocalic consonants; as argued by Cser (2003), sonority-increasing lenition tends to *increase* the typological markedness of a segment. I propose that the difference between these two lenition types can be modeled in OT on the basis of a formal distinction between positions and contexts. *Positions* are prosodically defined domains that are relevant for multiple, formally distinct constraints; *contexts* are linear phonological environments, often segmentally defined, that are phonetically relevant for individual constraints. It is a point of current debate in the OT literature whether positional constraints exist, or whether all domain-specific constraints are contextual. This paper shows that the study of lenition phenomena makes a contribution to that debate. Specifically, both constraint types are necessary if the distinction between the two classes of lenition processes is to be adequately formalized.

First, §2 gives a brief introduction to principles of the OT framework that will be essential in the discussion that follows. Then, §3 reviews the formal properties of an OT approach to neutralization-to-the-unmarked lenition patterns, considering the minimum formal requirements for an analysis of lenition and fortition and motivating the inclusion of positional constraints in the constraint set. §4 turns to sonority-increasing lenition and demonstrates the importance of contextual markedness constraints in modeling this class of phenomena. Finally, §5 reviews specific approaches to positional and contextual constraints that have been taken within OT, discusses further implications of the formal distinction between positional and contextual constraints advocated here, and offers general conclusions.

2. Some basic principles of Optimality Theory

Adopting the OT framework forces a reconceptualization of certain aspects of phonological analysis. This section reviews three basic principles of OT that are particularly relevant for the discussion of lenition and fortition

patterns in the sections that follow, and previews ways in which that discussion in turn sheds light on the nature of OT constraints.

2.1. Phonological "processes" through constraint interaction

In OT, phonological processes have no formal status. What is traditionally described as a process must instead be understood in terms of surface-oriented constraints that enforce some phonotactic pattern, interacting with constraints that block or limit the applicability of that pattern. Concrete examples of this point, and how various lenition and fortition processes can be modeled under these assumptions, are given in §3 and §4.

There are two basic constraint types (Prince and Smolensky 2004; McCarthy and Prince 1995). *Markedness* constraints are those that make reference only to output (surface) forms, requiring them to have or lack particular phonological properties. *Faithfulness* constraints compare an output form to its corresponding input (loosely speaking, underlying) form and require the two to be identical along some phonologically relevant dimension; for example, there are different faithfulness constraints that penalize epenthesis, deletion, and featural change.

Different rankings among markedness and faithfulness constraints lead to different phonological patterns. When (descriptively speaking) a process applies, this means that some markedness constraint outranks at least one conflicting faithfulness constraint and all conflicting markedness constraints; the "process" is actually the satisfaction of that high-ranking markedness constraint. Conversely, when a process fails to apply, this means that the markedness constraint whose satisfaction would result in the application of that process is dominated, either by all relevant faithfulness constraints, or by at least one conflicting markedness constraint.

A more complex situation, described in more detail in §3 and §4, is when a process applies in one position or context but not in another. This pattern means that either the markedness constraint driving the process, the markedness or faithfulness constraint(s) blocking the process, or both, are position- or context-specific. Since lenition and fortition processes as traditionally identified are positional or contextual by nature, analyzing such patterns contributes to our understanding of the role of positional or contextual constraints in OT.

2.2. Complementary distribution as two interacting "processes"

A standard OT assumption known as *richness of the base* holds that there are no language-particular restrictions on input forms (Prince and Smolensky 2004: §9.3). That is to say, all systematic or predictable aspects of the phonological system of a given language (aside from basic, cross-linguistically uniform assumptions about what constitutes a legitimate phonological object) must be enforced by its constraint ranking, not by devices such as morpheme structure constraints that restrict input forms to "basic" or "unmarked" allophones. Thus, English lacks front rounded vowels because the constraint ranking for English always *chooses* an output form *without* front rounded vowels, even given an input that does contain such vowels. It is important to appreciate that this is not logically equivalent to a claim that English speakers have, in their mental lexicon of underlying representations for actual morphemes, URs with front rounded vowels. Instead, applying the principle of richness of the base to an analysis of English phonology ensures that the constraint ranking for English is robust enough to remove front rounded vowels from output forms, even if they happened to appear in a hypothetical input form – thereby capturing the insight that the absence of front rounded vowels is a systematic part of the linguistic competence of the native speaker.

Richness of the base entails that even default or unmarked phonological properties are actively enforced by the grammar when they appear in a predictable distribution. This means that any case of complementary distribution must be seen as two "processes" (unfaithful mappings): not only one enforcing the contextual alternant, but also one enforcing the basic alternant. On this view, lenition and fortition co-occur more frequently than might be recognized in other frameworks – whenever strengthening in the strong position accompanies weakening in the weak position to result in complementary distribution of the strong and weak alternants, both lenition-driving and fortition-driving constraints must be active in the grammar (Kirchner 2000: 531; Smith 2005: §5.3.3). To give a schematic example, assume a case where obstruents are voiced intervocalically and voiceless elsewhere. The grammar must ensure, not only that input voiceless obstruents are mapped to output voiced obstruents in intervocalic position, but also that input *voiced* obstruents are mapped to output voiceless obstruents when *not* intervocalic. The need to enforce all predictable phonological information, even when "default" or "unmarked", plays a significant role in the discussion of positional and contextual constraints in §3 and §4.

2.3. Factorial typology

A third important premise of the OT framework is that the analysis of any individual language also makes predictions about the cross-linguistic typology of phonological patterns. Since constraints are (by hypothesis) universal, any constraint that is proposed as part of the analysis of one language is taken to be present in the grammars of other languages as well. Therefore, a well-motivated constraint is one that makes appropriate typological predictions under its different potential rankings with respect to other relevant constraints. The set of all possible rankings of a set of constraints is known as the *factorial typology* of that set of constraints (Prince and Smolensky 2004: §6). In §3 and §4, predictions made by the factorial typology of the constraints needed to capture a particular lenition/fortition pattern are used to distinguish among competing analyses of that pattern.

2.4. Overview: Lenition and fortition in OT

The discussion in the next two sections of the paper proceeds from these three fundamental points – that phonological "processes" are the result of interacting constraints; that default as well as context-specific allophones need to be enforced by the phonological grammar; and that the factorial-typology predictions that accompany a phonological analysis provide a means of evaluating or justifying that analysis.

§3 and §4 consider in turn the two different general classes of lenition processes that have been distinguished (see, for example, Lavoie 2001; Ségéral and Scheer 2001; Cser 2003; Szigetvári, this volume). One class, explored in §3, involves neutralization to typologically unmarked feature values or segments, and is traditionally described as occurring in syllable-final or word-final position.[1] This class of phenomenon has been extensively investigated in the OT literature, although it has not necessarily been discussed explicitly in terms of lenition and fortition. The goal of §3 is to establish the basic formal properties of constraints that are needed to model the neutralization-to-the-unmarked class of lenition phenomena and related

[1]It is assumed for this initial discussion that prosodically defined positions such as "onset" and "coda" are the appropriate characterizations of the domains for lenition and fortition processes; alternatives to this assumption are discussed in §5 below.

fortition phenomena, with particular attention to the question of which types of constraints may or must be positional or context-specific. §3 also considers the role of functional grounding (phonetic motivation) and factorial typology in deciding between competing formal approaches to this set of phenomena.

The other class of lenition processes, examined in §4, generally involves an increase in sonority, and is most commonly found in intervocalic or intersonorant position. In some respects, this is seen as a more prototypical lenition pattern in the general lenition/fortition literature. For example, Lavoie (2001) restricts her empirical investigation of weakening to the intervocalic environment, and Cser (2003) defines lenition as necessarily involving an increase in sonority. However, there has been less systematic treatment of the general properties of this lenition/fortition pattern within OT (Kirchner 2000, 2004 discusses various cases of this pattern in great detail, but does not necessarily relate its properties to those of other types of phonological phenomena in the way that has been done for the neutralization-to-the-unmarked pattern). §4 compares the formal properties of the two types of lenition, motivating the proposed distinction between *positional* constraints (for fortition and neutralization-to-the-unmarked lenition) and *contextual* constraints (for sonority-increasing lenition). This section also considers the full factorial typology of a constraint set that includes constraints driving both lenition types, as well as fortition-driving constraints, context-free markedness constraints, and faithfulness constraints.

3. Basic formal requirements for constraints on lenition and fortition

One phonological pattern often classified as a lenition process involves a weak position that undergoes neutralization of some phonological contrast to the typologically unmarked member (the pattern labeled "decomplexification" by Szigetvári, this volume). *Typologically unmarked* is taken here to mean unmarked as a member of a consonant inventory, or unmarked in a context-free sense; the question of markedness relative to specific phonological contexts is taken up below in §4.2.

To illustrate the formal properties of the neutralization-to-the-unmarked lenition pattern, this section examines debuccalization, that is, the loss of supralaryngeal place features and neutralization to glottal place, in syllable coda position. (A formally parallel example, that of coda devoicing, is dis-

cussed in §4.1 below). The claim that glottal is the typologically unmarked consonant place is widely accepted (see, e.g., Lombardi 2001; de Lacy 2006), though not entirely uncontroversial (Steriade to appear; Rice 2004).

A positional fortition pattern that is the inverse of coda debuccalization is the *avoidance* of glottal consonants in onset position. Neutralization patterns specific to strong positions, like this one, typically involve the enforcement of greater perceptual salience (Smith 2000, 2005). In this case, consonants with supralaryngeal [Place] specifications are arguably more perceptually salient than glottal consonants, because only the non-glottal consonants impose formant transitions on surrounding vowels (Stevens 1971), and rapid spectral changes such as those involved in formant transitions have been found to have greater perceptual salience (Ohala 1992; Warner 1998). It is important to recognize that fortition, like lenition, actually involves the potential neutralization of some phonological contrast. Therefore, what makes strong positions different from weak ones is not that they *never* undergo position-specific neutralization, but rather that the motivating force behind the position-specific neutralization is distinct from typological unmarkedness.

Because the typologically unmarked consonant place is not the same as the perceptually salient consonant place, the effects of the lenition-driving and fortition-driving constraints are easily distinguished. Therefore, consonant place of articulation is a useful starting point for examining the formal characteristics of lenition and fortition phenomena. This section presents an examination of the formal properties of an OT system that can model coda debuccalization and onset glottal avoidance. For clarity of exposition, the neutralization of consonant place contrasts to glottal is assumed to be a response to a requirement that consonants be placeless,[2] which can be formalized as the constraint *PLACE in (1). Because this constraint refers exclusively to surface forms – enforcing a particular phonotactic pattern regardless of the content of the input form – it is a markedness constraint (M).

[2]The same patterns of contrast and neutralization discussed in this section can also be modeled under the assumption that glottal consonants have a [pharyngeal] place feature, as long as that is the least marked place feature for consonants. See Smolensky (1993) and Lombardi (2001) for discussion; in brief, this would require a scale of [Place] markedness constraints ({*Lab, *Dors} >> *Cor >> *Phar), or a set of stringency constraints on [Place] (Prince 1997; de Lacy 2006), with [pharyngeal] at the least-marked end of the scale.

(1) M constraint responsible for debuccalization:
*PLACE
Assign one '*' to each output consonant with at least one Place feature

The effects of this constraint, or its positional counterpart, are attested whenever neutralization to the unmarked place occurs, as in codas (to be addressed in this section).

The opposite pattern, in which glottal consonants are avoided, is driven by a markedness constraint that bans placeless consonants, HAVEPLACE.

(2) M constraint responsible for banning glottal consonants:
HAVEPLACE (Parker 2001)
Assign one '*' to each output consonant that lacks a supralaryngeal place

The effects of HAVEPLACE can be seen in the onset glottal-avoidance pattern of interest here, as well as in languages that have no glottal segments at all; among the examples of such languages listed in Maddieson (1984) are Lithuanian, French, Ostyak, Yakut, Nyangi, and Chuave.

*PLACE and HAVEPLACE conflict with each other; if an output consonant bears a [Place] feature, it will violate *PLACE, and if it does not, it will violate HAVEPLACE. However, since the OT formalism assumes that constraints can conflict, there is nothing intrinsically problematic about the existence of two M constraints that make opposite demands in this way. If OT constraints are formally arbitrary, the fact that both of the relevant phenomena are empirically attested is enough to motivate the inclusion of both M constraints in the constraint set. Even in approaches to OT that assume phonetic grounding (Archangeli and Pulleyblank 1994) for some or all constraints, it is possible to have pairs of opposing constraints when different dimensions of phonetic motivation are involved. In this case, the general motivation for a constraint like *PLACE would likely be ease of articulation ("do not expend effort making a supralaryngeal constriction"), while the general motivation for HAVEPLACE would arguably be perceptual distinctiveness ("use only consonants that have formant transitions to aid in their identification").

A third constraint that is relevant for this demonstration is the faithfulness constraint (F) that penalizes disparities in Place features between input and output forms. This faithfulness constraint is modeled here as an

IDENT constraint (McCarthy and Prince 1995) on phonological features belonging to the Place class (Padgett 2002).

(3) F constraint against disparities in [Place] features
IDENT[Place] (McCarthy and Prince 1995)
Assign one '*' to any pair of corresponding input and output segments that do not agree in their [Place] feature specification

IDENT[Place] potentially conflicts with both of the markedness constraints on Place features. If a placeless input is altered to satisfy HAVEPLACE, or a Place feature is deleted to satisfy *PLACE, in either case this will lead to a violation of IDENT[Place].

In summary, these are the three constraints that are central to lenition and fortition phenomena involving consonant place of articulation. The markedness constraint responsible for the lenition process (M-len) is *PLACE, driving debuccalization to produce glottal consonants, which have the unmarked Place specification in typological terms. The markedness constraint responsible for the fortition process (M-fort), necessary for keeping "weak" glottal consonants out of strong positions, is HAVEPLACE, which penalizes glottal consonants for being perceptually non-distinct. Finally, the faithfulness constraint (F) that is violated when input place specifications are altered (as occurs in phenomena of either the "lenition" or the "fortition" type) is IDENT[Place]. In §3.1–§3.3, the roles of these constraints and their positional counterparts are examined in three different patterns involving lenition and fortition. Then, §3.4 explores the implications of the three lenition and fortition patterns for a general theory of positional constraints.

3.1. Lenition in weak positions; contrast maintained in strong positions

The first pattern to be examined may be called *lenition+contrast*. In this pattern, weak positions are subject to neutralization to the unmarked feature value, but strong positions maintain a contrast among all possible feature values, including the neutralization target found in weak positions. In terms of the debuccalization example, onsets may be glottal or consonants with any supralaryngeal Place, but codas must be glottal. A language that demonstrates this lenition+contrast pattern is Slave (Rice 1989: 144, 150). All consonantal codas in Slave must be glottal ([h] or [ʔ]); non-glottal

stem-final consonants are neutralized to [h] when no vowel follows. However, possible onsets include both glottal and non-glottal consonants; in fact, the usual epenthetic onset is [h] (Rice 1989: 147).

(4) Coda neutralization to [h] in Slave (Rice 1989: 144); /-ɛ/ is a possessive suffix, tones not shown

/ts'ad/	ts'ah	-ts'adɛ	'hat'
/seɡ/	seh	-zeɡɛ	'saliva' (Hare dialect)
/tl'uɮ/	tl'uh	-tl'uɮɛ	'rope'
/xaz/	xah	-ɣazɛ	'scar'
/ʔah/	ʔah	-ahɛ	'snowshoe' (Slavey dialect)

In the lenition+contrast pattern, the strong position is allowed to maintain a phonological contrast that is not subject to neutralization, but the weak position does undergo neutralization. Formally, this means that F (IDENT[Place]) takes priority over M-len (*PLACE) for the strong position, but M-len (*PLACE) takes priority over F (IDENT[Place]) for the weak position. Of course, no language can simultaneously have IDENT[Place] >> *PLACE and *PLACE >> IDENT[Place], so at least one of these two constraints has to have a positional counterpart, which specifically applies to strong or weak positions. (See §5 for references to influential proposals concerning positional constraints in OT.) That is, either there is a positional faithfulness constraint that makes reference to strong positions (F(str)), or there is a lenition-driving positional markedness constraint that makes reference to weak positions (M-len(wk)).[3]

If it is the faithfulness constraint that is positional, the relevant ranking is IDENT[Place](onset) >> *PLACE >> IDENT[Place]. For onsets, F(str) takes priority, penalizing changes in onset place (5a.iii, 5b.ii) and therefore allowing all contrast options in that position. Outside of onsets, which is to say in codas, M-len takes priority, so non-onset consonants that retain Place features are penalized (5a.i). ('►' indicates the winning candidate.)

[3]Additionally, HAVEPLACE must be ranked below constraints preferring glottals in this language type, or it would rule them out.

(5) Lenition+contrast with F(str): F(str) >> M-len >> F

a. Coda C realized as [ʔ]

/kap/			ID[Place](ons)	*PLACE	ID[Place]
	i.	kap		**!	
►	ii.	kaʔ		*	*
	iii.	ʔaʔ	*!		**

b. Onset may be any C, including [ʔ] (compare [k] in (a) above)

/ʔo/			ID[Place](ons)	*PLACE	ID[Place]
►	i.	ʔo			
	ii.	to	*!	*	*

Alternatively, if it is the markedness constraint that is positional, the relevant ranking is *PLACE(coda) >> IDENT[Place] >> *PLACE. For codas, M-len(wk) takes priority, so codas may not retain Place features (6a.i). For non-codas, F is the highest relevant constraint, so changes either to or from glottal are avoided in onsets (6a.iii, 6b.ii).

(6) Lenition+contrast with M-len(wk): M-len(wk) >> F >> M-len

a. Coda C realized as [ʔ]

/kap/			*PLACE(coda)	ID[Place]	*PLACE
	i.	kap	*!		**
►	ii.	kaʔ		*	*
	iii.	ʔaʔ		**!	

b. Onset may be any C, including [ʔ] (compare [k] in (a) above)

/ʔo/			*PLACE(coda)	ID[Place]	*PLACE
►	i.	ʔo			
	ii.	to		*!	*

The lenition+contrast pattern is also compatible with the assumption that *both* M-len and F have positional counterparts; as long as M-len(wk) >> F and F(str) >> M-len, codas will neutralize while onsets remain fully contrastive.

3.2. Fortition in strong positions, with contrast in weak positions

Another pattern to consider is *fortition+contrast*. In this pattern, strong positions are forbidden to have a particular "weak" characteristic (even though it may be typologically unmarked in a context-free sense). Weak positions, on the other hand, are allowed to have a full range of contrast. In terms of the current debuccalization example, this would be a case in which onsets must have a supralaryngeal place specification, which rules out glottals, while codas may be glottal or any consonant with a supralaryngeal place. An example of a language that shows this pattern is Chamicuro (Parker 1994, 2001), where [h] and [ʔ] contrast with each other and with other consonants in coda position, but glottal onsets do not occur.

(7) Contrast in codas, but no glottal onsets, in Chamicuro (Parker 2001: 36)

a**ʔ**tikana	'we'	sa**ʔ**pu	'lake'
a**h**tini	'path, trail'	ka**h**pu	'bone'
uana**s**ti	'I watch, look'	sje**k**putsle	'pot-bellied'

This pattern is the formal opposite of the lenition+contrast pattern. This time, it is the strong position that is subject to a phonotactic requirement, which is to say, neutralization – although this is neutralization to avoid a "weak" segment, which is different from the neutralization to the typologically unmarked value that tends to occur in weak positions. Thus, in the strong position, M-fort (HAVEPLACE) takes priority. However, the weak position is allowed to maintain a phonological contrast that is not subject to neutralization: F (IDENT[Place]) takes priority. Again, since it is not possible for one single language to have the mutually incompatible rankings HAVEPLACE >> IDENT[Place] and IDENT[Place] >> HAVEPLACE, at least one of the two constraint types must have a positional counterpart; the constraint set must include either M-fort(str), a fortition-driving marked-

ness constraint specific to the strong position, or F(wk), a faithfulness constraint specific to the weak position.[4]

If it is the markedness constraint that is positional, the relevant ranking is HAVEPLACE(onset) >> IDENT[Place] >> HAVEPLACE, so that glottal onsets are ruled out (8a.ii), but codas must not alter their input Place specifications even if they are glottals (8b.ii). For concreteness, the potential onset [ʔ] is shown below being mapped to [t]; precisely how the banned glottal segments are altered in the optimal output forms will depend on the ranking of other markedness and faithfulness constraints in the language.

(8) Fortition+contrast with M-fort(str): M-fort(str) >> F >> M-fort

a. Onset /ʔ/ realized as a C with supralaryngeal Place (e.g., [t])

/ʔap/	HAVEPLACE(ons)	ID[Place]	HAVEPLACE
i. ʔap	*!		*
► ii. tap		*	

b. Coda may be any C, including [ʔ] (compare [p] in (a) above)

/koʔ/	HAVEPLACE(ons)	ID[Place]	HAVEPLACE
► i. koʔ			*
ii. kot		*!	

If it is the faithfulness constraint that is positional, the necessary ranking is IDENT[Place](coda) >> HAVEPLACE >> IDENT[Place]. With this ranking, codas in particular may not change input place specifications even to avoid a glottal (9b.ii), but outside the coda position, the ban on glottals outranks the requirement that Place contrasts be fully preserved (9a.ii).

[4]The constraint penalizing non-glottal consonants, *PLACE, must also be ranked low enough not to override the crucial interactions being discussed here.

(9) Fortition+contrast with F(wk): F(wk) >> M-fort >> F

a. Onset /ʔ/ realized as a C with supralaryngeal Place (e.g., [t])

/ʔap/	ID[Place](coda)	HAVEPLACE	ID[Place]
i. ʔap		*!	
► ii. tap			*

b. Coda may be any C, including [ʔ] (compare [p] in (a) above)

/koʔ/	ID[Place](coda)	HAVEPLACE	ID[Place]
► i. koʔ		*	
ii. kot	*!		*

As seen in §3.1 for lenition+contrast, the fortition+contrast pattern is also compatible with a system in which *both* M-fort(str) and F(wk) constraints are included. Any ranking in which M-fort(str) >> F and F(wk) >> M-fort will produce a language in which onsets must not be glottal, but codas may be glottal or non-glottal.

3.3. Lenition and fortition in complementary distribution

A third logically possible pattern involving lenition and fortition is the lenition+fortition complementary distribution pattern, in which weak positions undergo neutralization to the typologically unmarked value *and* strong positions undergo neutralization to increase perceptual salience. With respect to consonant place of articulation, this would be a language in which glottal onsets are prohibited, while codas are consistently debuccalized. A language that is a reasonably close match to this pattern is Awa. Word-initial onsets may be any of the consonants with a supralaryngeal place (except [j], although [w] is possible), but coda obstruents may only be [ʔ] (Loving 1973: 12).

(10) Glottal ban in initial onsets and requirement in coda obstruents, in Awa (Loving 1973: 12-13; tones not shown)

ojoʔmedoʔ	'they pulled up'	pateʔta	'plate'
katiaiʔ	'slippery'	tæʔtate	'two'

Awa differs in two respects from the basic lenition+fortition complementary distribution pattern described above. First, there are some codas that are not glottal; namely, nasals. However, nasal codas are possible only word-medially, and they have the same place as the following onset (Loving 1973: 12). This indicates that nasal codas too avoid sponsoring [Place] features of their own by sharing [Place] with the following onset, so it is actually part of the larger no-coda-place generalization; formally speaking, a faithfulness constraint such as IDENT[nasal] or IDENT[sonorant] prevents the nasal codas from being neutralized all the way to [ʔ]. The second complication is that, while *word-initial* onsets may not be glottal, [ʔ] is a possible *medial* onset. This is an example of the fact that fortition processes sometimes affect word-initial position only. According to the model developed in Smith (2000, 2005), this shows that M-fort constraints can, under certain conditions, be positionally relativized to the strong position initial syllable.

In any case, Awa may not be a pure example of the complementary distribution pattern, but it does show a lenition process and the corresponding fortition process both at work in the same language. Examples of the lenition+fortition complementary distribution pattern for other phonological contrasts include the vowel reduction pattern in Muscovite *prostorechie* Russian described by Crosswhite (1999, citing O.V. Dedova): Stressed vowels must not be schwa, but unstressed vowels must be schwa.

In a language with the lenition+fortition pattern, all three of the constraint types introduced above are active, as summarized in (11) (for the context-free versions of the constraints).

(11) General constraint types needed to enforce this pattern

a. Weak position is subject to a markedness-reducing requirement: M-len (*PLACE)
b. Strong position is subject to a prominence-enhancing requirement: M-fort (HAVEPLACE)
c. Neither position is allowed to maintain a phonological contrast, so F (IDENT[Place]) is ranked below both M constraints

For the lenition+contrast and fortition+contrast patterns discussed above, formally possible analyses were available on the assumption that *either* the markedness constraint *or* the faithfulness constraint was positional. That is, positional markedness was not a formal necessity. For the lenition+fortition pattern, however, at least one of the markedness constraints *must* be positional. Otherwise, one single phonological process (either lenition or fortition) would be enforced in both strong and weak positions under either ranking between the markedness constraints, as seen in (12). Moreover, it is clearly not a positional faithfulness constraint that is at work here, since the positional pattern is not a case of faithfulness (preservation of contrasts) but rather markedness (enforcement of phonotactic characteristics).

(12) Lenition+fortition pattern impossible if both M are context-free

a. Fortition constraint prevails – all positions are strengthened

/ʔoʔ/		HAVEPLACE	*PLACE	IDENT[Place]
	i. ʔoʔ	*!*		
▶	ii. tot		**	**

b. Lenition constraint prevails – all positions are weakened

/kap/		*PLACE	HAVEPLACE	IDENT[Place]
	i. kap	*!*		
▶	ii. ʔaʔ		**	**

As long as at least one of the markedness constraints is positional, however, the lenition+fortition pattern can be modeled.

(13) Having one positional M constraint is sufficient

a. M-fort is positional, M-fort(str): HAVEPLACE(Onset)
M-len is general: *PLACE

Fortition in onsets

/ʔoʔ/	HAVEPLACE(Ons)	*PLACE	IDENT[Place]
i. ʔoʔ	*!		
► ii. toʔ		*	*
iii. tot		**!	**

Lenition in codas

/kap/	HAVEPLACE(Ons)	*PLACE	IDENT[Place]
i. kap		**!	
► ii. kaʔ		*	*
iii. ʔaʔ	*!		**

b. M-len is positional, M-len(wk): *PLACE(Coda)
M-fort is general: HAVEPLACE

Fortition in onsets

/ʔoʔ/	*PLACE(Coda)	HAVEPLACE	IDENT[Place]
i. ʔoʔ		**!	
► ii. toʔ		*	*
iii. tot	*!		**

Lenition in codas

/kap/	*PLACE(Coda)	HAVEPLACE	IDENT[Place]
i. kap	*!		
► ii. kaʔ		*	*
iii. ʔaʔ		**!	**

Finally, the lenition+fortition pattern can also be produced when both markedness constraints are positional.

(14) Lenition+fortition with two positional M

Fortition in onsets

/ʔoʔ/	HAVEPL(Ons)	*PLACE(Coda)	IDENT[Place]
i. ʔoʔ	*!		
► ii. toʔ			*
iii. tot		*!	**

Lenition in codas

/kap/	HAVEPL(Ons)	*PLACE(Coda)	IDENT[Place]
i. kap		*!	
► ii. kaʔ			*
iii. ʔaʔ	*!		**

In this case, however, the ranking between the two markedness constraints is not crucial (as indicated by the dashed line in (14)), as long as each dominates the faithfulness constraint.

3.4. Claims about positional constraints in the model

As §3.1–§3.3 have shown, a constraint-based account of phonological processes that are restricted to particular positions is only possible if at least some of the constraints are themselves specific to particular positions. But what types of constraints can or must be positional, and what types of positions can constraints refer to? There are various logical possibilities, as outlined in (15).

(15) Logical possibilities for positional constraints

a. Are positional constraints markedness constraints or faithfulness constraints (or both)?

b. Do positional constraints refer to strong positions or weak positions (or both)?

One way of beginning to answer this question is to see what the minimum necessary assumptions about positional constraints are, such that the three general lenition and fortition patterns that have been considered in this section can be accounted for. However, this question is complicated, in part because each of the patterns considered in this section has been shown to be compatible with multiple approaches to positional constraints, as summarized in (16).

(16) Minimum necessary assumptions about positional constraint types

	Pattern	*Necessary positional constraint types*		
a.	Lenition+contrast (§3.1)	F(str)	*or*	M-len(wk)
b.	Fortition+contrast (§3.2)	M-fort(str)	*or*	F(wk)
c.	Lenition+fortition (§3.3)	M-fort(str)	*or*	M-len(wk)

The only logically necessary conclusion that can be drawn from §3.1–§3.3 is that in order to model the lenition+fortition pattern, at least one of M-fort(str) or M-len(wk) must be included in the system. Therefore, the universal constraint set must include at least markedness constraints that are positional.

Although no further claims can be made in the basis of (16) about constraint types that are absolutely necessary or absolutely impossible, additional considerations can be taken into account when choosing among proposed sets of constraints.

One such consideration is *functional grounding*, in the sense of Archangeli and Pulleyblank (1994). Some approaches to the constraint set Con (e.g., Hayes 1999; Pater 1999; Flemming 2001) hold that most or all constraints should be functionally grounded, which is to say, phonetically plausible or natural. With respect to the positional constraint types that are listed in (16), there is no apparent functional motivation for F(wk) constraints. Faithfulness constraints for strong positions are plausibly motivated (Steriade 1995; Beckman 1997, 1999), because strong positions are phonetically or psycholinguistically salient and therefore maintaining contrasts in those positions is easier, more useful, or both. Markedness constraints that target weak positions, acting to eliminate phonological contrasts in those positions, are also plausible from a functional perspective (Steriade 1999), because these are positions in which contrasts are less

easily recoverable or less useful. Even markedness constraints that target strong positions are motivated if they are constraints that act to enforce perceptually salient properties in those strong positions (Smith 2000, 2005), and this is precisely the type of constraint that is needed to drive a fortition process such as glottal avoidance (§3.2) or obstruent devoicing (see §4.1 below) in onset position; see also Donegan and Stampe (1979) and Kirchner (2000) for discussion of a perceptual motivation for fortition processes.

On the other hand, there seems not to be any particular motivation for constraints that work to preserve phonological contrasts specifically in weak positions (as opposed to context-free faithfulness constraints, which apply to strong and weak positions alike). Therefore, considerations of functional grounding indicate that F(wk) should be rejected as a possible constraint type. This in turn means that the fortition+contrast pattern (§3.2) is best handled with M-fort(str) constraints and general F constraints, as in (17).

(17) Positional constraints needed for lenition and fortition, without F(wk)

Pattern	*Necessary positional constraint types*		
a. Lenition+contrast	F(str)	*or*	M-len(wk)
b. Fortition+contrast		M-fort(str)	
c. Lenition+fortition	M-fort(str)	*or*	M-len(wk)

As (17) indicates, however, the best approach to the lenition+contrast pattern has still not been uniquely determined. Incorporating M-fort(str) constraints into the model means that M-len(wk) constraints are not necessary for an account of the lenition+fortition pattern, so the system could be set up without M-len(wk) constraints at all, in which case the lenition+contrast pattern would be modeled with F(str) constraints. On this view, the types of positional constraints in Con would be as shown in (18).

(18) The formal system, assuming F(str) for lenition+contrast

Pattern		*Positional constraint types*		*Context-free constraint types*
a.	Lenition+contrast	F(str)	>>	M-len (>> F)
b.	Fortition+contrast	M-fort(str)	>>	F (>> M-fort)
c.	Lenition+fortition	M-fort(str)	>>	M-len (>> F)

In this system, both markedness and faithfulness constraints may be positional, but all positional constraints refer only to strong positions.

Alternatively, based on (17), a different approach can be taken toward a formal account of lenition and fortition. The complementary distribution lenition+fortition pattern requires *at least* one of M-len or M-fort to be positional, but this pattern is also compatible with a system in which *both* markedness constraint types are positional. This means that handling the lenition+contrast pattern with M-len(wk) constraints is also a viable option, as shown in (19).

(19) The formal system, assuming M-len(wk) for lenition+contrast

Pattern		*Positional constraint types*		*Context-free constraint types*
a.	Lenition+contrast	M-len(wk)	>>	F (>> M-len)
b.	Fortition+contrast	M-fort(str)	>>	F (>> M-fort)
c.	Lenition+fortition	M-fort(str) , M-len(wk)	>>	(F)

In this system, all positional constraints are markedness constraints, but positional constraints can refer to both strong and weak positions.[5]

[5]Actually, Zoll (2004) shows that many constraints of the type M(wk) can be recast as constraints of the COINCIDE family, which require marked structures to coincide with strong positions. For example, *PLACE(Coda) could be restated as COINCIDE(Place, Onset) 'every [Place] feature coincides with some onset'. If all M-len(wk) constraints can indeed be restated in this way, then we could have a system in which all positional constraints are markedness constraints, and all positions mentioned by constraints are strong positions.

In addition to a difference in assumptions about what constraint types can be positional, the formal models shown in (18) and (19) also make different claims about what types of context-free constraints are necessary. (For each pattern, the lowest-ranked constraint type is indicated in parentheses, because these are not formally necessary for modeling the pattern in question.) Thus, for a system with F(str) constraints but no M(wk) constraints, as in (18), viable accounts of the lenition+contrast pattern and the lenition+fortition pattern are possible only if M-len exists as a context-free constraint. In the same way, for a system with M(wk) constraints but no F(str) constraints (19) to handle the lenition+contrast pattern, F must exist as a context-free constraint.

These different claims about the existence of context-free constraints could in principle help distinguish between the two models, if one type of context-free constraint proved to be better motivated than another. In the case of consonant Place features, no strong result emerges from this comparison, because for the neutralization-to-the-unmarked scenario, both a context-free F constraint like IDENT[Place] and a context-free M-len constraint like *PLACE are reasonably well motivated. Context-free IDENT[Place] is motivated by considerations of factorial typology; this constraint, when ranked higher than competing M constraints like HAVE-PLACE and *PLACE, can account for languages with neither lenition nor fortition, in which glottal and non-glottal consonants are contrastive in both onset and coda positions. As for context-free *PLACE, it is true that we do not find any languages in which this constraint is ranked highest (such a language would have only glottal consonants), but to the extent that debuccalization is seen as an instance of neutralization to the typologically unmarked value, this context-free markedness constraint is conceptually motivated. But while an examination of the context-free constraints that would be needed under the two competing approaches does not provide conclusive results here, considerations of this sort play a role in §4.2 below, in the case of sonority-increasing lenition.

In summary, an examination of the neutralization-to-the-unmarked lenition pattern and its related fortition pattern has shown several things about the constraint set Con. First, Con must contain positional constraints in order to account for positional phonological patterns. Additionally, at least one type of positional M constraint (M(str) or M(wk)) is needed to account for the lenition+fortition pattern. The implausibility and lack of functional grounding for putative constraints of the F(wk) type mean that M(str) constraints are the best way to model the fortition+contrast pattern. Finally, the

lenition+contrast pattern is compatible with an approach that uses either F(str) or M(wk) constraints.

4. Sonority-increasing lenition and contextual markedness constraints

This section turns to the second type of lenition pattern, which involves not typological unmarkedness, but sonority increase. The phonological patterns used here for illustration and discussion are those involving the [±voice] feature in obstruents, because intervocalic voicing is a well-known example of sonority-increasing lenition.

Lenition and fortition patterns involving [±voice] in obstruents are somewhat complex, because there are a number of interacting factors. However, if the different subpatterns involved are examined separately, their relationships to other kinds of lenition and fortition patterns can be clarified. This section discusses the constraints that are needed in order to account for lenition and fortition patterns involving obstruent voicing and devoicing, their similarities and differences as compared to the consonant place phenomena discussed in §3, and the predicted factorial typology of the interactions among these constraints. First, §4.1 presents those aspects of obstruent voicing that belong to the neutralization-to-the-unmarked lenition pattern, as discussed in §3 for consonant place of articulation. Then, §4.2 introduces the additional constraint needed for an analysis of intervocalic voicing, and classifies this constraint as one that is not positional but rather *contextual.*

4.1. Devoicing patterns as lenition and fortition

As discussed above, fitting a phonological pattern into a classification as lenition or fortition requires an understanding of whether that pattern affects strong or weak positions, and whether that pattern involves a reduction in typological markedness, an increase in sonority, or an increase in perceptual salience. This section presents an examination of obstruent devoicing patterns, showing that voicelessness is both typologically unmarked (an outcome of lenition) and perceptually salient (an outcome of fortition).

Whether it is voiced or voiceless obstruents that are unmarked or phonetically natural depends largely on the environment in which the obstruents are found. For example, stops that occur between vowels and stops that occur after nasals are more compatible with voicing than voicelessness, at least on articulatory and aerodynamic grounds (Westbury and Keating 1986; Hayes 1999). However, where context-free markedness or segmental inventory structure is concerned, phonologists have long classified voiceless obstruents as less marked than voiced obstruents. The view that voiceless obstruents are typologically unmarked finds support from the survey of voicing patterns by Keating, Linker, and Huffman (1983: 279): Some languages have *only* voiceless obstruents, even in contexts such as the intervocalic one where there is a conflicting, articulation-based preference for voicing (see §4.2 below for more on contextual voicing constraints). Examples of this pattern discussed by Keating, Linker, and Huffman (1983) include Hawai'ian, Alyawarra, and Tiwi.

As outlined above, typological unmarkedness is enforced by a context-free markedness constraint. The one that is relevant here is *OBSTVOI.

(20) M constraint leading to obstruent devoicing
*OBSTVOI (e.g., Ito and Mester 2003)
Assign one '*' to each output segment that is [–son, +voi]

In a language where *OBSTVOI is ranked above all conflicting markedness and faithfulness constraints, obstruents are always voiceless; thus, the status of voiceless obstruents as the unmarked case is accounted for in the model.

According to the constraint classification system developed in §3, *OBSTVOI would be classified as M-len, since it drives neutralization to an unmarked feature value. As outlined above, weak positions such as syllable codas are especially susceptible to neutralization-to-the-unmarked lenition effects. On these grounds, we would expect to find languages with a lenition+contrast pattern, where coda obstruents are neutralized to voiceless, while non-coda obstruents are allowed to maintain a voicing contrast. This kind of coda-devoicing pattern is of course well attested (some cases have been argued to involve incomplete neutralization, but this is controversial; see, e.g., Dinnsen and Charles-Luce (1984), Port and O'Dell 1985, and Fourakis and Iverson (1984) for discussion). Examples from Keating, Linker, and Huffman (1983) of languages with syllable-level "final" devoicing effects, or suppression of a voicing contrast specifically in coda

position, include German and Thai (see §5 for alternatives to "coda" as the appropriate position).

Just as was done for the coda debuccalization lenition+contrast pattern described above, there are two ways of formalizing a coda devoicing pattern. The general versions of the constraints that crucially interact are *OBSTVOI and a faithfulness constraint that calls for the preservation of input voicing, formalized as IDENT[voice].

(21) F constraint against disparities in [voice]
IDENT[voice] (McCarthy and Prince 1995)
Assign one '*' to any pair of corresponding input and output segments that do not agree in their [voice] feature specification

As demonstrated in §3.1, a lenition+contrast pattern, where there is neutralization in the weak position only, needs at least one of M-len or F to be positionally relativized. Here, the options would be to enforce devoicing specifically in codas with M-len(wk) (22a), or to protect specifically onsets from a context-free devoicing constraint with F(str) (22b).

(22) Rankings for lenition+contrast pattern (codas are voiceless; contrast elsewhere)
a. *OBSTVOI(coda) >> IDENT[voice] >> *OBSTVOI
b. IDENT[voice](onset) >> *OBSTVOI >> IDENT[voice]

Although either approach could be taken, subsequent discussion will assume for the sake of simplicity that the constraint set includes the M(wk) constraint, *OBSTVOI(coda), rather than the F(str) constraint. Prince and Tesar (2004: §6) argue, based on learnability algorithms, that it is preferable to introduce specific/general constraint pairs into the markedness system rather than the faithfulness system.

The existence of a context-free IDENT[voice] constraint is empirically supported, since there are numerous languages that allow both onsets and codas to contrast in voicing, the pattern that would be expected when IDENT[voice] is ranked above all conflicting constraints. Examples of languages in Keating, Linker, and Huffman (1983) with positionally unrestricted voicing contrasts (aside from assimilation between the members of a consonant cluster, which is due to other constraints not under discussion here) include French and Hungarian.

Continuing the comparison of obstruent voicing patterns with consonant place of articulation as explored in §3, the next pattern to look for is one in which the strong position, namely, the syllable onset, is subject to a fortition requirement. As explained in §3, a fortition-driving constraint is a markedness constraint that forces strong positions to be neutralized, not to a category that is typologically unmarked in a context-free sense, but rather to a category that is perceptually salient. For onsets, lower sonority gives rise to greater perceptual salience (Ohala and Kawasaki-Fukumori 1997; Gordon 2003; Wright 2004). Therefore, the members of the *ONSET/X constraint family (Smith 2005, to appear, after *MARGIN/X in Prince and Smolensky 2004), which formalize the preference for onsets to be low in sonority, qualify as fortition-driving constraints. One member of this constraint family is a constraint that penalizes voiced obstruents in onset position, thereby preferring voiceless onsets: *ONSET/D (where 'D' stands for 'voiced obstruent').

(23) M constraint leading to obstruent devoicing in onsets (M-fort(str))
*ONSET/D
Assign one '*' to each output segment that is a syllable onset and is [–son, +voi]

In a sense, a *ONSET/X constraint such as *ONSET/D is intrinsically positional, since it specifically refers to consonants that are syllabified as onsets. Therefore, in our current classification system, this can be represented as M-fort(str).[6]

In §3.2, a fortition+contrast pattern was identified for consonant place of articulation. In this pattern type, the strong position is subject to neutralization while the weak position is allowed to maintain contrast. Such a situation arises when the fortition-driving constraint M-fort(str) outranks the faithfulness constraint, which in turn outranks all markedness constraints that would otherwise drive contrast neutralization in the weak position.

[6]As shown in Smith (2004, 2005, to appear), the *ONSET/X constraints can themselves be relativized to other types of strong positions, such as stressed syllable or initial syllable.

(24) Schematic ranking for the fortition+contrast pattern
M-fort(str) >> F >> any M that affects the weak position

The obstruent-voicing instantiation of this pattern would be as follows.

(25) Fortition+contrast pattern for obstruent voicing
*ONSET/D >> IDENT[voice] >> *OBSTVOI, *OBSTVOI(coda)

In a language with this ranking, onset obstruents must be voiceless, whereas other obstruents contrast for [±voice]. Languages of this type, with obstruent neutralization to voiceless in onsets only, do not seem to exist.[7] However, the absence of this pattern is arguably an accidental gap. To the extent that fortition processes increase perceptual salience and target strong positions, this fortition+contrast pattern is predicted to be a possible pattern for human language, regardless of the theoretical framework employed for phonological analysis. Moreover, there is empirical support for the constraints of the *ONSET/X family (Prince and Smolensky 2004: §8; Moreton, Feng, and Smith to appear) and their further positionally relativized counterparts (Smith 2004, 2005, to appear).

One final pattern produced by the constraints that have been introduced so far is the lenition+fortition pattern, which arises when strong positions are subject to fortition *and* weak positions are subject to lenition. In the specific case of obstruent voicing, however, the prominence-enhancing fortition pattern leads to the same surface effect as the neutralization-to-the-unmarked lenition pattern: devoicing. For this reason, obstruent voicing phenomena make an interesting comparison with consonant place phenomena. The lenition+fortition ranking, which produced complementary distribution between non-glottal onsets and glottal codas (§3.3), will in this case force both onset and coda obstruents to be voiceless, since both the lenition- and fortition-driving constraints favor voicelessness. Formally, however, this is still a "complementary distribution" ranking, even though its surface effects are the same as those of the context-free markedness constraint *OBSTVOI on its own.

[7] The related pattern that adds intervocalic voicing to the mix along with fortition in non-intervocalic onsets and full contrast only in codas (pattern (VIb) in chart (25)) likewise does not seem to be attested.

So far, the aspects of obstruent voicing that have been discussed are formally similar to the consonant place of articulation patterns presented in §3. To investigate the full range of voicing-related lenition and fortition effects, however, the effect of sonority-increasing lenition constraints must also be taken into account. This is the topic of §4.2.

4.2. Intervocalic voicing: Lenition as sonority increase

In addition to coda devoicing as neutralization-to-the-unmarked lenition, there are additional well-attested lenition patterns in which intervocalic obstruents (a subset of onsets) become *voiced.* These are cases of a distinct lenition type, lenition as sonority increase (called "sonorization" by Szigetvári, this volume). The combined effect of these various patterns is that as traditionally classified, "lenition" may involve either voicing or devoicing, and processes that involve onsets may include both "lenition" and "fortition". (Lavoie 2001: 7 also discusses the complexity of voicing with respect to lenition and fortition patterns, but handles it by classifying coda devoicing as a case of "neutralization" that is distinct from "lenition" proper.)

As recognized by Szigetvári (this volume) and Cser (2003), a consonant lenition process that involves an increase in sonority – typically involving voicing, spirantization, or gliding – does not usually produce a typologically less marked segment. From the perspective of context-free markedness, voiced obstruents are more marked than voiceless obstruents (as discussed in §4.1). Likewise, fricatives are more marked than stops, and glides are marked or non-prototypical consonants.

Given that sonority-increasing lenition does not lead to typologically unmarked segment types, it is significant that the contexts that are subject to this kind of lenition pattern are not necessarily the same as those that are subject to neutralization-to-the-unmarked lenition effects. As argued above, neutralization-to-the-unmarked lenition constraints are plausibly seen as the effect of a potentially context-free markedness constraint acting specifically on a weak position, either because the M constraint actually has a weak-position counterpart, or because the antagonistic F constraint has a strong-position counterpart that leaves the weak position unprotected from the effects of the M constraint. Sonority-increasing lenition constraints differ in that they are not plausible as context-free markedness constraints. Instead, they appear to be intrinsically *contextual* markedness

constraints; that is, they encode the fact that particular phonological feature values are less marked specifically in, e.g., an intervocalic or intersonorant environment. Therefore, it is not surprising that these constraints differ formally from a positionally relativized version of a context-free markedness constraint. In this paper, the term *positional constraint* is used for a positionally relativized version of a plausible context-free constraint, while a *contextual (markedness) constraint* is one that has no context-free version. Further predictions made by a system that ditinguishes positional and contextual cosntraints are discussed in §5.

The example of a sonority-increasing lenition process that will be discussed here with respect to phonetic grounding and typological predictions is the constraint that drives intervocalic voicing in obstruents. Similar functional motivations can be found, and similar patterns are predicted, when slightly different environments (intersonorant, postvocalic) and other types of sonorization (spirantization, gliding) are considered (see, e.g., Kirchner 2000, 2004; Lavoie 2001; Cser 2003).

The constraint responsible for driving intervocalic voicing can be formalized as follows.

(26) Contextual M constraint
INTERVVOI (IVV) (e.g., Hayes 1999)
Assign one '*' to each output segment that is [–son, –voi] in the context V_V

The phonetic basis for proposing such a constraint is as follows. Results presented by Westbury and Keating (1986), based on an articulatory model of the vocal tract, indicate that the phonetically natural state for an intervocalic stop in which the vocal folds are adducted as appropriate for voicing is to be voiced – the aerodynamic conditions are such that voicing is expected to occur unless it is actively prevented. By contrast, they find that stops in utterance-initial (specifically, #_V) or utterance-final (V_#) position are more compatible with voicelessness than voicing. Therefore, a context-free markedness constraint requiring stops, or obstruents, to be voiced is not phonetically grounded, as is consistent with the positing of the context-free constraint *penalizing* voiced obstruents, *OBSTVOI, in §4.1. However, a context-specific constraint that refers to a context in which obstruent voicing is articulatorily favored, such as INTERVVOI, is phonetically grounded. (See Kirchner 2000, 2004 for extensive discussion

of intervocalic lenition constraints, including constraints for voicing, spirantization, and degemination, and their phonetic basis.)

With the introduction of this constraint into the system, there are now five constraints under discussion, as summarized in (27).

(27) Constraints related to obstruent voicing patterns

a.	Context-free M	*OBSTVOI
b.	Positional M-len(wk)	*OBSTVOI(coda)
c.	Positional M-fort(str)	*ONSET/D
d.	F for voicing contrasts	IDENT[voi]
e.	Contextual M-len(ctxt)	INTERVVOI

With five constraints, the total number of possible rankings is 5!, or 120. The factorial typology of these constraints is presented in (28) below. The left column summarizes a ranking type that gives rise to a particular phonological pattern, while the right column indicates what attribute of that ranking type is phonologically significant. The numerical value in the center column gives the number of individual rankings that result in each phonologically distinct pattern.[8] For example, section (I) of the chart concerns a ranking type, labeled "ID highest," in which faithfulness prevails in all positions and therefore all positions have a contrast. There are 24 distinct rankings of these five constraints in which IDENT[voi] is highest (IDENT[voi] >> *OBSTVOI >> *OBSTVOI(coda) >> *ONSET/D >> INTERVVOI, IDENT[voi] >> *OBSTVOI(coda) >> *OBSTVOI >> *ONSET/D >> INTERVVOI, etc.), so the phonological pattern labeled "ID highest" has the indicated '#' value of 24.

[8] Anttila (1997) proposes that the number of distinct rankings that produce a particular phonological pattern should correlate with how frequently that pattern occurs in natural language. However, there are reasons to believe that is not in fact the case. In particular, Prince and Tesar (2004) argue that in the course of grammar learning, certain ranking types are systematically preferred over others based on criteria such as the restrictiveness of the grammars that they represent. Therefore, no particular significance is assumed here for the fact that different patterns in the factorial typology are produced by more or fewer distinct rankings.

(28) Factorial typology of voicing patterns

PATTERN TYPE	**#**	**CRUCIAL RANKING FACTOR**
(I) Contrast in all positions		*French, Hungarian*
ID highest	24	F has priority
(II) No voiced obstruents in any position		*Hawai'ian, Alyawarra, Tiwi*
*OV highest	24	Context-free M has priority
*O/D » *OV at top	6	Context-free M dominated only by [–voi]-favoring M
*OV(cod) » *OV at top	6	
{*O/D, *OV(cod)} at top	12	"Comp. dist." pattern: Onsets [–voi]; codas [–voi]
*O/D » IVV » {{*OV *or* *OV(cod)} » ID}	4	
(III) Lenition+contrast patterns *(2 types)*		*(a) German, Thai; (b) Burmese*
*OV(cod) » ID at top	6	(a) Coda devoicing only
IVV » ID at top	6	(b) Intervocalic voicing only
(IV) Complementary distribution: VdV, else voiceless		*Old English*
IVV » *OV at top	6	IVV » all [–voi]-favoring M; F dominated
IVV » *O/D » {{*OV *or* *OV(cod)} » ID}	4	
IVV » *OV(cod) » {{*OV *or* *O/D} » ID}	4	
*OV(cod) » IVV » {{*O/D *or* *OV} » ID}	4	M(cod) irrelevant for V_V; otherwise as above
(V) Contrast in #_, C._ only; lenition in V_V, coda		*"Coda Mirror" contrast*
{IVV, *OV(cod)} » ID » {*OV, *O/D}	4	F saves non-V_V onsets only
(VI) Contrast in coda position only *(2 types)*		*Unattested? (Accidental gap?)*
*O/D » ID at top	6	(a) Fortition+contrast pattern: All onsets [–voi]
*O/D » IVV » ID » {*OV, *OV(cod)}	2	
IVV » *O/D » ID » {*OV, *OV(cod)}	2	(b) VdV; other onsets [– voi]

Several of these ranking patterns – (I), (II), (IIIa), (VIa) – do not crucially involve INTERVVOI; languages instantiating these patterns (and a mention of (VIb)) were given in the preceding section. But now there are additional patterns to consider, where INTERVVOI is ranked high so as to exert an influence on phonological patterns.

First, with a second type of lenition constraint, there is now a second type of lenition+contrast pattern, where intervocalic obstruents must be voiced, but obstruents in other positions may contrast (pattern (IIIb) in (28)). Burmese (Okell 1969) is a fairly close match for this pattern, as voiced and voiceless (as well as voiceless aspirated) stops contrast in initial position, but are neutralized to voiced intervocalically within "compound words and expressions" (Okell 1969: 12). Burmese codas do not strictly speaking contrast for obstruent voicing, as the only possible codas are [ŋ] and [ʔ] word-finally or fully assimilated oral and nasal stops word-medially. Still, both voiced and voiceless codas do appear on the surface as a result of assimilation to the following onset.

(29) Burmese obstruents: Voicing contrast neutralized intervocalically, at least under certain morphological conditions (tones not shown)

a. Medial voicing alternation (Okell 1969: 12-13)

poũ	'can'	s^{h}iboũ	'oil can'
te	'hut'	boude	'rest house'
caʔ	'rupee'	ŋaɟaʔ	'five rupees'
/ka/	'dance'	kəjiŋga	'Karen dance'

b. Initial voiced obstruents (Okell 1969: 19)

boum^{h}u	'Major'
di	'this'

There is also a new type of complementary distribution, where intervocalic obstruents must be voiced, but other obstruents must be voiceless (pattern (IV) in (28)). This is the pattern seen in Old English fricatives, which were voiced intervocalically (as well as in cases where fricatives were subject to cluster assimilation constraints), and otherwise voiceless (Lass and Anderson 1975: 177–178).

(30) Old English fricatives: Voiceless and voiced in complementary distribution (Lass and Anderson 1975: 176)

a. Voiceless: word-initially and word-finally

[f]rēo	'free'	heal[f]	'half'
[θ]ēoh	'thigh'	ā[θ]	'oath'
[s]mītan	'smite'	mū[s]	'mouse'

b. Voiceless: geminate or in cluster with voiceless consonant

o[ff]rian	'offer'	æ[f]ter	'after'
mo[θθ]e	'moth'		
a[ss]a	'ass'	mæ[s]t	'mast'

c. Voiced: intervocalic

o[v]er	'over'
brō[ð]or	'brother'
rī[z]an	'rise'

A final pattern, (V) in (28), is one where both lenition patterns are operative, leading to voicing in intervocalic position and devoicing in coda position, so that only non-intervocalic onsets maintain a phonological voicing contrast. This pattern does not appear to be included in the survey of voicing patterns by Keating, Linker, and Huffman (1983). However, a special ability of the subset of non-intervocalic onsets to maintain particular phonological contrasts that are neutralized elsewhere – in particular, in onsets that are intervocalic – is precisely the type of evidence that has led Ségéral and Scheer (2001, this volume; Scheer 2004) to identify a position they call the Coda Mirror (because its linear characterization, '{#,C}_', is the mirror image of the coda position, '_{#,C}'). Since the Coda Mirror is documented as resisting both synchronic and diachronic lenition processes (Ségéral and Scheer 2001), it is fully expected that it should be able to maintain a voicing contrast in obstruents even when intervocalic onsets and codas undergo their respective lenition types.

Interestingly, however, the factorial typology in (28) suggests that in this OT approach to lenition and fortition processes, the behavior of the Coda Mirror as phonologically strong can be derived without formalizing the Coda Mirror as a "position," in the sense of a phonological constituent that can be directly referred to by the grammar. There are two basic types of strong behavior in the Coda Mirror as discussed by Scheer (2004) and Ségéral and Scheer (2001, this volume): *fortition* and *contrast preserva-*

tion. Both of these special behavior types are included in the factorial typology in (28). The pattern where only the Coda Mirror maintains a phonological contrast is the one in pattern (V). Here, the coda position is subject to neutralization-to-the-unmarked lenition and the intervocalic context is subject to sonority-increasing lenition, leaving only the non-intervocalic onsets as a kind of elsewhere case – the only obstruents still protected by the non-positional, non-contextual faithfulness constraint IDENT[voi]. Similarly, the pattern where only the Coda Mirror undergoes fortition can be seen among the rankings in (IV) of (28). Any ranking in which onset devoicing occurs (*ONSET/D >> IDENT[voi]), but intervocalic voicing takes even higher priority (INTERVVOI >> *ONSET/D >> IDENT[voi]), will produce a language in which only Coda Mirror consonants undergo fortition – intervocalic onsets submit to lenition, leaving initial and post-C onsets once again to form an elsewhere case.

Whether or not all known cases of Coda Mirror behavior can likewise be reduced to the status of an elsewhere case is a question that deserves further investigation. Ségéral and Scheer (2001, this volume) and Scheer (2004) specifically argue that this is not always possible or desirable. Some of their arguments hinge on the descriptive symmetry of the coda and the Coda Mirror: preceding versus following the {#,C} disjunction, and being subject to lenition on the one hand versus fortition on the other. Other arguments are based in a particular theoretical conception of lenition and fortition processes. Because the phonological framework used by Ségéral and Scheer is significantly different from that assumed here, arguments of these two types need more systematic and detailed consideration than is possible in this paper. However, as one more contribution to the debate, I can note two hypothetical phonological patterns that are not predicted under the system in (28), but are predicted if the Coda Mirror is a phonological position.

First, the constraint types in (28) cannot account for a pattern in which all[9] Coda Mirror consonants either remain unchanged or undergo lenition while intervocalic onsets undergo fortition. This is because intervocalic onsets are only subject to fortition by virtue of being onsets, a natural class that also includes Coda Mirror consonants. So unless the Coda Mirror is a phonological position, there is no way to account for this set of consonants

[9]Strong behavior in word-initial onset position only is something that the OT approach can model; see the related discussion in §3.3.

failing to undergo fortition along with intervocalic onsets. (Recall that the same problem does not arise when intervocalic onsets undergo lenition, since the V_V context does have context-specific lenition constraints.) Interestingly, Scheer (2004: 683) derives the following effect from his formal treatment of the Coda Mirror: "if lenition occurs in the Strong Position [the Coda Mirror position], it is predicted that weak positions will also be affected." So the discovery of a phonological pattern of this type would actually be a problem both for the model in (28), in which the Coda Mirror has no official phonological status, and for the specific formalization of the Coda Mirror as a phonological position in Scheer (2004).

The second pattern that, if attested, would pose problems for the view that the Coda Mirror reduces to an elsewhere case would be a language in which all Coda Mirror consonants were subject to fortition but intervocalic consonants were left unchanged, fully contrastive for the phonological property in question. This is because the system in (28) allows intervocalic onsets to be exempt from a fortition process affecting all other onsets (i.e., Coda Mirror consonants) only by virtue of undergoing lenition. If intervocalic lenition is out of the picture, then (28) predicts either all onsets undergoing fortition, or all onsets remaining unchanged.

In any case, pending an additional examination of the typology of Coda Mirror effects, it is clear that much of the phonological behavior specific to that position is derivable as an elsewhere effect within the factorial typology of a set of lenition-driving, fortition-driving, and faithfulness constraints like that in (28).

4.3. Comparing the two lenition types

The discussion in §4.2 identifies a significant difference in how the two types of lenition are to be approached in the OT framework. Namely, the space of possible OT analyses for sonority-increasing lenition is more highly constrained than that for neutralization-to-the-unmarked lenition. As discussed in §3.4, a neutralization-to-the-unmarked lenition pattern such as coda devoicing has two possible formal approaches: positional markedness (M(wk)) or positional faithfulness (F(str)) constraints. For sonority-increasing lenition, however, the domain-specific constraint can only be a markedness constraint, for two reasons. First, the context "other than V_V" is not a phonological natural class that a putative "contextual" faithfulness constraint could refer to. Second, even if such a context-specific faithful-

ness constraint could be stated, it would have to interact with a context-free markedness constraint. But the existence of such a constraint would not generally be plausible, since the types of phonological processes involved in sonority-increasing lenition are not guaranteed to result in typologically less-marked segments – only *contextually* less-marked segments. Thus, sonority-increasing lenition receives a typologically consistent, functionally grounded account only in terms of a contextual markedness constraint, such as INTERVVOI, which has the context specified as part of the intrinsic definition of the constraint.

As pointed out by an anonymous reviewer, another difference between the two lenition types is that sonority-decreasing lenition appears to be less likely to obliterate contrasts between phonemic categories in a language. For example, a language might have a pair of lenition processes that form a chain shift, such as intervocalic voicing of voiceless stops along with intervocalic spirantization of voiced stops. In such a language, the /p/-/b/ contrast is consistently maintained whether the two categories are realized as [p]-[b] or as [p]-[β]. Gurevitch (2004) presents a survey of 230 phonological processes in 153 languages, nearly all of which are cases of what would be classified here as sonority-increasing lenition, and reports that 92% of the processes considered are "non-neutralizing" (Gurevich 2004: 6).

It is important to interpret this claim carefully, however, because Gurevich uses the term *(phonological) neutralization* in a very specific sense: to describe a situation in which a phonological process actively applies such that in some particular context, two phoneme categories that are distinctive elsewhere in the language are realized with the same surface allophone. This use of the term *neutralization* explicitly excludes a number of situations that *would* be classified as neutralization in OT, given richness of the base (§2.2), because any time there is a predictable phonotactic pattern or an inventory restriction, showing that a markedness constraint dominates a faithfulness constraint, then it is the case that some *potential* phonological contrast is neutralized. For example, a language in which phoneme A is never found in a particular environment would be considered a neutralization between A and something else (possibly zero, possibly another phoneme) in that environment. Gurevich's survey includes ten such cases, which she classifies under the label "distributional property" (Gurevich 2004: 301–312), but in her system they are categorized as non-neutralizing because they are not the result of active alternations.

Similarly, if obstruent voicing is predictable in a language, this would be seen as a case of neutralization in OT (even if the realization of the

[±voice] feature varies by context), because the faithfulness constraint IDENT[voice] is dominated by one or more markedness constraints that render the potential contrast between voiced and voiceless obstruents neutralized. However, in Gurevich's system, Ao (to take just one example), which has voiced obstruents intervocalically and adjacent to other voiced consonants but voiceless obstruents elsewhere – similar to the complementary distribution pattern (IIIb) in (28) – is also categorized as non-neutralizing (Gurevich 2004: 58). Thus, if the results of the Gurevich survey were systematically reclassified using an OT-compatible definition of neutralization, the percentage of non-neutralizing cases would be considerably lower than 92%.

This is not to say that *all* of the cases discussed by Gurevich (2004) are neutralizing in the OT sense. Chain-shift patterns do also occur; for example, languages in the Gurevich survey that have both voicing of voiceless stops and spirantization of voiced stops in the same phonological context include Malayalam, Northern Corsican, Sanuma, and Senoufo. But it is still not clear that there is anything deeply significant about the apparently greater tendency for sonority-increasing lenition to avoid neutralization between (attested) phonemes[10] as compared to neutralization-to-the-unmarked lenition. By definition, neutralization-to-the-unmarked lenition forces certain phonemes to be realized as less marked phonological categories, which in the usual case already exist in the language by virtue of their typologically less-marked status (see also Cser 2003 on phonological processes that result in "anchored" versus "unanchored" segment types). On the other hand, it has already been shown that sonority-increasing lenition is not constrained by typological markedness, and so the probability that the outcome of a process of this type is a segment category not already present in the language is necessarily higher.

5. The two lenition types and the debate over positional constraints

The main goal of this paper has been to show how lenition and fortition processes can be modeled from the perspective of Optimality Theory, and

[10]Formal proposals in which the avoidance of contrast neutralization between phoneme categories of a language plays an active role in an OT grammar include Flemming (2001) and Lubowicz (2003).

to use facts about lenition and fortition to advance our understanding of the phonological constraint set Con. Several general results were obtained, identifying certain formally necessary characteristics of the universal constraint set. Fundamentally, it has been demonstrated that positionally or contextually restricted phenomena like lenition and fortition can be modeled in the first place only if Con includes constraints that are positionally or contextually relativized. Further results were then established about the nature of these positional or contextual constraints. Namely, the insight that neutralization-to-the-unmarked lenition and sonority-increasing lenition must be distinguished (Cser 2003; Szigetvári, this volume) translates into an OT-based observation that the first type of lenition is driven by positionally relativized versions of context-free markedness constraints (or entirely context-free markedness constraints interacting with positionally relativized faithfulness constraints), while the second type is driven by constraints that are inherently context-specific and need have no context-free counterparts. The fact that the specific positions or contexts involved in the two kinds of lenition are different (e.g., intervocalic position seems to be subject only to the second type) further reinforces the argument that these two types of lenition deserve formally distinct treatments.

Crucially, then, the discussion in §4 above assumes that part of the formal difference between the two lenition types involves a distinction between positional and contextual constraints. However, there is a debate in the OT literature as to whether there is such a thing as a positional constraint at all, or whether all domain-specific constraints should be formalized with reference to linear segmental contexts only. In early OT work in this area, it was generally proposed (or assumed) that there is a set of prosodically or morphologically defined strong and/or weak positions, such as syllable onset or coda, stressed or unstressed syllable, morphological root or affix, and initial or non-initial syllable, to which constraints can be positionally relativized. Phenomena of the neutralization-to-the-unmarked type have been addressed in this way by, among others, Beckman (1997, 1999) and Casali (1996, 1997) with positional faithfulness constraints, Zoll (1996, 1997, 2004) with positional markedness constraints, and Walker (2001) for both. Prosodically and morphologically defined positions have also been examined with respect to sonority and other perceptual salience-enhancing fortition effects by, for example, de Lacy (2001), Parker (2001), Smith (2000, 2004, 2005), and Gordon (2004). Smith (2004, 2005) presents a general formal mechanism by which constraints can be combined with such positions to produce positional constraints whose definitions are

formally computable from the definition of the context-free constraint and the nature of the position involved.

However, other researchers have argued that positions of this sort, especially prosodically defined positions, are not the appropriate way to characterize the domain of application of phonological processes, especially neutralization processes such as "coda" devoicing. Alternatives that refer to non-prosodically defined contexts have been proposed by, among others, Steriade (1999, to appear), Côté (2000), and Blevins (2003). In response to such proposals, work such as that by Gerfen (2001), Howe and Pulleyblank (2001), Wagner (2002), Flack (2006), and Moreton, Feng, and Smith (to appear) has argued that there are nevertheless cases where prosodically defined positions are necessary after all.

The distinction between the two types of lenition processes discussed in §3 and §4 has a contribution to make to this debate. If there are no positional constraints, then even neutralization-to-the-unmarked lenition would necessarily be contextual and not positional, making it more like sonority-increasing lenition, which is, as argued above, intrinsically contextual. However, this may not be a desirable outcome. There are several differences between the two subtypes of lenition that can be systematically accounted for if positional and contextual constraints are formally distinguished in the constraint set. In addition to the differences discussed above, concerning their relationship to typological markedness and the type of domain in which they apply, a third distinction between the two lenition types is their degree of phonological abstractness. Positional constraints involve the phonological combination of separately motivated constraints and positions, while contextual constraints involve an inherent phonetic relationship between the context and the constraint's requirement. This predicts greater phonological abstractness for markedness-decreasing lenition than for sonority-increasing lenition.

Indeed, markedness-decreasing lenition in Spanish (Gerfen 2001) and Nuu-chah-nulth (Howe and Pulleyblank 2001) involves marked segments being banned from coda position, despite being phonetically compatible with the linear context they would occupy as codas. That is, this pattern is phonologically abstract, not transparently phonetic. Conversely, sonority-increasing lenition is more restricted. For example, voicing and spirantization both occur intervocalically (Kirchner 2000). But only voicing occurs after nasals, and only spirantization occurs in the context V_C, because the phonetic contexts favoring voicing and spirantization are different. Contexts, being intrinsic to specific constraints, are not phonologically recom-

binable. This difference in phonological abstractness serves as a further argument that maintaining a formal distinction between positional and contextual constraints captures an important difference between the two types of lenition pattern.

In conclusion, while the question of what positions or contexts are relevant for phonological constraints is an area of ongoing controversy, it is clear that its outcome will both affect and be affected by our general understanding of lenition and fortition processes.

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