Treatments of weakness in phonological theory[1]

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In order to tackle questions such as "how have weak consonants or vowels behaved in the history of English", the authors in this volume have first had to decide what "weak" means: What counts as a weak segment, and what consequences does weakness have for that segment's behavior? What environments subject segments to weakening? What constitutes a weakening rule or process? This chapter attempts to provide some background for those decisions by giving a brief overview of how weakness, cross-linguistically, has been treated in phonological theory. For a detailed review of the history of the concept of lenition/weakness in phonological theory, see Honeybone (to appear).

Section 1 examines theories of which segments count as weak, and section 2 reviews explanations for weakening that have been offered. Section 3 returns to the question of what counts as weak, but now looking at a segment's context rather than its intrinsic properties. Section 4 discusses word-frequency effects. Finally, section 5 lists some items for further reading.

A few notes on terminology: First, the term "weak" is used comparatively here; one sound can be said to be weaker than another. Second, when discussing weakening processes, the term "weak" will be applied to sounds that have undergone the process (X weakens to Y) rather than to sounds that are vulnerable to the process. For example, if *aka* weakens to *aha*, it is *h* that is said to be weak (or at least weaker than *k*), because it is the end result of weakening, not *k* that is said to be weak because of its vulnerability to weakening. Third, this chapter will freely use "strong" to refer to the opposite end of the weakness scale (interchangeably called a strength scale) from "weak". And fourth, the terms "weakening" and "lenition" will be used interchangeably when referring to consonants, even though (as Honeybone to appear discusses) the two have not always been synonymous—*lenition* being derived from Latin *lenis* 'soft'; and the terms "weakening" and "reduction" will be used interchangeably when referring to vowels.

1. Segment-intrinsic weakness

Many researchers have proposed placing segments along a scale of strength, according to their intrinsic (that is, context-independent) properties. (See Harris 1985 ch. 2 and Honeybone to appear for reviews of this literature.) For example, we might claim that the segment *h* is weaker than *k*, all else being equal. Both operational and conceptual definitions of segment-intrinsic weakness have been used.

1.1 Operational definitions

Definitions of weakness run the risk of being circular, as noted by Harris (1985): we identify some segments as weak because they are the product of a rule that we regard as being a lenition/weakening rule. But the rule is identified as a lenition rule because it produces segments that we regard as weaker than the segments that were input to the rule. Defining weakness in terms of some observable independent property can help to escape this loop.

[1] Thanks to Donka Minkova, Patrick Honeybone, and Dani Byrd for their comments on this chapter; they should not be held responsible for its defects.

1.1.1 Pathways to zero

A definition of weakness that is useful for diachronic research—and very widely cited—is the one formulated by Hyman (1975); he credits the idea to Theo Vennemann: "a segment X is said to be weaker than a segment Y if Y goes through an X stage on its way to zero" (Hyman 1975, p. 165). For example,[2] Indo-European **k* became *h* in Germanic, as in proto-Indo-European **peku* 'wealth' > Old English *feoh* 'cattle, money'; this *h* then (at least in syllable-final position—and in some dialects, in all positions) became zero, as in Old English *feoh* 'cattle, money' > Modern English *fee* in the sense of 'wealth' (Watkins 2000). Under this definition, *h* is thus weaker than *k*. This definition is consistent with the practice of designating as weak those sounds that are vulnerable to deletion: X is weaker because it is farther along a chain of sounds that leads to zero.

Hyman and Vennemann's definition could be taken as generating a cross-linguistic scale of weakness (with perhaps some contradictions here and there that are due to peculiarities in individual languages' development). Or, it could be interpreted more narrowly, as defining a weakness scale that is valid for the language (or chain of successive languages, as in the example above) in which the change takes place. In either case, the underlying assumptions seem to be the following:

- (i) that zero is the weakest "segment" of all
- (ii) that any process causing deletion is inherently a weakening process, rather than a process of some other kind that happens to involve deletion in certain circumstances
- (iii) that whatever process changes Y to X is the same as the process that changes X to zero—hence the phrasing "Y goes through an X stage on its way to zero", rather than merely "Y becomes X, and then X becomes zero"

By assumption (i), zero is weaker than X, so by (ii), the process must be a weakening one. By assumption (iii), the change from Y to X must also represent a weakening, and X is thus weaker than Y. Assumption (i) seems plausible enough, and can be taken as a definitional assumption more than an empirical one; (iii), on the other hand, seems vulnerable as a general assumption about how changes are related. Bauer (1988), for example, in questioning this assumption, cites examples of circular shifts (*a* > *b*, *b* > *c*, *c* > *a*)—which cannot represent a movement in the same direction along any (Euclidean) dimension (though his circular examples do not involve deletions, and they appear to involve not a diachronic trajectory that doubles back on itself, but rather three changes occurring in parallel: *a*, *b*, *c* > *b*, *c*, *a*). Assumption (iii) seems most plausible when all three items—X, Y, and zero—can be observed to coexist as variants. This seems to be the situation (again, at least for syllable-final position), in many dialects of Spanish (see Bybee 2001 ch. 6), where conservative *s* coexists with the more innovative *h* and the most innovative variant, zero: the Hyman-Vennemannian interpretation would be that *h* is thus weaker than *s*. Ideally, to support (iii), we would be able to show grading, such as *s* predominating in the slowest or most careful speech, zero predominating in the fastest or least careful speech, and *h* predominating in speech of intermediate speed or carefulness. Hickey (this volume) reports such a case, where, in some varieties of Irish English, realizations of *t* in a word like *pity* can range from [t̪] through [h] and [ʔ] to Ø, with the glottal and zero realizations apparently more colloquial.

[2] Thanks to Donka Minkova for this example.

We could assign a synchronic interpretation to this definition, too: if a language has a rule whereby X becomes zero in some context and a rule whereby Y becomes X in the same or a similar context, then we could say that X is weaker than Y. For example, in Palauan (Flora 1974, Josephs 1975/1990, also Zuraw 2002), there is a synchronic chain shift whereby long /ii/ becomes short [i] when unstressed, but underlying short /i/ deletes (or, in many words, becomes [ə]) when unstressed: *ʔíis* 'escape', *ʔis-ɛ́l* 'his/her escape' vs. *ðík* 'wedge', *ðk-ɛ́l* 'its wedge'. (Similar changes apply to other vowels and diphthongs, but this is the clearest case because *i* is the vowel that deletes, rather than becoming [ə], most often.) If we assume, again, that zero is the weakest "segment", then the deletion of *i* when unstressed is a case of weakening; if we further assume that all changes occurring from a stressed to an unstressed syllable are of the same nature, then the change from *ii* to *i* must also constitute a weakening, and thus *i* is weaker than *ii*.

1.1.2 Segment-context associations

Another approach is to assume that weakening and non-weakening contexts exist (without stipulating which contexts are which; see section 3 for a review of strong and weak positions), and look for correlations between segment inventories and contexts. For example, we could look cross-linguistically at which vowels occur in stressed syllables and which in unstressed syllables (see Crosswhite 2001 for just such a survey). We could also look at which vowels occur in word-initial syllables and which in other syllables. We could collect (a) the set of all vowels that at least one language allows in stressed syllables but not unstressed, (b) the set of vowels that some language allows in unstressed but not stressed syllables, (c) the set of vowels that some language allows in initial but not non-initial syllables, and (d) the set of vowels that some language allows in non-initial but not initial syllables.[3] For example, on the dimension of nasality, Beckman's (1999) survey of positional faithfulness effects includes a language (Dhangar-Kurux—see p. 53) that allows both oral and nasal vowels in root-initial syllables, but only oral vowels in other syllables. Thus (a) would include nasal and oral vowels; (b) would be empty for the languages in Beckman's survey. Beckman's survey also includes two languages (Nancowry and Guaraní—see p. 126) that allow both oral and nasal vowels in stressed syllables and only oral vowels (except by harmony) in unstressed syllables. Thus (c) would, like (a), include both oral and nasal vowels, and (d) would, like (b), be empty (for comparisons on the dimension of nasality).

Suppose, as in the example above, we found that sets (a) and (c) were very similar, as were (b) and (d). Then we might conclude that stressed and initial syllables constitute "Type I" contexts, and the vowels in (a) and (c) are "Type I"-ish vowels; unstressed and non-initial syllables would constitute "Type II" contexts, and the vowels in (b) and (d) would be "Type II"-ish. We could then, arbitrarily, assign the labels "stronger" to Type I-ish vowels and "weaker" to Type II-ish vowels—we could also assign the labels using some less arbitrary criterion, such as Barnes's (2006) definition of weak contexts as those that allow a smaller range of contrasts. At least implicitly, this is the strategy that has been adopted by many researchers for identifying both weakening contexts and weak segments.

[3] More realistically, we would attempt to formulate implicational relationships among the vowels.

1.2 Conceptual definitions: phonetic and phonological hierarchies

It has also been proposed that a segment's degree of weakness follows from its articulatory or acoustic properties. Attempts to identify these properties have generally relied, at least implicitly, on some independent criterion of weakness (such as the Hyman-Vennemann definition above): we can't test the proposition that a phonetic property promotes weakness unless this weakness has some consequence that we can observe. Researchers often proceed by using some operational definition to identify weak segments and then seeking a shared phonetic property among those segments.

1.2.1 Resistance to airflow/constriction degree

Lass and Anderson (1975; p. 151) propose "resistance to airflow through the vocal tract" as one criterion for consonantal strength: the less resistance, the weaker the segment. In some cases, resistance to airflow corresponds to degree of constriction between the active articulator (for example, the tongue) and the passive articulator (for example, the palate). For example, oral stops (for example, *p*, *t*, *k*, *b*, *d*, *g*) involve a complete sealing off of the vocal tract (full constriction)—no air can flow out of the mouth or nose until the stop is released. These would be the strongest consonants. In fricatives, by contrast (for example, *f*, *s*, *v*, *z*), the constriction is incomplete, so that a small stream of air flows out the mouth. Fricatives are thus weaker than stops—this is consistent with many cases of stop-to-fricative changes that have been interpreted as weakening. Although *h* is usually classified as a fricative, it is a bit of a special case: turbulence in airflow arises not from a narrow constriction in the mouth but from substantial airflow through a relatively open glottis. Moreover, *h* lacks any oral articulatory target: Keating (1988) shows that the oral configuration during English *h* is an interpolation between the surrounding vowels'. Thus, *h* should be weaker than other fricatives—and has long been regarded as such—as supported by the Spanish *s* > *h* lenition mentioned above and other, similar changes. Papers in this volume by Crisma and Schlüter both deal with the weak behavior of *h* in the history of English.

The relationship between airflow and constriction becomes more complicated when we turn to sonorant consonants (for example, *r*, *l*, *m*, *n*, *w*, *y*); they allow a strong flow of air out the mouth or nose, but also may involve complete oral closure (*m*, *n*) or an active articulator that is partly in contact with the passive articulator, as in *l*, where the tongue tip or blade may be touching the alveolar ridge or the back of the teeth, but air is able to flow out the mouth around one or both sides of the tongue; thus airflow resistance and constriction degree are not as clearly correlated. Because fricatives, for example, do not seem to weaken to nasals (Kirchner 2004)—nasals having greater constriction than fricatives—constriction degree seems more likely to be the key factor.

The definition does not apply straightforwardly to vowels. Lower vowels (for example, *a*) have even less resistance to airflow than higher vowels (for example, *i*, *u*), but lower vowels seem to be less subject to deletion, and less compatible with positions thought to be weak, such as unstressed syllables (though see Crosswhite 2001, 2004 for a distinction between prominence reduction and contrast reduction—these two types of vowel reduction treat *a* differently).

1.2.2 Constriction duration

The *duration* of a consonant's constriction gesture has also been taken to be important (Kirchner 2004), with longer-lasting constrictions being regarded as stronger. This would—in accordance with the lenition literature—make the dialectal English flap or tap ([ɾ]), which has fleeting contact between tongue and alveolar ridge, weaker than *t* and *d*, where the contact is sustained. (But see section 3.2.1: Byrd & Saltzman 2003 show that gestural magnitude and gestural timing are hard to disentangle. Byrd & Saltzman discuss how timing changes can affect spatial magnitude, but we can also imagine the converse: a reduction in a stop gesture's spatial magnitude—without reduction of the gesture's duration—should cause full closure to be attained later and lost earlier, resulting in a shorter closure duration.) In addition, geminates would be counted as stronger than singleton consonants, and degemination would be considered a weakening process.

Among vowels, we could view vowels that take longer to realize as stronger. For example, the tongue position for schwa ([ə]) generally requires only a small excursion from the surrounding sounds (although of course this depends on just what the surrounding sounds are). Low vowels like *a*, by contrast, should take longer to articulate because of the greater jaw opening that must be achieved, and high vowels (*i*, *u*) could also take longer to reach, depending on the consonantal context. (See Crosswhite 2001, Barnes 2006 for reviews of the phonetics.) Thus, schwa would be weaker than other vowels. In tone languages, inherent differences in how long a vowel's tone takes to articulate (see Zhang 2002, 2004), could also conceivably affect vowel strength.

1.2.3 Acoustic amplitude

Another possibility would be to treat sounds with lower acoustic amplitude—corresponding perceptually to less loudness—as weaker. This would produce quite a different scale, and an unsatisfactory one in some respects. For instance, unreleased oral stops are very quiet, and so would be classed as weaker than fricatives, contradicting the usual assumption that the change from a stop to a fricative (spirantization) is an instance of lenition. Lower vowels are now, however, predicted to be stronger than higher vowels—the more-open vocal tract of lower vowels gives them higher amplitude, all else being equal.

1.2.4 Complexity

Many processes typically identified as consonant lenition involve loss of articulatory gestures: **debuccalization**, for instance, in which an oral stop becomes [ʔ] or an oral fricative becomes [h], involves loss of the oral constriction gesture. Building on this, Harris (1994, 1997) treats lenition as the loss of material from a segment's representation, and weakness as the relative lack of sub-segmental material. To take one of Harris's examples, *p* is made up of three **elements**—similar to privative features in other frameworks: labiality, stop-hood, and noise. The sound *p* is stronger than *f*, because *f* lacks stop-hood and is made up only of labiality and noise; *p* and *f* are both stronger than *h*, which is made up of noise only, or *w*, which is labiality only; *p* is also stronger than *ʔ*, which is stop-hood only (and all are presumably stronger than Ø, which would be the result of deleting all three elements). Harris treats vowel reduction and weakness in vowels similarly: *ə* is the weakest vowel, because it lacks any elemental content (see Lass this volume on schwa); the peripheral vowels *i*, *a*, *u* are stronger, each having a single element, and other vowels, such as mid vowels, are stronger still—that is, require more-direct licensing (see section 3.2.3)—being composed of multiple elements.

1.2.5 Abstract weakness

A weakness hierarchy could also, in principle, rely on an abstract phonological property rather than a more-concrete phonetic property. On the subject of abstract phonological properties in general, Flack 2007 argues that some properties of segments or contexts could be observable from phonetic experience—and thus constraints referring to those properties need not be innate but rather could be constructed by the learner using innately available templates—whereas others are not observable, and must be referred to by innately available constraints. These latter properties could be thought of as phonological rather than strictly phonetic. Flack takes as an example sonority, citing Parker 2002 to argue that it is an abstract phonological property that is correlated with but not identical to the phonetic property of acoustic intensity.

We might thus imagine that there is, similarly, an abstract property of strength/weakness, perhaps diagnosable from segment-context associations of the type sketched in 1.1.2. In Foley 1977, for example, there are various strength scales, all asserted to be purely abstract and divorced from their phonetic correlates. Foley's scales are derived from observing which rules apply to which segments in which contexts.

Anderson and Ewen (1987; see especially p. 176), note that processes they consider to be lenitive can involve changes along at least two distinct articulatory dimensions, voicing and reduction of constriction, which would require reference to diverse features such as [voice], [continuant], and [sonorant]. Anderson and Ewen take this as an argument against such features and in favor of segmental representations made up of |V| (vowel) and |C| (consonant) elements in various configurations. In this framework, lenition rules all have in common that a segment gains somehow becomes more vowel-like (lenition is a "shift towards |V|" p. 176), whether by gaining a |V|, by losing a |C|, or by moving an existing |V| to a more dominant position in the sub-segmental structure.

2. Markedness constraints driving weakening

Research that has attempted to explain why a set of changes regarded as lenitory should affect certain segments in certain contexts has yielded insights into what constitutes a weakening context or a weak segment.

2.1 Reduction of effort

The idea that speakers avoid articulatory effort (teleologically or epiphenomenally) has a long history in linguistics. Following the example of Boersma (1998), we could cite Passy (1890) and Martinet (1955), and add Zipf (1949), Donegan and Stampe (1979), and Boersma himself as other important proponents of **economy** as a driving force in language production, and thus in shaping linguistic typology.

The view of lenition processes specifically as arising from economy has been developed most extensively by Kirchner (1998, 2004), and has roots in Bauer's (1988) speculations about activity of the posterior cricoarytenoid muscle and its antagonist, the interarytenoid muscle. Bauer suggested that weaker segments might involve less muscular activity. Although Jacobs (1996) does not invoke effort in his analysis of French diachronic lenition, he does invoke the more general idea that in leniting contexts, if the grammar forbids some marked configuration such as voiced stops, the repair chosen will default to whatever is less marked—for example, if the [–continuant] specification of the [b] in Latin *habere* 'to have' is deleted, the default value for the feature ([+continuant] in this case) will be filled in, yielding **aβere* > modern *avoir* (see also Jacobs & Wetzels 1988 for a rule-based account).

Working in the framework of Optimality Theory (Prince & Smolensky 1993/2004) Kirchner proposes a constraint family LAZY whose members penalize the expenditure of effort, equated with biomechanical energy.[4] A segment that requires only a low expenditure of effort is viewed as weaker, and a process that reduces the effort expended to produce a segment is viewed as a weakening (lenition) process. The predicted effort of producing some consonant—Kirchner is concerned exclusively with consonants—is a function of the articulatory configuration required to achieve the consonant, the phonological context, and the speech register (essentially the speech rate here).

For example, changing *aka* to *aha* constitutes weakening, because the effort needed to move the tongue body from its low position in *a* to contact with the palate and back again is eliminated. At least in this context, *h* is weaker than *k*, because it requires less effort. The context *a__a* is a weakening context (at least for stops), because the effort required to achieve a complete constriction after and before the large jaw opening of *a* is great. The pressure to weaken would be stronger at a faster speech rate, because moving the tongue body faster is more effortful. Articulations that require precision are also considered more effortful (see 2.1.2).

Boersma (1998) takes a similar approach, calling the constraints penalizing effort *ENERGY rather than LAZY. Boersma decomposes the *ENERGY constraints into *DISTANCE, which penalizes displacing an articulator (in the direction away from the neutral position) by more than a certain distance; *HOLD, which penalizes keeping an articulator away from neutral position for more than a certain duration, and *FAST, which penalizes completing an articulator's displacement in less than a certain amount of time. He finds no evidence, however, for the phonology's treating these three components of the energy function separately.

In itself, an effort-based view doesn't distinguish lenition from other changes that reduce articulatory effort, such as place assimilation, where two successive gestures are simplified to one (for example, *anpa* → *ampa*, eliminating *n*'s tongue-tip/blade gesture); Donegan and Stampe (1979) explicitly group such processes together. It is unclear whether this is a desirable or an undesirable consequence—that is, which makes better predictions, separating processes traditionally viewed as lenition from other effort-reducing processes, or uniting them? Assimilation has been argued to occur in similar environments as lenition (see Harris 1994, 1997, where contrast-neutralizing assimilation, consonant lenition, and vowel-reduction are all linked), so perhaps uniting at least some of these processes is desirable.

2.1.1 Articulatory vs. acoustic weakening

The discussion above has focused on **articulatory weakening**, but there is also the possibility of **acoustic weakening**, especially in a diachronic perspective. Browman and Goldstein's (1990) classic example of acoustic weakening without articulatory reduction is of a token of the phrase *perfect memory* in which the *t* is articulated but is not audible, because it is overlapped by the surrounding consonants. Learners exposed to a language with many tokens like this might (mis)learn that the *t* should be articulatorily deleted. Thus, even though the context

[4] As pointed out by Pouplier (2003), the difficulty of producing a sound—as assessed, for example, by tendencies towards making speech errors—also depends on higher-level factors in the planning and coordination of gestures.

k__m might not be one that especially promotes articulatory weakening of *t* synchronically, it could well be a context that promotes diachronic weakening. (See Blevins 2004 on the diachronic effects of phonological mislearning, and see Davidson 2006 for evidence that English schwa deletion in fast speech is caused by overlap.)

McMahon (this volume) suggests that one of the factors favoring diachronic deletion of coda *r* in English was its acoustic similarity to the schwa that had come to precede it in most environments: a sequence like a sequence like *kliəɹ* 'clear' would be easy to mislearn as *kliə*.

2.1.2 Consequences of the effort-based perspective

Kirchner (2004) reviews a number of interesting consequences of viewing lenition in terms of biomechanical effort.

First, strength is not exactly equivalent to constriction degree or gestural magnitude. The precision required to produce the partial constriction of *s* could render it more effortful than the full constriction of *t*. Kirchner suggests that this could be due to the action of antagonist muscles that is required to hold the articulator in place. (Strident consonants like *s* require particular precision to achieve their characteristic strong turbulence.)

Second, when traditional featural descriptions of sounds don't match their gestural makeup, those descriptions may be misleading. For example, the voicing of intervocalic obstruents has been characterized as lenition. Consistent with this, Kirchner reports aerodynamic simulations finding that, intervocalically, a voiceless singleton stop requires an extra gesture of glottal spreading (*ata* is thus more effortful than *ada*); by contrast, in Kirchner's simulations a voiced geminate stop requires some extra gesture of cavity expansion (*adda* is thus more effortful than *atta*). Because [+voice] and [–voice] are implemented differently in the two types of sound, which feature value counts as weaker can be different.

Third—a closely related point—what counts as strengthening or weakening can depend on the context. As we just saw, under an effort-based view, intervocalically voicing a voiceless stop is weakening (because it eliminates the glottal abduction gesture that would be needed to suppress voicing—see Kirchner 1998 p. 70), but word-finally *de*voicing a voiced stop could be seen as weakening, because, just as with geminates, extra effort is needed to maintain voicing in this context.

2.2 Vowel reduction

Turning to vowels, the analog to lenition seems to be vowel reduction, which refers to changes that vowels in many languages undergo when in unstressed syllables. For example, many vowels in English become [ə] when unstressed, as in *photógraphy* (ph[ə]t[ɑ]gr[ə]phy) vs. *phótogràph* (ph[oʊ]t[ə]gr[æ]ph). Shortening of long vowels in unstressed position also occurs, as in the Palauan example above.

Crosswhite (2001, 2004) has argued that only some vowel-reduction systems involve reduced articulations. In these systems, vowels requiring greater jaw opening (for example, *a*) or greater displacement from neutral position (*a*, but also *i*, *u*) are disfavored in unstressed syllables. We could view this as effort minimization—especially in languages whose unstressed syllables are shorter than the stressed syllables, so that the rapid movement required to produce *a* in an unstressed syllable requires particular effort—but Crosswhite argues, on the basis of converse phenomena that increase the effort required in stressed syllables, that the phenomenon is actually something more abstract: an alignment of acoustically prominent vowels to prosodically prominent positions (stressed syllables).

Crosswhite also discusses an entirely different type of vowel reduction system, in which *non*-peripheral vowels—vowels other than *a*, *i*, *u*—are avoided in unstressed syllables. Crosswhite proposes that in these systems, difficult-to-perceive contrasts are licensed only in stressed syllables. (See also Flemming 2004 on dispersion.) She notes that in all languages known to be of this type, stressed syllables have longer duration, and argues that the shorter duration of unstressed syllables makes it more difficult to perceive subtle contrasts.

Barnes (2006) also examines vowel reduction cross-linguistically. He argues that typological patterns in which positions can support more contrasts result from phonologization of phonetic effects such as duration differences (for example, shorter duration can lead to articulatory undershoot and thus a smaller distinguishable vowel inventory in unstressed syllables).

The emphasis on weakening as a reduction in the number of contrasts supported by some position is mostly confined to vowels, though some authors have considered the neutralizing aspect of certain consonantal lenitions (for example, Harris 1997). Gurevich's (2004) survey of 230 lenition rules in 153 languages finds that 92 per cent of the processes are non-neutralizing: either (i) the result of lenition is distinct from any other phoneme or any allophone of another phoneme (the *t* → *t̺* change of Irish English discussed by Hickey in this volume is presumably a case of this type), or (ii) there is a chain shift such that the phoneme encroached upon itself undergoes a change and thus remains distinct (for example, /kk/ → [k] but /k/ → [x], as in a diachronic change in Numic discussed by Gurevich), or (iii) the contrast is shifted to another segment, as in American (and some other) English flapping, where /t/ and /d/ both become [ɾ], but a distinction is maintained in the length of the preceding vowel: [siɾəd] 'seated' vs. [siːɾəd] 'seeded' (cf. [sit] 'seat' vs. [siːd] 'seed').

3. Characteristically strong and weak positions

It has long been observed (for example, Escure 1977, Donegan & Stampe 1979, and even dating back to medieval grammarians of Late Latin, as discussed by Honeybone to appear) that some contexts are more associated with weakening than others. Consonants in intervocalic position, for example, display much more weakening than consonants in word-initial position.

3.1 Following from effort reduction

In the effort-reduction view described in section 2.1, a context for some segment is a weakening one to the extent that producing the segment in that context is effortful. Thus, whether a context is weakening can depend on the segment in question, just as which segment is weak can depend on the context.

3.1.1 Surrounded by segments that are far from the articulatory target = weak

The larger the movement needed to get to and from the target segment in some context, the more potential that context has to weaken the segment. (In Kirchner's terms, a faithful realization of the segment would violate a higher-ranked LAZY constraint.) For example, *a__a* is a powerful weakening context for stops, because the vocal tract is far from being in stop position during *a*. The context *i__i* is also a weakening context for stops, but less so, because less displacement is required to move from *i* to a stop and back again. Kirchner gives the example of Gorgia Toscana, an optional rule of Florentine Italian (using data from Gianelli & Savoia 1979; the discussion here draws also on Villafaña Dalcher 2006), where *p*, *t*, *k*, *g*, *tʃ*, *dʒ* become *ɸ*, *θ*, x, ɣ, *ʃ*, *ʒ* intervocalically (Gianelli & Savoia shown that sonorants and voiced stops can lenite too, and that the environment *V__{l,r}V* can also trigger lenition): *[k]asa* 'house' but *la [x]asa* 'the house'. The lenition can be even more extreme: *k*'s lenited realization can vary from *x* to *x̞* to *h* to zero. Kirchner argues that the zero realization of *k* is least common when the following vowel is high, supporting the idea that less effort is needed to produce a tongue-body constriction in the context of a high vowel than in the context of a lower vowel.

Various authors have reported that *k* is more susceptible to Gorgia Toscana (and it is velar lenition that presumably gives the phenomenon its name). Villafaña Dalcher considers various possible explanations for this, including aerodynamic and perceptual explanations. But an articulatory explanation that she discusses is particularly relevant here. Villafaña Dalcher notes that the gestural components—in the sense of Browman & Goldstein 1992—of vowels and velar consonants are in direct competition for the position of the tongue body: producing the sequence *aka* requires moving the tongue body all the way from *a*'s position to contact with the hard palate for *k*'s and then back again, a relatively large effort. By contrast, the competition between *a* and *t* for tongue-body position in indirect: *t* requires the tongue tip/blade to be in contact with the alveolar ridge or the back of the upper teeth—since the tongue tip and blade are connected to the tongue body this would be difficult to accomplish while keeping the tongue body exactly in position for *a*, but the tongue body can nonetheless remain close to its *a* position. The competition between *a* and *p* is also indirect, in that *a*'s tongue-body position is facilitated by an open jaw position, and lip closure for *p* is facilitated by a closed jaw.

3.1.2 In a context of short duration = weak

All else being equal, completing a movement in a shorter time requires more effort. Thus, contexts that require a segment to be executed quickly have more potential to weaken the segment. The simplest example is fast speech, which is well known to have a leniting effect. Positions within the word, phrase, or utterance that involve slowing, such as final positions within prosodic domains (see Byrd, Krivokapić & Lee 2006 for a literature review on lengthening at prosodic boundaries), would also be expected to show less lenition.

Kirchner proposes that the same force could be responsible for the greater leniting tendency of singleton consonants as compared to geminate consonants. In Gorgia Toscana, for example, geminate consonants rarely lenite—see Villafaña Dalcher p. 109).[5]

3.1.3 In context where clarity is less prized = weak

Regardless of speech rate, there may be more lenition in casual speech registers. Casualness could be a separate parameter in the calculation of effort, so that the same movement counts as more effortful in casual speech. Kirchner adopts this approach for convenience, but points out that different registers could also be associated with different constraints or constraint rankings.

[5] More generally, Kirchner 2000 proposes that the long-observed phenomenon of geminate inalterability, whereby geminates fail to undergo rules that apply to singleton consonants, holds universally only of lenition rules, not to other rules, which may or may not display geminate inalterability.

Effort might conceivably be reduced in contexts where contrasts will be less perceptible anyway. This is along the lines of Steriade's (1999a, 1999b) approach to positional neutralization: faithfully maintaining a distinction, for example that between *m* and *n*, becomes less important in contexts where that distinction is difficult to perceive.

3.2 Imposed by prosodic structure

Prosodic structure—the organization of phonological material into hierarchical units—can also create contexts of weakening and strengthening. At the phrasal and utterance levels, these effects are likely to be variable, but at the word level they could become phonologized and thus more regular.

3.2.1 Prosodic-domain-initial positions as strong

Keating 2006 provides a review of phonetic work, much of it by Keating and collaborators, showing that the beginnings of prosodic domains are associated with stronger articulations. For example (Fougeron & Keating 1997), there is more contact between the tongue and the palate during English speakers' articulation of *n* at the beginnings of units such as utterance, intonational phrase, phonological phrase, and phonological word than inside those units; overall, the higher the prosodic unit, the more contact at the beginning of that unit (though none of the speakers in Keating et al. 2003 distinguished all four unit types).[6]

We thus expect segments in prosodic-domain-initial positions to be less subject to weakening. For example, word-initial consonants should resist weakening. This prediction is somewhat difficult to test: for example, in a hypothetical word (of a hypothetical language) *keke*, the word-internal *k* is always intervocalic, whereas the first *k* could be preceded by a variety of segments, or even be utterance-initial. Thus, there could be other reasons why the first *k* should resist phonologized lenition. When it comes to variable lenition, however, the prediction is clearer: in a hypothetical two-phrase utterance like *bate kefe, kera min*, where the two *k*s are in identical segmental environments but the first is phrase-internal and the second is phrase-initial, the first *k* should be more likely to lenite.

Keating leaves open the question of how domain-initial strengthening is implemented in the grammar, suggesting some possibilities. It could be that articulatory targets become more extreme domain-initially. A possibility raised by Byrd and Saltzman (2003) in a simulation study is that domain-initial positions are associated instead with temporal stretching;[7] this increases the temporal duration of gestures, but also reduces overlap of adjacent segments' gestures, so that each can be realized with greater spatial magnitude.

3.2.2 Prosodic heads as strong

In the prosodic model of Nespor and Vogel (1986), prosodic domains not only group segments hierarchically, but also assign strong and weak status to their members. For example, a foot in English can group two syllables, marking the first as strong and the second as weak:

[6] Onsets of domain-final syllables were similar to onsets of domain-medial syllables. Strictly domain-final consonants were not included in the study; the utterances were composed of CV syllables. As for vowels, Fougeron and Keating found *strengthening* of domain-final vowels—in the sense of less linguo-palatal contact—perhaps because of their increased duration. There were no strictly domain-initial vowels, but vowels in domain-initial syllables and those in medial syllables were similar.

[7] Byrd & Saltzman are careful to state that temporal slowing provides just one possible mechanism for explaining initial strengthening, and that their results don't rule out other explanations.

foot

strong-syll. weak-syll.
bás *ket*

Within the English foot, the strong-weak distinction projects the stressed-unstressed distinction. Prominence at higher levels determines relative stress, as in the two-word phrase *wícker básket*, whose second member is marked as strong and receives greater stress.

Association to a strong position—especially a stressed syllable as opposed to an unstressed syllable—has been found to protect segments from lenition (see Lavoie 2001, this volume; González 2003). This follows from the effort-based theory of lenition in languages whose stressed syllables have longer duration, but might require an independent explanation—perhaps along the lines of Crosswhite's proposal about association of prominent segmental material to prominent prosodic positions—in other languages. Even more striking are González's findings for certain Panoan languages, where foot heads act as strong contexts and foot non-heads as weak contexts even when there is no stress anywhere in the foot, or the stress pattern has changed so as to contradict the footing suggested by the segmental alternations.

Schlüter (this volume) argues for a converse effect in the history of English: [h] was reintroduced—or strengthened, under the proposal that it had not really disappeared—in (Romance/Greek) words with initial stress (*héro*), but words without initial stress (*heróic*) resisted the reintroduction.

3.2.3 Well-licensed positions as strong

Some work on lenition in Dependency Phonology and Government Phonology has relied on structural relations to assign strength by position (for example, Harris 1994, 1997; Ségéral & Scheer to appear—for a comparison of the two approaches, see Szigetvári 1999).

In Harris 1994 and 1997, in order to be pronounced the featural material in a segment's representation must be **licensed** by association to a segment—if featural material is deleted or unpronounced because of being unlicensed, lenition results (see 1.2.4). A segment must in turn be licensed by its relationship to a syllable head (nucleus), which, if not itself stressed, must be licensed by another nucleus that is. The more indirect the association of a segment to a stressed nucleus, the less able the segment is to license featural material, and the more subject it is to lenition. In the English words *bút* or *bútter* (using acute accent to mark stress), for example, the *t* is in a weak position, because, in this framework, it is licensed by the following nucleus—in the case of *bút*, an empty following nucleus—which in turn requires licensing by the stressed nucleus *ú*. Accordingly, these *t*s are subject to lenition in various dialects (for example, see Hickey this volume for Irish English). In *tóp* or *atóp*, by contrast, the *t* is in a relatively strong position, because it is licensed directly by the following stressed *ó*. Harris extends the approach to vowels: an unstressed vowel is in a weaker position because it requires licensing by a stressed vowel.

In Ségéral and Schemer's (to appear) approach, consonantal positions are either licensed (if followed by an overt vowel) or unlicensed (if not), with unlicensed consonants, as in *at*, weaker than licensed, as in *ta*. There is a second source of weakness, however: **government**. A consonant is governed if it is both followed and preceded by an overt vowel (as in *ata*), and being governed renders a consonantal position weak. Ségéral and Scheer argue that unlicensed consonants and governed consonants are subject to different types of weakening, and this idea is explored further in Szigetvári 1999.

3.3 Interactions of segmental weakness and positional weakness

The relationship between inherently weak segments and weak positions is unclear. There are cases where weak segments are absent from weak positions, such as the absence of syllable-final [h] in English, and of syllable final [r] in many dialects of English. This could be thought of synchronically as a ban on weak segments in weak positions, but diachronically these segments simply underwent weakening—to zero—as would be expected in a weak position.

There do seem to be cases of weak segments' being banned in strong positions. Flack (2007) discusses segments that some languages ban in syllable onsets but allow in syllable codas: [ŋ] (as in English), glottals, liquids, rhotics, and glides. Depending on our definition of segment-inherent weakness, many of these would be considered weak segments. She demonstrates the same segments can be banned word-initially (even when allowed in word-medial syllable onsets), and some of them are banned utterance-initially or foot-initially.

4. Frequency effects

As Bybee and colleagues (see Bybee 2001 for review) have shown in a variety of languages, lenition is more advanced in words that are more frequent. For example, Bybee has shown (in Hooper 1976) that in English, schwa deletion is more advanced in high-frequency words like *every*, *camera*, *memory* and *family* than in low-frequency words like *mammary*, *artillery*, and *homily*.[8]

Bybee's explanation is that phonetic changes—especially weakening changes—apply every time a word is used, and the phonetic detail in the lexical entry for the word is updated in response by the listener and/or speaker, affecting subsequent productions of the word. Since higher-frequency words are used more often, they are subjected to this process more times and develop more-lenited lexical representations. Pierrehumbert (2001) has implemented this idea within an exemplar model. Whether weakening is special in its interaction with frequency is unclear, as Labov 2006 points out.[9] Pierrehumbert notes (2002, p. 118) that, in the Pierrehumbert 2001 model, the nature of the sound change—for example, lenition vs. fortition—plays no role, and all types of "systematic bias in the allophonic outcome" (as opposed to analogical changes) should have the same interaction with frequency. Thus, if lenition is indeed different, something more must be added to the model.

[8] But see also Phillips 2006, which examines lexical diffusion in many different English sound changes, and finds that some changes affect the most frequent words first, but others affect the least frequent words first. Phillips concludes that changes affecting the most frequent words first are those that involve relatively raw phonetic motivations, with no access to other components of the grammar needed.

[9] Examining the fronting of certain vowels—/uw/ as in *too*, /ow/ as in *toe*, /aw/ as in *cow*—that is currently taking place in most of North American English, Labov does not find evidence for a word-frequency effect, though the data he examines were not collected with frequency in mind and may simply not have a wide enough variety of word-frequencies to test for an effect.

5. Further reading

- Kirchner 1998, a dissertation on lenition, proposes and develops the LAZY theory. A shorter presentation of the main idea can be found in Kirchner 2004.
- Brandão de Carvalho, Scheer, and Ségéral (eds--to appear) is a volume on lenition and fortition.
- Crosswhite 2001 and Barnes 2006 are book-length treatments of vowel reduction. Crosswhite 2004 presents some of the ideas in Crosswhite 2001 in shorter form.

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