CHAPTER 5

[t, d]-DELETION IN ENGLISH

In English, a coronal stop that appears as last member of a word-final consonant cluster is subject to variable deletion – i.e. a word such as *west* can be pronounced as either [wɛst] or [wɛs]. Over the past thirty five years, this phenomenon has been studied in more detail than probably any other variable phonological phenomenon. Final [t, d]-deletion has been studied in dialects as diverse as the following: African American English (AAE) in New York City (Labov et al., 1968), in Detroit (Wolfram, 1969), and in Washington (Fasold, 1972), Standard American English in New York and Philadelphia (Guy, 1980), Chicano English in Los Angeles (Santa Ana, 1991), Tejano English in San Antonio (Bayley, 1995), Jamaican English in Kingston (Patrick, 1991) and Trinidadian English (Kang, 1994), etc.[1] Two aspects that stand out from all these studies are (i) that this process is strongly grammatically conditioned, and (ii) that the grammatical factors that condition this process are the same from dialect to dialect. Because of these two facts [t, d]-deletion is particularly suited to a grammatical analysis. In this chapter I provide an analysis for this phenomenon within the rank-ordering model of EVAL.

The factors that influence the likelihood of application of [t, d]-deletion can be classified into three broad categories: the following context (is the [t, d] followed by a consonant, vowel or pause), the preceding context (the phonological features of the consonant preceding the [t, d]), the grammatical status of the [t, d] (is it part of the root or

---

[1] This phenomenon has also been studied in Dutch – see Schouten (1982, 1984) and Hinskens (1992, 1996). With a few exceptions the factors determining the likelihood of deletion in Dutch are virtually identical to those observed in English.

is it a suffix).[2] The contribution of each of these three factors can be summarized as follows: (i) *The following context*. [t, d] that is followed by a consonant is more likely to delete than [t, d] that is followed by either a vowel or a pause. Dialects differ from each other with regard to the influence of following vowels and pauses. In some dialects, a following vowel is associated with higher deletion rates than a following pause. In other dialects this situation is reversed – i.e. more deletion before a pause than a vowel. (ii) *Preceding context*. In general, the more similar the preceding segment is to [t, d], the more likely [t, d] is to delete. Similarity has been measured in terms of sonority (higher deletion rates after obstruents than sonorants), but also in terms of counting the number of features shared between [t, d] and the preceding consonant. (iii) *Grammatical category*. Generally speaking, [t, d] that is part of the root (in a monomorpheme like *west*) is subject to higher deletion rates than [t, d] that functions as a suffix (the past tense suffix in *locked*).

Of these factors, the first two can be classified as phonological and the third as morphological. Even though I acknowledge that morphology interacts with the process of [t, d]-deletion, I will discuss only the two phonological factors here. The rest of the chapter consists of a discussion within a rank-ordering model of EVAL of the following phonological context in §1, and the preceding phonological context in §2. There are at least three alternative accounts of variation in the OT literature. In section §3 I discuss these alternatives and show how they compare to the rank-ordering model of EVAL.

---

[2] In a summary statement of the phenomenon Labov (1989:89-90) actually identifies three additional factors, namely (i) whether the syllable to which the [t, d] belongs is stressed or unstressed, (ii) whether the cluster that the [t, d] belongs to consists of two or more consonants, and (iii) the voicing of the segments flanking the [t, d]. These three factors are less robust. Many studies that do report on these factors have found them not to contribute significantly to the likelihood of [t, d]-deletion. Several studies do not even report on these factors.

I assume familiarity with the rank-ordering model of EVAL in this chapter. For a general discussion of this and an illustration of how variation is accounted for in this model, refer to Chapter 1 and Chapter 3.

1. The following phonological context

One of the aspects that influence the rate of [t, d]-deletion is the nature of what follows the word-final [t, d]. The basic generalization can be stated as follows: (i) A [t, d] followed by a consonant is more likely to delete than a [t, d] followed by either a vowel or a pause. (ii) Dialects differ with respect to the relation between a following vowel and a following pause. In some dialects a following vowel is associated with higher deletion rates than a following pause, while in other dialects a following pause is associated with higher deletion rates than a following vowel. In this section I present an analysis of the effect of the following context on the [t, d]-deletion rate.

I will analyze the influence of the following context within the "licensing by cue" approach to phonological neutralization (Steriade, 1997). According to this approach, a sound is more likely to be neutralized in a context where it is more difficult to perceive the sound accurately. The assumption is that sounds are perceived/identified based on acoustic cues to their identity. However, not all cues are equally robust in all contexts. For instance, one of the cues for identifying the place of articulation of a consonant is the formant transitions from the consonant into a following vowel. This cue for place of articulation is therefore licensed in pre-vocalic position. However, if a consonant is not followed by a vowel, this cue for identifying the place of articulation of the consonant is not available as robustly. Place of articulation is therefore licensed more robustly in pre-vocalic than, for instance, pre-consonantal position. Consequently, place of articulation is more likely to be neutralized in pre-consonantal than in pre-vocalic position.[3]

I will claim that stop consonants are less robustly licensed in pre-consonantal position than either pre-vocalic or pre-pausal position. This is the reason why [t, d] in pre-consonantal position deletes (is neutralized) more frequently than [t, d] in pre-pausal or pre-vocalic position. The robustness of licensing in pre-vocalic and pre-pausal position is subject to dialectal variation. In some dialects stop consonants are licensed more robustly pre-vocalically than pre-pausally, and *vice versa* in other dialects. This explains why some dialects delete [t, d] more before vowels and others more before pauses.

The rest of this section is structured as follows: In §1.1 I will present a selection of the data from the literature on the influence of the following context on [t, d]-deletion. These data will be analyzed within the rank-ordering model of EVAL in §1.2. Finally, in §1.3 I will consider alternative explanations for the influence of the following context. In particular, an analysis will be considered that relies on re-syllabification across word boundaries rather than on licensing by cue.

1.1 The data

The table in (1) contains a representative sample of the data on how [t, d]-deletion interacts with the following phonological context. Before discussing the pattern observed in these data, I will first give background on how the data were collected.

---

[3] This is indeed true. When a two consonant cluster occurs inter-vocalically, it is usually the first consonant that assimilates in place to the second – i.e. the place of the pre-vocalic consonant is preserved while the place of the pre-consonantal consonant is neutralized. See, for instance, place assimilation between the English negative prefix /in-/ and labial or velar initial roots: *i*[mp]*ratical* and *i*[ŋk]*onclusive*.

(1) **The influence of following context on [t, d]-deletion (in percentage)**[4]

		Pre-C	Pre-V	Pre-Pause
Chicano English (Los Angeles)	*n*	3,693	1,574	1,024
	% deleted	62	45	37
Tejano English (San Antonio)	*n*	1,738	974	564
	% deleted	62	25	46
AAE (Washington, DC)	*n*	143	202	37
	% deleted	76	29	73
Jamaican mesolect (Kingston)	*n*	1,252	793	252
	% deleted	85	63	71
Trinidadian English	*n*	22	43	16
	% deleted	81	21	31
Neu data	*n*	814	495	–
	% deleted	36	16	–

The data on the Chicano English are from Santa Ana (1991:76, 1996:66). These data are based on 45 speakers of Chicano English in the Barrio of Los Angeles that represent a balanced sample in terms of age and socio-economic status.

The data on Tejano English were collected by Bayley (1995:310). The data are from 32 speakers of Tejano English, all of whom live in the same housing project in San Antonio.

---

4 Guy (1980) also reports on the English spoken by white Philadelphians and white New Yorkers. Unfortunately, he only reports the VARBUL factor values associated with the different contexts and not the actual deletion rates. Since it is not possible to determine the deletion rates based on the factor weights, I cannot use Guy's data. One thing that is clear from Guy's data, however, is that also in these two dialects pre-consonantal position is associated with higher deletion rates than pre-vocalic and pre-pausal position.

Labov *et al.* (1968:102) report on the English spoken by African Americans and Puerto Ricans in Harlem. Unfortunately, they lumped pre-consonantal and pre-pausal contexts together. They found high deletion rates before consonants and pauses (85% out of 1,929 tokens), and low deletion rates before vowels (34% out of 992 tokens).

The Washington, DC AAE data are from Fasold (1972:76). It is based on data collected from 51 speakers from a wide range of socio-economic classes and ages. Fasold considered only [t, d] that served as past tense markers – i.e. these data do not include deletion rates in monomorphemic words such as *west*.

The Jamaican data were collected by Patrick (1991:181) from 10 speakers of the Jamaican mesolect spoken in the Veeton suburb of Kingston. The speakers are representative of the social and educational classes of the community.

The data on Trinidadian English are from Kang (1994:157), and are based on the English of 13 middle class male speakers of standard Trinidadian English.[5]

The last set of data in data in (1) is from Neu (1980:45). It is based on the speech of 15 speakers from diverse backgrounds. Even so, Neu claims that these data reflect a sample from a homogeneous population. She performed several chi-square tests to test the null hypothesis that all the speakers showed the same deletion patterns (p. 41). The null hypothesis could never be rejected. Neu unfortunately did not report on pre-pausal context.

Now we can consider the patterns that are visible in these data. The data show that in all of these dialects of English, pre-consonantal context is associated with higher deletion rates than both pre-vocalic and pre-pausal context. It also shows that in some

---

5 The very low number of tokens makes these results somewhat tentative. However, the general pattern agrees with the pattern observed in other dialects of English (more deletion in pre-consonantal than pre-vocalic or pre-pausal context). We can therefore tentatively accept these data. Kang also reports on the mesolectal and basilectal versions of Trinidadian Creole. However, these varieties of Trinidadian show very high deletion of final [t, d] across the board, something that Kang attributes to "strict syllable structure constraints … which rarely allow syllable-final consonant clusters" (p. 155). The combination of the high deletion rate and the very small number of tokens in Kang's corpus results in insignificant differentiation between the different contexts.

dialects [t, d] in pre-pausal context deletes more than [t, d] in pre-vocalic context (Tejano, Washington, DC AAE, Jamaican). In other dialects [t, d] in pre-vocalic context deletes more often than [t, d] in pre-pausal context (Chicano). The dialects can therefore be divided into two classes with deletion rates related as follows (in order of declining deletion rate): (i) pre-consonantal > pre-pausal > pre-vocalic, (ii) pre-consonantal > pre-vocalic > pre-pausal.

The data from table (1) are represented in a different format in (2). In this table the three contexts for each dialect are arranged according to the deletion rate associated with each context. Contexts with higher deletion rates occur to the left, and contexts with lower deletion rates occur to the right. A broken vertical line is drawn to indicate the 50%-mark. Contexts to the left of these lines are associated with deletion rates of above 50%, and contexts to the right of these lines show less than 50% deletion.

(2) **The influence of following context on [t, d]-deletion**

(Pre-C = pre-consonantal, Pre-V = pre-vocalic, Pre-P = pre-pausal.)

		← More deletion		50% ↓	Less deletion →	
Chicano (Los Angeles)			Pre-C		Pre-V	Pre-P
Tejano (San Antonio), Trinidian			Pre-C		Pre-P	Pre-V
AAE(Washington, DC)		Pre-C	Pre-P		Pre-V	
Jamaican (Kingston)	Pre-C	Pre-P	Pre-V			
Neu data					Pre-C	Pre-V

In the rank-ordering model of EVAL we account for two aspects of variation: (i) *Inter-contextual variation*. For a specific input, which of the two variants (deletion or retention) is the more frequently observed variant? For the English dialects discussed here, this information can be read off from the table in (2) as follows: If a context appears to the left of the 50% mark, then deletion is preferred is the more frequent variant. If it appears to the right of the 50% mark, then retention is the more frequent variant. (ii) *Intra-contextual variation*. Here we compare inputs from different contexts and ask which context has the higher deletion rate. This information can also be read off table (2). If for some dialect $context_1$ appears to the left of $context_2$, then $context_1$ has a higher deletion rate than $context_2$.

1.2 The analysis

In this section I will provide an analysis for the data in table (2). The section will start out in §1.2.1 with a discussion of the constraints involved. In §1.2.2 I will then show how the constraints can be ranked to account for each of the patterns exemplified in (2). Section §1.2.3 will consider the factorial typology that is predicted by the constraints that I propose in §1.2.1 – i.e. in addition to the dialects in table (2), which other dialects are predicted to be possible? Finally, in §1.2.4 I will discuss two outstanding questions: (i) does only [t, d] delete, and (ii) does word-final [t, d] also delete post-vocalically?

1.2.1 The constraints

Since the unfaithful mapping that we are dealing with here is one of deletion, the faithfulness constraint involved in explaining this pattern is the anti-deletion constraint MAX. In order to explain why this constraint is sometimes violated, we need markedness constraints that would be violated by the faithful non-deletion candidates. I will argue that the relevant markedness constraints are contextual licensing constraints (Steriade, 1997).

This type of constraint was first formulated to explain the contextual distribution of phonological contrasts. The idea is that a contrast is preserved (licensed) more easily in contexts where the cues for its perception are more salient than in contexts where these cues are less salient. For instance, one of the most salient cues for the voicing distinction in stop consonants is voice onset time (VOT) (Lisker and Abramson, 1964, Lisker, 1986). VOT is the time that elapses between the release of consonantal closure and the onset of voicing. VOT is more robustly licensed before a sonorant segment such as a vowel than before a word boundary. The result is that voicing is more easily neutralized before a word-boundary than before a vowel. Steriade (1997) captures this generalization by formulating a markedness constraint against voicing in each of these two contexts, i.e. *voice/ __ [+sonorant] (violated *inter alia* by a voiced stop in pre-vocalic position) and *voice/ __ # (violated by a voiced stop before a word-boundary). Steriade further argues that the constraint against voicing in the less robustly licensing context universally outranks the constraint against voicing in the more robustly licensing context, i.e. ||*voice/ __ # o *voice/ __ [+sonorant]||. A word-final voiced stop then violates a higher ranking markedness constraint than a pre-vocalic voiced stop. This implies that a word-final voiced stop is more likely to devoice than a pre-vocalic voiced stop.

In this section I am distinguishing three different word-final contexts that interact with the likelihood of [t, d]-deletion, namely pre-consonantal, pre-vocalic and pre-pausal. I propose a constraint against realizing a [t, d] in each of these three contexts. The three constraints are stated in (3a). Furthermore, based on the fact that pre-consonantal context is associated with higher deletion rates in all of the dialects studied, I claim that the constraint against [t, d] in this context outranks the other two markedness constraints. This is shown in (3b). A motivation for these constraints and this ranking follows below.

(3) a. **Markedness constraints**

*Ct#C: A word-final [t, d] is not allowed if it is both preceded and followed by a consonant.

*Ct##: A word-final [t, d] is not allowed if it is preceded by another consonant and followed by a pause.

*Ct#V: A word-final [t, d] is not allowed if it is preceded by another consonant and followed by a vowel.

b. **Ranking**

||*Ct#C o {*Ct##, *Ct#V}||

In order to motivate the existence of the constraints in (3a) we need to determine what the cues are for identifying a [t, d], and then we need to show that these cues are differently realized in these three contexts. In order to motivate the ranking in (3b), we need to show that the cues for identifying [t, d] are less robustly realized in pre-consonantal context than in pre-pausal or pre-vocalic context.

There are two aspects of the identity of a [t, d] that need to be conveyed in order to distinguish [t, d] from other consonants: (i) its manner of articulation (to distinguish it from continuants and sonorants), and (ii) its place of articulation (to distinguish it from stops of other places of articulation). Since the environment preceding the [t, d] is the same in all three contexts under consideration, I will focus only on the following environment – i.e. what are the cues for place and manner of articulation following a consonant?

In the literature two aspects are identified that can cue the place and manner of articulation of a consonant, namely the release of the consonant and the formant transitions from the consonant into a following sonorant. I will first discuss the cues available in consonant releases, and then the cues available in formant transitions.

Consonant releases. With regard to consonant releases, Stevens and Keyser argue that the most important distinctions in both place and manner of articulation can be cued successfully by how spectral energy distributions change at consonant releases (Stevens and Keyser, 1989:87). The distinction between [-continuant] and [+continuant] consonants is cued by the fact that non-continuants are characterized by an abrupt increase in amplitude over a range of frequencies at the release of the consonant. This is a result of the fact that the energy is absent (at most or all frequencies) during the closed phase of a non-continuant. In a continuant consonant energy is present over a wide range of frequencies during the complete consonantal pronunciation. There is therefore no abrupt rise in energy at the completion point of a continuant. With regard to place of articulation, Stevens and Keyser only comment on the distinction between coronal and non-coronal consonants. They argue that coronal consonants are cued by a greater increase in spectrum amplitude at high frequencies than at low frequencies at the termination point of the consonant. For non-coronals, spectrum amplitude is more likely to increase in the lower frequency ranges.

At least for place of articulation there is more evidence that the consonantal release carries enough information to cue the different places of articulation. See for instance Lahiri *et al.* (1984) who show that it is possible to correctly distinguish between labial and coronal voiceless stops based on the shape of the spectral energy distribution from the consonantal release to the onset of voicing. See also Malécot (1958) who shows that word-final stop consonants are more accurately identified when they are released than when they are not. All of this serves as evidence that consonant releases do contain cues that can be used to identify [t, d].

Formant transitions. There is also ample evidence that formant transitions from a consonant into a following sonorant can cue both place and manner distinctions. For instance, Stevens and Blumstein (1978:1363) found that synthetic stops that were cued by only formant transitions were identified 72% more accurately than synthetic stops that were cued by only bursts (i.e. releases). See also Kewley-Port (1983) and Kewley-Port *et al.* (1983) (and their references) for evidence that such "time-varying" cues can be used to identify place of articulation.

There is a large body of literature on "locus equations" (e.g. Celdran and Villalba, 1995, Eek and Meister, 1995, Fowler, 1994, Fruchter and Sussman, 1997, Nearey and Shammass, 1987, Sussman *et al*., 1991, Sussman and Shore, 1996). A locus equation is the equation for a straight line that connects the second formant (*F2*) height at vowel onset with *F2*-height at the vowel midpoint. These equations are remarkably constant within consonants with the same place of articulation, so that it is possible to define a single equation that characterizes each place of articulation. On the other hand, the locus equations for consonants that differ in place of articulation are very different. Locus equations can therefore be used to classify consonants successfully in terms of their place of articulation. This shows that formant transitions between a consonant and a following sonorant contain robust cues for identifying the place of articulation of the consonant.

What about manner of articulation? We have evidence that formant transitions can cue the distinction at least between stops and glides. Diehl and Walsh (Diehl and Walsh, 1989, Walsh and Diehl, 1991), for instance, have shown that the duration of the formant transitions can serve as a successful cue for the distinction between stops and glides. Longer formant transitions cue a glide percept, and shorter formant transitions cue a stop percept.

We therefore know that both the release of a [t, d] and the formant transitions from a [t, d] into a following segment contain cues for its identification. How are these cues realized in the three word-final contexts that interact with [t, d]-deletion? *Pre-vocalic.* In pre-vocalic position, both consonantal releases and formant transitions can be realized – i.e. both cues are potentially present in this context. However, realization of these cues requires that [t, d] be released into and transition into a vowel *across* a word boundary.[6] *Pre-pausal.* With a pre-pausal [t, d] the possibility of transitioning into a following vowel does not exist – since there is no vowel following the [t, d]. For a [t, d] in this context, the cues contained in the formant transitions are therefore not available at all. However, pre-pausal stops can be released.[7] The cues contained in the consonantal

---

6 In this respect it differs from a consonant that precedes a vowel that is part of the same word – such a consonant can be released into and transition into the following vowel without crossing a word boundary. We can therefore expect that both release and formant transitional cues will be less robust for a word-final consonant followed by a vowel than for a consonant followed by a vowel that is part of the same word. This is borne out by patterns observed in neutralization processes – consonants in onset position (i.e. preceding a vowel that is part of the same word) is much less likely to undergo a neutralization process than a consonant in word-final position.

7 See Holmes (1995:443) who claims that pre-pausal word-final /t/ is often aspirated in New Zealand English. Especially in aspirated stops, the release cues will be strongly present. Although I am not

release are therefore potentially available for [t, d] in pre-pausal position, and these release cues can be realized without crossing a word-boundary. *Pre-consonantal.* A pre-consonantal stop is practically never released,[8] so that the cues contained in the consonantal release are not generally available for pre-consonantal [t, d]. A consonant is also much less likely to have formant transitions into a following consonant than into a following vowel. In general, a consonant will only show formant transitions into a following sonorant consonant, and even then the transitions are less robust than transitions into a vowel. Weak formant transitional cues are therefore potentially available for a [t, d] followed by a sonorant consonant. As with the pre-vocalic context, formant transitions into a following sonorant would also require that the [t, d] transitions cross a word boundary. The table in (4) summarizes discussion.

The comparison in table (4) shows that pre-consonantal context is least likely to contain the cues necessary to identify [t, d]. Only transitional cues are potentially present. And even if they are present, they are present only weakly and only before a small subset of the consonants. This context is therefore the weakest in licensing the presence of [t, d].

---

aware of data showing that some American dialects aspirate pre-pausal word-final [t]'s, New Zealand English shows that it is at least possible.

8 Browman and Goldstein (1990:363-366) analyze two utterances of the sequence "perfect memory". In the first utterance the words were pronounced with a pause between them. In the second utterance they were pronounced as part of a sentence – i.e. with no intervening pause. They say of the second utterance: "the final /t/ in 'perfect' is deleted in the traditional sense – careful listening reveals no evidence of the /t/" (p. 365). Browman and Goldstein tracked the movement of the tongue tip with X-ray. A movement of the tongue tip towards the alveolar ridge was interpreted as evidence that the coronal articulation was indeed performed. They found evidence for the coronal articulation in both articulations, and in particular they found that the articulation was of roughly equal magnitude in both utterances. The perceptual absence of the /t/ is therefore not due the coronal articulation not being made. The difference between the utterances is located in the release. In the first utterance there is very clear evidence of a release in the waveform, but about the second utterance they say that "no release can be seen in the waveform" (p. 365). The reason for this is that the articulation of the /m/ from "memory" partially overlaps with the articulation of the /t/ from "perfect". When the coronal closure is released the labial closure is therefore already in place. The result is that the coronal release has no aerodynamic/acoustic consequences. This lends evidence to the claim that the acoustic cues contained in the consonantal release are not generally available in pre-consonantal position.

This can be captured by ranking the constraint against [t, d] in this context higher than the constraint against [t, d] in the other contexts – as is done in (3b) above. No clear ordering can be established between pre-pausal and pre-vocalic context. In pre-vocalic context both release and transitional cues are available, but they require that the cues be realized across a word-boundary. In pre-pausal context only the release cues are available, but these cues can be realized without crossing a word-boundary. It can therefore be expected that there will be more freedom in how likely these two contexts are to sponsor a [t, d]. This can be captured by not imposing a universal ranking between the constraints against [t, d] in these contexts – as is done in (3b).

(4) **The presence of cues in different contexts**

__ # V		**__ ##**		**__ # C**	
Release	**Transition**	**Release**	**Transition**	**Release**	**Transition**
Yes Cross #	Yes Cross #	Yes	No	No	Weakly Pre-sonorant Cross #

1.2.2 Accounting for the observed patterns

There are two aspects of the variation pattern that we need to account for. (i) *Intra-contextual variation*. Consider the Chicano English data. In this dialect pre-consonantal context has a deletion rate of more than 50%. For a [t, d] input in which the final [t, d] occurs before a consonant, the deletion candidate therefore has to be rated as more well-formed than the retention candidate. The opposite is true in pre-vocalic and pre-pausal contexts. Here less than 50% of [t, d] deletes, so that the retention candidate has to be rated better than the deletion candidate. This is the first aspect of the variation that we have to account for – for a specific input, which of the variants is the more frequently observed variant. Since dialects can differ in this respect, we have to consider each dialect individually. (ii) *Inter-contextual variation*. Consider again the Chicano dialect. Although [t, d] deletes less than 50% in both pre-vocalic and pre-pausal position, it deletes more in pre-vocalic than in pre-pausal position. We also have to account for this difference in deletion rates between the different contexts. In the rest of this section I first discuss the intra-contextual variation (§1.2.2.1) and then the inter-contextual variation (§1.2.2.2).

1.2.2.1 Intra-contextual variation

In the phenomenon of final [t, d]-deletion, two variants are observed – the retention candidate in which the [t, d] is preserved in pronunciation, and the deletion candidate (I will use ∅ to stand for this candidate). In contexts where [t, d] is observed more frequently than ∅, [t, d] has to be the more accessible candidate. EVAL must therefore rate [t, d] better than ∅ in that context, i.e. |t/d ™ ∅|. In contexts where ∅ is the more frequent variant, EVAL has to impose the opposite rank-ordering on these two candidates, i.e. |∅ ™ t/d|.

In all of the dialects discussed in §1.1 above variation is observed in all three contexts. This means that in all three contexts neither the deletion candidate ∅ nor the retention candidate [t, d] can be disfavored by any constraint ranked higher than the critical cut-off. In all these dialects the cut-off is therefore located above MAX and the three markedness constraints from (3a).

Tableau (5) shows the violation profiles of a retention candidate and a deletion candidate in each of the three contexts. The only ranking that is assumed in this tableau is that *Ct#C outranks *Ct## and *Ct#V – see (3b) above. In particular, I make no claim yet about the ranking of MAX in this tableau – I indicate my agnosticism about the ranking of MAX by separating it from the other constraints by a squiggly line. This tableau does not yet represent the grammar of any specific dialect. It is presented here only to facilitate the discussion that follows. In this and all further tableau /Ct#C/ stands for an input where word-final [t, d] is followed by a consonant, /Ct#V/ where it is followed by a vowel, and /Ct##/ where it is followed by a pause.

(5) **Violation profiles of deletion and retention candidates in each of the contexts**

		*Ct#C	*Ct#V	*Ct##	MAX
/Ct#C/	t	*			
	∅				*
/Ct#V/	t		*		
	∅				*
/Ct##/	t			*	
	∅				*

Consider the pre-consonantal context. Suppose that we are dealing with a dialect in which the retention candidate were the preferred variant in this context – i.e. EVAL would have to impose the ordering |t ™ ∅| on the candidates in this context. In order to achieve this, the highest ranked constraint that distinguishes between the two candidates has to be a constraint that favors the retention candidate over the deletion candidate: MAX has to outrank *Ct#C, or ||MAX o *Ct#C||. Now suppose that we were dealing with a different dialect in which the deletion candidate was the preferred variant in pre-consonantal context. Everything is now simply turned around. EVAL has to impose the ordering |∅ ™ t| on the candidate set, and in order to achieve that we need the ranking ||*Ct#C o MAX||. In fact, this gives a general heuristic for ranking MAX and the markedness constraints. Since I will use this heuristic over and over again in the discussion below, I state it explicitly in (6).

(6) **Heuristic for ranking MAX and the contextual licensing constraints**

Let *x* stand for some context, and CON-*x* for the markedness constraint against [t, d] in that context.

a. **|t ™ ∅|**

If in context *x* the retention candidate is the preferred variant, then:

||MAX o CON-*x*||.

b. **|∅ ™ t|**

If in context *x* the deletion candidate is the preferred variant, then:

||CON-*x* o MAX||.

Now we can consider the dialects separately. Let us start with Chicano, Tejano and Trinidadian English. In all three of these dialects the retention candidate is the preferred variant in pre-vocalic and pre-pausal contexts. However, in pre-consonantal context, the deletion candidate is observed more frequently than the retention candidate. In pre-consonantal position clause (6b) therefore applies to these dialects – i.e. we need the ranking ||*Ct#C o MAX||. However, in pre-pausal and pre-vocalic contexts, clause (6a) applies – i.e. we need the ranking ||MAX o {*Ct#V, *Ct##}||. We still need to determine where to the critical cut-off should be located. Since variation between the deletion and retention candidates is observed in all three contexts, it means that neither of these candidates can be disfavored by a constraint ranked higher than the critical cut-off. This implies that MAX and all three markedness constraints rank lower than the cut-off.

(7) **Chicano, Tejano and Trinidadian English**

			DEP	*Ct#C	MAX	*Ct#V	*Ct##
/Ct#C/	2	t		*			
	1	∅			*		
	3	Vt	*!				
/Ct#V/	1	t				*	
	2	∅			*		
	3	Vt	*!				
/Ct##/	1	t					*
	2	∅			*		
	3	Vt	*!				

Output of EVAL

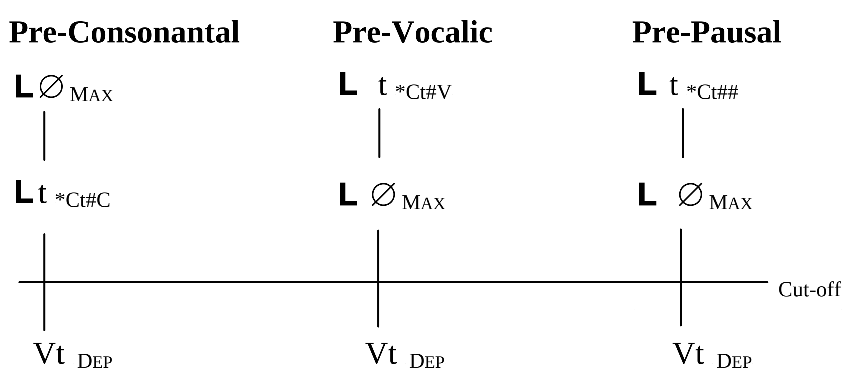


Tableau (7) represents a partial grammar of Chicano, Tejano and Trinidadian English. In addition to the deletion and the retention candidate, I also include a candidate that avoids the markedness violation by epenthesis. This candidate serves as an example of a candidate that is never observed as a variant for any of the inputs considered here. The epenthetic candidate will also occupy a slot in the rank-ordering that EVAL imposes on the candidate set. To explain why the language user never accesses this candidate as a variant we have to call on the critical cut-off. The epenthetic candidate has to be disfavored by a constraint ranked higher than the critical cut-off. I therefore rank the anti-epenthesis constraint DEP higher than the critical cut-off. The epenthetic candidate stands in here as representative of all candidates never observed as variants – all such candidates will be disfavored by at least one constraint ranked higher than the cut-off. For the typographical conventions used in this tableau, see Chapter 1 §2.2.1 and §2.2.3

In pre-consonantal context EVAL imposes the rank-ordering |∅ ™ t ™ Vt| on the candidate set. Of these three candidates, the epenthetic candidate is disfavored by DEP which is ranked higher than the cut-off. Since there are candidates available that are not disfavored by any constraints ranked higher than the cut-off, this epenthetic candidate will never be selected as output. Of the two candidates that are possible outputs, the deletion candidate appears higher on the rank-ordering. It is therefore the more accessible of the two, and it is predicted to be the more frequently selected variant. In pre-vocalic and pre-pausal position, EVAL imposes the rank-ordering |t ™ ∅ ™ Vt| on the candidate set. In these contexts the epenthetic candidate is eliminated as output in the same manner as in the pre-consonantal context. Of the two possible outputs the retention candidate is here rated better and therefore more accessible. For these contexts, we expect more retention than deletion.

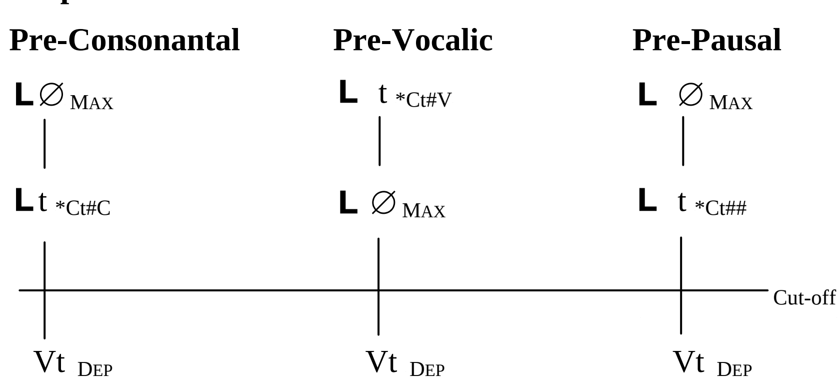
The other dialects are easily accounted for in a similar fashion. I will not discuss these other dialects in as much detail as these first three, since it is a straightforward matter to arrive at the correct ranking for each dialect using the heuristic stated in (6). In the rest of this section I therefore only give the tableaux for the other dialects, with minimal discussion of each dialect.

In the AAE of Washington, DC the retention candidate is the preferred variant in pre-vocalic context. However, in both pre-consonantal and pre-pausal context, deletion is preferred over retention. The tableau for this dialect is given in (8).

(8) **Washington, DC AAE**

			DEP	*Ct#C	*Ct##	MAX	*Ct#V
/Ct#C/	2	t		*			
	1	∅				*	
	3	Vt	*!				
/Ct#V/	1	t					*
	2	∅				*	
	3	Vt	*!				
/Ct##/	2	t			*		
	1	∅				*	
	3	Vt	*!				

Output of EVAL

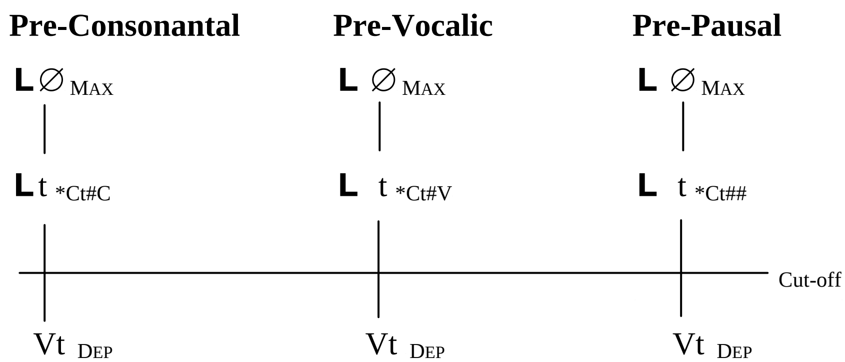


In Jamaican English deletion is preferred over retention in all three contexts. The tableau for this dialect is given in (9).

(9) **Jamaican English**

			DEP	*Ct#C	*Ct##	*Ct#V	MAX
/Ct#C/	2	t		*			
	1	∅					*
	3	Vt	*!				
/Ct#V/	2	t				*	
	1	∅					*
	3	Vt	*!				
/Ct##/	2	t			*		
	1	∅					*
	3	Vt	*!				

Output of EVAL



In the data reported by Neu (1980) retention is preferred over deletion in both pre-consonantal and pre-vocalic position. Since Neu did not report the pre-pausal deletion rates, I am not considering an input from this context. The tableau in (10) represents the grammar represented by these data.

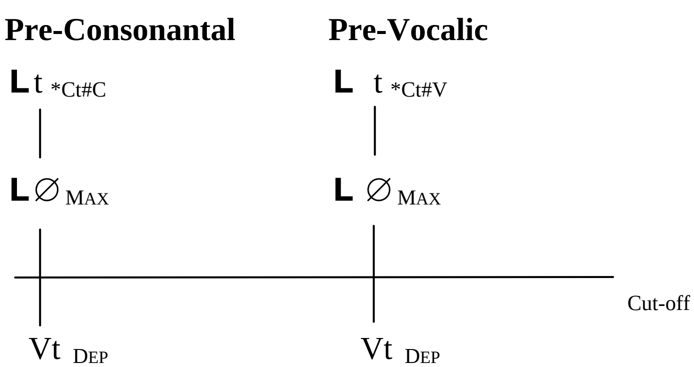
This section has shown how intra-contextual variation can be accounted for in the rank-ordering model of EVAL. In each context, either the deletion or the retention candidate is the more frequent variant. For a context in which the deletion candidate is more frequent, the markedness constraint against [t, d] in that context outranks MAX, i.e.

||Markedness o MAX||. With this ranking EVAL imposes the rank-ordering |∅ ™ t/d| on the candidate set. In a context where retention is more frequent, MAX outranks the markedness constraint, i.e. ||MAX o Markedness||. This results in EVAL imposing the opposite rank-ordering on the candidate set for that context: |t/d ™ ∅|.

(10) **The Neu data**

			DEP	MAX	*Ct#C	*Ct##	*Ct#V
/Ct#C/	1	t			*		
	2	∅		*			
	3	Vt	*!				
/Ct#V/	1	t					*
	2	∅		*			
	3	Vt	*!				

Output of EVAL



But this still accounts for only one aspect of the variation pattern. Consider Chicano English as an example. Both in pre-vocalic and in pre-pausal position the retention candidate is the preferred variant. The ranking ||MAX o {*Ct#V, *Ct##}|| accounts successfully for this. However, although both of these contexts are associated with retention rates of more than 50%, the contexts do differ. Pre-vocalic context has a higher deletion rate than pre-pausal context. This inter-contextual variation still has to be explained. This is the topic of the next section.

1.2.2.2 Inter-contextual variation

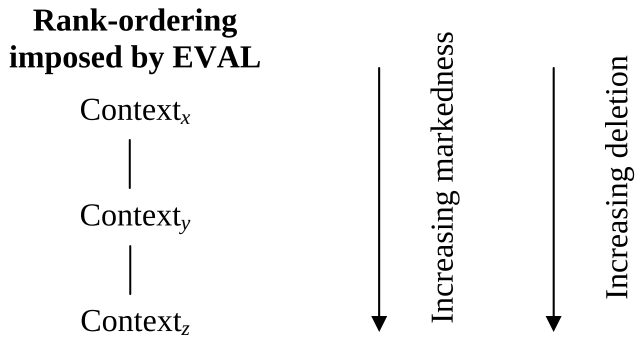
In order to account for inter-contextual variation we have to rely on the ability of EVAL to evaluate non-generated comparison sets (see Chapter 1 §1.2 and §2.2.2). One non-generated comparison set is of particular relevance in accounting for the inter-contextual variation in [t, d]-deletion. This is the set that contains the faithful candidates from each of the three different contexts, i.e. {/Ct#C/ → [t], /Ct#V/ → [t], /Ct##/ → [t]}.[9] EVAL will evaluate these three candidates in exactly the same way as it does ordinary generated comparison sets, and it will also impose a harmonic rank-ordering on these three candidates. Since these are the faithful candidates, they will only differ in terms of markedness violations. Consequently, the lower a candidate appears in the rank-ordering, the more marked it is.

The force that drives unfaithfulness is markedness. The more marked some faithful candidate, the stronger the drive to be unfaithful to that candidate. Therefore, the lower a candidate appears in the rank-ordering, the stronger the drive to delete, and the higher the deletion rate is expected to be in the context represented by that candidate. This discussion is represented graphically in (11).

---

[9] Another kind of non-generated comparison set can also be relevant, namely the set that contains the unfaithful (deletion) candidates from each of the three contexts: {/Ct#C/ → ∅, /Ct#V/ → ∅, /Ct##/ → ∅}. Of the constraints that we are considering here, all three of these candidates violate only MAX. EVAL can therefore not distinguish between them. In this particular instance, consideration of this non-generated comparison set is not informative.

(11) **Comparison between faithful candidates from different contexts**



In all dialects of English pre-consonantal position is associated with the highest deletion rate. This means that the drive to delete must be stronger in pre-consonantal context than in either pre-vocalic or pre-pausal context. Put in terms of a comparison between the faithful candidates: the faithful candidate from the pre-consonantal context must be more marked than the faithful candidate from both of the other two contexts. This can be achieved by ranking the markedness constraint against [t, d] in pre-consonantal position higher the constraints against [t, d] in the other two contexts, i.e. ||*Ct#C o {*Ct#V, *Ct##}||. This is indeed also the ranking that was argued for (3b) above based on the robustness of the cues for correctly identifying [t, d]. The cues for identifying [t, d] are least robust in pre-consonantal position, and therefore the constraint against [t, d] in this position was ranked the highest.

Dialects diverge in terms of deletion rates before vowels and before pauses. Although all dialects have lower deletion rates in these contexts than before consonants, some dialects delete more before a vowel than a pause (Chicano), and others delete more before a pause than before a vowel (Tejano, Washington, DC AAE, Trinidadian, Jamaican). This difference can be explained by ranking the constraints against [t, d] in pre-pausal and pre-vocalic position differently. In those dialects where pre-vocalic position is associated with higher deletion rates, we need the faithful candidate from a pre-vocalic context to be more marked than the faithful candidate from a pre-pausal context. This can be achieved by the ranking ||*Ct#V o *Ct##||. On the other hand, in dialects where pre-pausal position is associated with more deletion, the faithful candidate from the pre-pausal context has to be more marked than the faithful candidate from the pre-vocalic context. This can be achieved by the ranking ||*Ct## o *Ct#V||. Referring back to (3b) will show that I did not claim a fixed ranking to exist between these two constraints. It does not seem to be the case that the cues for identifying [t, d] are inherently more robust in one of these contexts than the other.[10]

There are two kinds of dialects, and therefore two rankings between markedness constraints. These two kinds of dialects and the rankings associated with each are summarized in (12).

(12) **Different deletion rates in different contexts following [t, d]**

a. **Type A**

Deletion rates: Pre-C > Pre-V > Pre-Pause

Dialects: Chicano English

Ranking: ||*Ct#C o *Ct#V o *Ct##||

---

[10] It is not clear what determines which ranking is chosen in a specific dialect. It is possible that this is an arbitrary choice that has to be stipulated for every language. It is also possible that it can be related to finer details of phonetic implementation. Some dialects of English may more readily release stop consonants in pre-pausal position than other dialects. If this is true, then these pre-pausal release dialects will be dialects in which the cues in pre-pausal position are particularly robust. These could be the dialects in which in pre-pausal position is associated with lower deletion rates than pre-vocalic position. However, no data is available on whether pre-pausal stops are released or not in the dialects of English under investigation here. This therefore remains speculation for the time being. See Guy (1994:143) for similar speculation.

((12) continued)

b. **Type B**

Deletion rates: Pre-C > Pre-Pause > Pre-V

Dialects: Tejano, Washington, DC AAE, Jamaican, Trinidadian

Ranking: ||*Ct#C o *Ct## o *Ct#V||

As an illustration, I will discuss one dialect of each kind in more detail. I start with Chicano English as and example of dialect type A. In (7) above I have argued for the following partial ranking for this dialect: ||DEP o cut-off o *Ct#C o MAX o {*Ct#V, *Ct##}||. All that was missing to make this a complete ranking, is a ranking between the licensing constraints for pre-vocalic and pre-pausal position. Since pre-vocalic position is associated with higher deletion rates, we know that the constraint for this context has to outrank the constraint for the pre-pausal context, i.e. ||*Ct#V o *Ct##||. Tableau (13) considers the non-generated comparison set with the faithful candidates from the three contexts with this ranking added.

(13) **Chicano English: Comparing the faithful candidates**

		DEP	*Ct#C	MAX	*Ct#V	*Ct##
3	/Ct#C/ → [t]		*			
2	/Ct#V/ → [t]				*	
1	/Ct##/ → [t]					*

Output of EVAL

Pre-pausal: /Ct##/ → [t] $_{\text{*Ct\#\#}}$

|

Pre-vocalic: /Ct#V/ → [t] $_{\text{*Ct\#V}}$

|

Pre-consonantal: /Ct#C/ → [t] $_{\text{*Ct\#C}}$

This comparison shows that the faithful candidate in pre-pausal context is the least marked. Changing the input in this context (by deletion) will lead to the smallest decrease in markedness. The drive to be unfaithful is therefore the weakest in this context, and we are predicting the lowest deletion rate in this context. The faithful candidate from the pre-consonantal context is most marked, so that deleting the [t, d] from an input in this context will lead to the largest decrease in markedness. The drive to delete is strongest in this context, and we are predicting that this context will be associated with the highest deletion rates.

Consider Jamaican English as an example of a type B dialect. In this dialect the different contexts are related as follows in terms of deletion: Pre-C > Pre-Pause > Pre-V. In (9) I argued for the following hierarchy for this dialect: ||DEP o Cut-off o *Ct#C o {*Ct##, *Ct#V} o MAX ||. All we need to do is add the ranking between the constraints for pre-pausal and pre-vocalic contexts. Tableau (14) considers the non-generated comparison set with the faithful candidates from the three contexts for this dialect.

(14) **Jamaican English: Comparing the faithful candidates**

		DEP	*Ct#C	*Ct##	*Ct#V	MAX
3	/Ct#C/ → [t]		*			
1	/Ct#V/ → [t]				*	
2	/Ct##/ → [t]			*		

Output of EVAL

Pre-vocalic: /Ct#V/ → [t] $_{*Ct\#V}$

|

Pre-pausal: /Ct##/ → [t] $_{*Ct\#\#}$

|

Pre-consonantal: /Ct#C/ → [t] $_{*Ct\#C}$

The faithful candidate in pre-vocalic context is the least marked, so that deletion in this context will lead to the smallest decrease in markedness. We are expecting the lowest deletion rate in this context. As in Chicano English, the faithful candidate from pre-consonantal context is the most marked. Deletion in this context will buy the largest decrease in markedness, so that this context is expected to have the highest deletion rate.

By allowing EVAL to compare non-generated comparison sets, we can also account for inter-contextual variation. The basic idea is that unfaithfulness to the input is motivated only in order to decrease in terms of markedness. The more marked the faithful candidate is, the more can be gained by being unfaithful to the input. The highest deletion rates are therefore expected in contexts where the faithful candidate is most marked, and the lowest deletion rates in contexts where the faithful candidate is least marked.

1.2.3 Factorial typology – what are the possible dialects?

One of the claims of OT is that every possible ranking between the constraints represent a possible grammar, and therefore a possible language (or dialect in the current context). In the discussion above I have used four constraints to account for the [t, d]-deletion patterns observed in different dialects of English – MAX and three markedness constraints. I have also argued that the constraint against [t, d] in pre-consonantal position universally outranks the constraints against [t, d] in pre-vocalic and pre-pausal position – see (3b). This implies that there are two rankings possible between these markedness constraints. These two rankings are represented in (15).

(15) **Rankings possible between the markedness constraints**

a. ||*Ct#C o *Ct#V o *Ct##||

b. ||*Ct#C o *Ct## o *Ct#V||

In each of these two rankings there are four positions into which MAX can rank, so that each of these rankings represent four rankings with MAX included. I list the four rankings that (15a) stands for as an example in (16).

(16) **Including MAX in (15a)**

a. ||MAX o *Ct#C o *Ct#V o *Ct##||

b. ||*Ct#C o MAX o *Ct#V o *Ct##||

c. ||*Ct#C o *Ct#V o MAX o *Ct##||

d. ||*Ct#C o *Ct#V o *Ct## o MAX||

We also have to take into account the critical cut-off. The critical cut-off can be located between any two constraints. In each of the four rankings in (16) there are five positions where the critical cut-off can occur. These four rankings therefore represent a total of twenty rankings. Similarly, the ranking in (15b) also represents twenty possible rankings. This gives a total of forty rankings that are possible between the four constraints and the critical cut-off. These forty rankings represent all and only the possible ways in which [t, d]-deletion can interact with the following phonological context. I will not go through all forty possible rankings here. A discussion of all the possible rankings can be found in the Appendix at the end of this chapter. What I will do here is: (i) formulate the conditions that must be met for variation to be observed at all, (ii) list all the possible deletion patterns predicted under the analysis developed here (patterns that would result from at least one of these rankings), and (iii) mention some of the most important deletion patterns that are predicted to be impossible (that cannot result from any of these rankings).

1.2.3.1 Conditions for variation

In order to see what the general conditions are that must be met for variation to be observed, consider the pre-consonantal context as an example. There are two relevant candidates, namely the retention candidate [t, d] and the deletion candidate ∅. The retention candidate [t, d] violates only *Ct#C, and the deletion candidate ∅ violates only MAX. Variation between these candidates is only possible when neither of them is disfavored by a constraint ranked higher than the cut-off. This implies that variation will only be observed if the ranking ||Cut-off o {MAX, *Ct#C}|| is observed. The tableaux in (17) show the six different ways in which these two constraints and the cut-off can be ranked. Note that variation is only predicted when both constraints rank below the cut-off.

In (17a) and (17b) neither of the candidates violates a constraint higher than the cut-off. As a result both candidates will be accessed as outputs in this context. The ranking between MAX and the markedness constraint determines which of the candidates will be the more frequent variant. In (17c) and (17d) one candidate is disfavored by a constraint higher than the cut-off while the other is not. Since there is a candidate that is not disfavored by a constraint higher than the cut-off, no candidates that are disfavored by such a constraint will be accessed as possible output in these grammars. In (17e) and (17f) both candidates are disfavored by a constraint higher than the cut-off. In such a situation the language user has no choice but to select a candidate that is disfavored by a constraint ranked above the cut-off. However, only the single best candidate is selected when this happens. In order for variation to be observed in some context, it is necessary for both MAX and the markedness constraint that applies in that context to be ranked lower than the cut-off. In (18) this requirement is stated in general terms.

(17) a. **Variation 1**

/Ct#C/		MAX	*Ct#C
1	t		*
2	∅	*	

Output of EVAL

L t *Ct#C

L ∅ MAX

Cut-off

b. **Variation 2**

/Ct#C/		*Ct#C	MAX
2	t	*	
1	∅		*

Output of EVAL

L ∅ MAX

L t *Ct#C

Cut-off

c. **No variation 1**

/Ct#C/		MAX	*Ct#C
1	t		*
2	∅	*!	

Output of EVAL

L t *Ct#C

Cut-off

∅ MAX

d. **No variation 2**

/Ct#C/		*Ct#C	MAX
2	t	*!	
1	∅		*

Output of EVAL

L ∅ MAX

Cut-off

t *Ct#C

e. **No variation 3**

/Ct#C/		MAX	*Ct#C
1	t		*
2	∅	*!	

Output of EVAL

Cut-off

L t *Ct#C

∅ MAX

f. **No variation 4**

/Ct#C/		*Ct#C	MAX
2	t	*!	
1	∅		*

Output of EVAL

Cut-off

L ∅ MAX

t *Ct#C

(18) **Necessary conditions for variation in each context**

a. General condition: ||Cut-off o MAX||

b. Context specific conditions:

(i) Pre-Consonantal: ||Cut-off o *Ct#C||

(ii) Pre-Vocalic: ||Cut-off o *Ct#V||

(iii) Pre-Pausal: ||Cut-off o *Ct##||

In addition to the requirements in (18) there is, of course, also one universally fixed ranking that needs to be taken into consideration – the constraint against [t, d] in pre-consonantal context universally outranks the constraints against [t, d] in the other two contexts. The way in which the conditions in (18) interact with this universal ranking determines the different possible deletion patterns. These patterns are discussed in more detail in the next section.

1.2.3.2 Possible deletion patterns

In (19) below I list all the deletion patterns that are predicted as possible by the analysis developed above. I do not motivate here that these are all and only the possible patterns. Nor do I give the rankings that are necessary for each of the patterns. This discussion can be found in the Appendix at the end of this chapter. In table (19) "D" stands for "categorical deletion", "R" for "categorical retention", "D > R" for "more deletion than retention" and "R > D" for "more retention than deletion". In order to make identifying patterns easier, I also shade all cells in which more deletion than retention is observed – i.e. both "D" and "D > R" cells.

(19) **Possible deletion patterns**

a. **No-variation**

Pre-Consonantal	Pre-Vocalic	Pre-Pausal
D	D	D
D	D	R
D	R	D
D	R	R
R	R	R

b. **Variation in all contexts**

Pre-Consonantal	Pre-Vocalic	Pre-Pausal
D > R	D > R	D > R
D > R	D > R	R > D
D > R	R > D	D > R
D > R	R > D	R > D
R > D	R > D	R > D

c. **Variation only in some contexts**

Pre-Consonantal	Pre-Vocalic	Pre-Pausal
D	D	D > R
D	D > R	D
D	D > R	D > R
D	D	R > D
D	D > R	R > D
D	R > D	D
D	R > D	D > R
D	R > D	R > D

Of the predicted patterns in (19a), none are actually observed. However, all of these seem to be very reasonable and likely. The last pattern, with categorical retention in all three contexts, would be a very conservative dialect. This is at least the normative dialect of standard American English, and this pattern might even be observed in very careful hyper-articulated speech.

The first pattern, with categorical deletion everywhere, is at the other endpoint of the spectrum. Of course, if the [t, d] is always deleted then re-lexicalization will occur – i.e. the next generation of learners will acquire underlying forms without the final [t, d]'s.[11] A dialect like Jamaican English, with high deletion rates in all three contexts (see (1) above), might be en route to this point. In fact, Patrick (1991) argues that re-lexicalization might indeed already have occurred for many words in this dialect.

Several of the patterns in (19b) are actually attested. For the deletion patterns of the different dialects, see (1) and (2) above. An important characteristic that all of the predicted patterns have in common is that pre-consonantal context shows at least as much deletion as the other two contexts – that is, there is no pattern where pre-consonantal context prefers retention and one of the other contexts prefers deletion. Under the licensing by cue analysis this is to be expected.

According to Guy (1980:27) the English spoken by white Americans in both New York and Philadelphia has categorical deletion in pre-consonantal context and variable deletion in the other contexts. Unfortunately Guy reports only the VARBUL factor weights for these dialects. Pre-consonantal context has a factor weight of 1.0 which translates into categorical deletion. The deletion rates for the other two contexts cannot be determined from their factor weights. We therefore know that these two dialects fall into one of the patterns in (19c), but we do not know in which specific one.

---

[11] This is true only for monomorphemes. Since the past tense of verbs that end on vowels will still be marked by a /-d/ suffix, the past tense of all verbs is still very likely to contain this /-d/-suffix.

1.2.3.3 Impossible deletion patterns

Perhaps more instructive are the deletion patterns that are predicted as impossible because they can never result from any of the possible rankings. If any of these patterns are actually encountered, it would count as strong evidence against the analysis developed above. Of the patterns that are predicted as impossible, none are actually attested to my knowledge.

One group of deletion patterns that are predicted as impossible, are patterns where pre-vocalic or pre-pausal contexts show more deletion than pre-consonantal context. The non-existence of these patterns is reasonable and expected. Pre-consonantal context is the weakest sponsor for [t, d]. We would therefore not expect to see more [t, d]'s retained in this context than in the other contexts that are more robust sponsors for [t, d]. A sample of these patterns is listed in (20).

(20) **Impossible patterns: More retention in pre-consonantal context than in the other contexts**

Pre-Consonantal	Pre-Vocalic	Pre-Pausal
R	D	D
R	D	R
R	R > D	R
R	R	R > D
R > D	R > D	D
R > D	D	R > D
R > D	D > R	R
R > D	R	D > R
R > D	D	D
D > R	R > D	D
D > R	D	R > D
D > R	D	D

The impossibility of these patterns follows from the universally fixed ranking between the markedness constraints in (3b): ||*Ct#C o {*Ct#V, *Ct##}||. Because of this ranking retention of [t, d] in pre-consonantal context will always be more marked than retention in either pre-vocalic or pre-pausal context. Since deletion is motivated by the drive to become less marked, the drive to delete will always be strongest in pre-consonantal context, and this context will therefore always show at least as much deletion as the other two contexts.

The exclusion of these patterns is a very desirable prediction of the analysis developed here, and can serve as a strong argument in favor of this analysis. However, there is also one group of patterns that are predicted as impossible even though they seem quite reasonable. I will discuss these patterns next.

Deletion patterns with variation in pre-consonantal context and categorical retention in pre-vocalic and/or pre-pausal position are predicted as impossible under the analysis developed above. I list a few examples of these patterns in (21).

Why are these patterns impossible in the account developed here? In order for variation to be observed in pre-consonantal position, the ranking ||Cut-off o {MAX, *Ct#C}|| is required (see the variation conditions in (18)). However, because the markedness constraint against [t, d] in pre-consonantal context universally outranks the constraints against [t, d] in pre-vocalic and pre-pausal context (see (3b)), we have by transitivity of constraint ranking also the ranking ||Cut-off o {MAX, *Ct#V, *Ct##}||. The variation conditions in (18) are therefore also met for pre-pausal and pre-vocalic context. The implication is that variation in pre-consonantal context is always accompanied by variation in pre-pausal and pre-vocalic context.

(21) **Impossible patterns: Variation in pre-consonantal context, and categorical retention in pre-pausal and/or pre-vocalic position**[12]

Pre-Consonantal	Pre-Vocalic	Pre-Pausal
D > R	R	R
D > R	R	R > D
D > R	R	D > R
D > R	R	R
D > R	R > D	R
D > R	D > R	R
R > D	R	R
R > D	R	R > D
R > D	R > D	R

These patterns all seem reasonable. In all of these patterns the less robust pre-consonantal sponsoring context of [t, d] shows at least as much deletion as the more robust pre-pausal and pre-vocalic sponsoring contexts. Although this prediction of the analysis seems potentially problematic, to the best of my knowledge no dialect has been reported to show any of these patterns. At the present time, I will therefore only acknowledge this as a falsifiable prediction of the analysis.

1.2.4 Two outstanding questions

In this section I will briefly discuss two outstanding questions. The analysis that I have developed above assumes that only [t, d] deletes. What about other consonants that

---

12 There are more patterns that would fit this general description, for instance:

Pre-Consonantal	Pre-Vocalic	Pre-Pausal
D > R	R	D
R > D	R	D > R

These patterns all show less deletion in pre-consonantal than pre-vocalic or pre-pausal context. They are therefore excluded under (20) and are not problematic at all.

appear word-finally in consonant clusters? I address this question in §1.2.4.1. The analysis also assumes that word-final [t, d] only deletes if it is part of a consonant cluster. What about word-final [t, d] that follows directly after a vowel? This question is discussed in §1.2.4.2.

1.2.4.1 Only [t, d]?

The markedness constraints that drive the deletion have been formulated above to refer specifically to [t, d]. Consequently, consonants other than [t, d] that occur as final members in word-final clusters will not violate these constraints. The prediction is therefore that only [t, d] will delete. This seems unlikely. If [t, d] deletes from words like *mist*, then it seems reasonable to expect that [k] might delete from a word like *whisk*, that [p, b] might delete from words like *wasp* or *bulb*, that [θ] might delete from words like *filth*, etc. In the rest of this section I will limit discussion to the other stop consonants, i.e. [k, g, p, b]. The reason for this is that the markedness constraints were formulated in terms of the cues necessary to identify [t, d]. Since at least some of the cues for the identification of fricatives and sonorants differ from those used in the identification of stops, it seems reasonable that these constraints will not apply to non-stop consonants.

With regard to the non-coronal stop consonants, there is in fact acknowledgement in the literature that they do delete in the same contexts in which [t, d] deletes (Guy, 1980:1, Labov *et al*., 1968:131-133, Wolfram, 1969:50). We therefore have to consider the implication of this fact for the analysis developed for [t, d]-deletion. Even though it is acknowledged that stops other than [t, d] also delete form word-final clusters, no data exist on the patterns associated with deletion of these other consonants.[13] We can therefore only speculate on how the deletion of these consonants will pattern. In the rest of this section I will consider two possibilities about how deletion of non-coronals might pattern, and show how we could account for these patterns in the analysis developed above for [t, d]-deletion.

The most straightforward possibility is that the deletion process does not distinguish between the stops in terms of place of articulation (i.e. [k, g, p, b][14] are subject to the same rates of deletion as [t, d] in the different contexts). It is very unlikely that this will be the case. However, if it were to be the case, it would be very easy to adapt the analysis developed above to accommodate the non-coronals. We can simply redefine the markedness constrains so that they are constraints on where stop consonants can occur rather than constraints on where coronal stops can occur. Everything else can be left as is.

A more likely scenario is that the non-coronals are subject to lower deletion rates than the coronals. Ohala (1990) conducted perception experiments in which he presented listeners with [VC_1-C_2V]-sequences. The tokens in the experiments differed in the length of the silence gap between C_1 and C_2. When this silence gap dropped below 100 ms in duration, listeners tended to perceive only one consonant rather than two. The single consonant percept was usually identical to C_2 rather than to C_1. This perceptual

---

13 The reason for this is undoubtedly that there is only a very small number of word-final consonant clusters that end in non-coronals (Fudge, 1969), and consequently there are very few words that end in these clusters. In order to identify with confidence patterns that might arise in the deletion of non-coronal stops we need a large number of tokens in which these consonants occur in the relevant context. However, since these kinds of tokens are so scarce, it is practically impossible to collect enough data on the deletion of these consonants.

14 Actually, [g] never appears as final member of a word-final consonant cluster – see Fudge (1969). [g] is therefore included in the discussion simply for the sake of completeness.

phenomenon is expected under the perceptual licensing approach to neutralization assumed above. Many of the cues for the perception of a consonant are carried in the consonantal release. As the duration between C_1 and C_2 decreases, there is less and less time for the release cues of C_1 to be realized. At a certain point these cues are so weakly realized that C_1 is not perceived at all.[15]

Kingston and Shinya (2003, see also Kingston, to appear) replicated these findings with stop consonants. However, they also extended the results in an interesting manner. They distinguished between the places of articulation, and found a difference between coronal and non-coronal stops. They calculated the likelihood that a coronal stop followed by a non-coronal will be identified as identical to the non-coronal.[16] They also calculated similar statistics for the non-coronals – i.e. the likelihood that a labial followed by a non-labial will be identified as the non-labial, and the likelihood that a velar followed by a non-velar will be identified as the non-velar. They found that the likelihood of identifying a coronal incorrectly is larger than the likelihood of identifying a labial or a velar incorrectly. Based on this result, Kingston and Shinya conclude that, in [VC_1-C_2V]-sequences, C_1 is more likely to delete if it is a coronal than if it is a non-coronal.

In all of these studies, the coronals did not appear as final member of a consonant cluster – they were directly preceded by a vowel. However, it is reasonable to assume that the same pattern would emerge even if C_1 in the sequence were preceded not by a

---

15 See also Repp (1978, 1982, 1983). He conducted experiments similar to those of Ohala and he found very similar results. However, unlike Ohala who used naturally produced stimuli that therefore could contain releases, Repp used synthesized stimuli. For the most part his stimuli did not include releases – i.e. the only cues to place of articulation were in the formant transitions.

16 If C_1 in a [VC_1-C_2V]-sequence is identified as identical to C_2 it can be interpreted as deletion of C_1, especially in light of the fact that English does not tolerate geminates.

vowel but by another consonant. Based on these results we can therefore expect that non-coronals will be subject to lower deletion rates than coronals.

If this turns out to be true, there are several ways in which the analysis developed for [t, d]-deletion above can be extended to account for the difference between coronals and non-coronals. I mention only the one of the more feasible options here. It is possible to reformulate the markedness constraints used above so that they do not refer to [t, d] specifically, but rather to all stop consonants. We can then define MAX constraints indexed to the different places of articulation – i.e. MAX$_{[\text{Cor}]}$ (violated by deletion of a coronal) and MAX$_{[\text{Non-Cor}]}$ (violated by deletion of a non-coronal). By ranking MAX$_{[\text{Non-Cor}]}$ higher than MAX$_{[\text{Cor}]}$ we can account for the lower deletion rates of non-coronals. Deletion of a non-coronal will violate a higher ranked faithfulness constraint and will therefore be more costly.

It does not seem unreasonable to define MAX constraints that refer to place of articulation. De Lacy (2002) argues that there is a universal tendency to be more faithful to the more marked elements on a markedness scale. It is generally accepted that coronals are less marked than non-coronals – see the place markedness hierarchies in *inter alia* de Lacy (2002), Gnanadesikan (1996), Jakobson (1968), Lombardi (2001), Prince (1998), and also the discussion on [sCvC]-forms in Chapter 6 §3.1.2.1. If we do have MAX constraints indexed to place of articulation, we would therefore expect the constraints referring to non-coronals to rank higher than the constraint referring to coronals.

1.2.4.2 What about [t, d] preceded by a vowel?

The definition of the markedness constraints that drive the deletion of [t, d] includes reference to a preceding consonant (see (3a)). As a consequence these markedness constraints will not be violated by a post-vocalic word-final [t, d]. From this follows that [t, d] will only delete from a consonant cluster. However, we know that this is not true. Even [t, d] that occurs in simplex codas does delete. Fasold (1972:41) reports that the final [d] in a word like *applied* is often not pronounced in AAE.[17] Mees reports that post-vocalic [t] in Cardiff English is subject to a weakening process. It most often glottalizes, but it is also deleted rather frequently (Mees, 1987). This is probably true of all glottalizing dialects of English. The studies by Repp (1978, 1982, 1983), Ohala (1990) and Kingston and Shinya (2003) discussed in the previous section also show that consonants can delete from simplex codas – all of these studies showed that C_1 can delete from [VC_1-C_2V]-sequences.

Since we know that post-vocalic word-final [t, d] is also subject to deletion, a more complete analysis of this phenomenon will take this fact into account. Unfortunately, other than acknowledgement of the fact that deletion also applies in this context, very little information is available on the actual deletion patterns associated with post-vocalic [t, d]. The literature on [t, d]-deletion reports nearly exclusively on deletion of [t, d] in post-consonantal context. We are therefore again forced to speculate about how [t, d]-deletion will pattern in post-vocalic context.

It is most likely the case that [t, d] will delete much less frequently in post-vocalic than post-consonantal position. There are at least two reasons for this. The literature on [t, d]-deletion devote a lot of attention to the influence of the preceding context on the rate of [t, d]-deletion. (Section §2 of this chapter is also devoted to that.) The general finding

---

[17] Schouten also reports that final [t, d] in Dutch deletes even when it is preceded by a vowel (Schouten, 1982:285).

is that [t, d] deletes more the more similar the preceding segment is to [t, d] – i.e. it deletes more if the preceding segment is a stop (*pact*) than if it is a fricative (*drift*), it deletes more if the preceding segment is a coronal (*banned*) than if it is a non-coronal (*crammed*), etc. Vowels are undoubtedly more different from [t, d] than any consonant. Based on this we would expect lower deletion rates after a vowel than after any consonant.

Also under the licensing by cue approach we would expect less deletion in post-vocalic than in post-consonantal position. In the discussion of the markedness constraints in §1.2.1 above, I have focused only on the perceptual cues that are present in the context following a consonant. However, there are also cues available in the context preceding the consonant. In the same manner that consonants are cued by formant transitions into following vowels, they are also cued by formant transitions from preceding vowels. There are therefore more cues available to the identity of a post-vocalic than a post-consonantal consonant.

Assuming that this speculation is correct – i.e. that (i) post-vocalic [t, d] also deletes, but (ii) at a lower rate than post-consonantal [t, d] – how can the analysis developed above be changed to incorporate this? The most obvious manner is to formulate three more markedness constraints. For each of the constraints in (3a) above, there will then be a counterpart that applies in post-vocalic position – i.e. a constraint against [t, d] in the context V __ # C, in the context V __ # V, and in the context V __ ##. Since these contexts each contain an extra cue to the identity of [t, d], they sponsor [t, d] more robustly. They will therefore rank lower than the constraints that apply in post-consonantal position. Since the post-vocalic constraints rank lower, candidates that violate them will be less marked than candidates that violate the post-consonantal constraints. The prediction would then be less deletion in post-vocalic than in post-consonantal context.

1.3 An alternative explanation

The analysis that I have developed above depends on the assumption that [t, d]-deletion is driven by licensing constraints rather than ordinary syllabic well-formedness constraints. [t, d] deletes when the cues for its perception are not robust enough. An alternative account is one that depends on syllabic well-formedness. [t, d] deletes from word-final clusters because a complex coda is more marked than a simplex coda – deletion of [t, d] is then driven by a constraint like *COMPLEX. Kiparsky (1993) and Reynolds (1994:119-137) (following Kiparsky) take this approach. In this section I will briefly review evidence against this *COMPLEX-approach.

In all the dialects of English that has been studied, pre-consonantal context shows more deletion than pre-vocalic context. This seems to be a strong generalization that should be formally captured in our analysis – i.e. the analysis should exclude the existence of a dialect with equal variable deletion rates in these two contexts. In the analysis that I developed in §1.2 this is indeed predicted to be the case. In this analysis there are different markedness constraints that drive the deletion of [t, d] in pre-vocalic and pre-consonantal context, namely *Ct#V and *Ct#C. The difference in deletion rates between the contexts then follows from the fact that non-deletion violates different markedness constraints in the different contexts.

However, the *COMPLEX-approach is different. Under this approach a grammar with variable deletion that does not distinguish between pre-vocalic and pre-consonantal context is possible (i.e. a dialect with equal variable deletion in pre-vocalic and pre-consonantal context). In this approach there is only one constraint that drives deletion in both pre-consonantal and pre-vocalic context. The difference in deletion rates between these contexts therefore has to be explained in a different manner. In this approach the difference is attributed to re-syllabification. The assumption is that a *COMPLEX-violation in pre-vocalic context can be avoided in two ways – either by deletion or by re-syllabifying the [t, d] across the word-boundary into the onset of the following syllable. A form such as *west end* can then be pronounced in three ways: (i) with a final consonant cluster [wɛst.ɛnd], (ii) with re-syllabification of the final [t] form *west* into the onset of the following syllable [wɛs.tɛnd], or (iii) with deletion of the final [t] from *west* [wɛs.ɛnd]. In pre-consonantal context, however, re-syllabification is not available as a way in which to avoid a *COMPLEX-violation. A form such as *west bank* can be pronounced in only two ways: (i) with a final consonant cluster in *west* [wɛst.bæŋk], or (ii) with deletion of the final [t] from *west* [wɛs.bæŋk]. Re-syllabification [wɛs.tbæŋk] is not available as an option.[18] Pre-vocalic context then shows higher retention rates since it can avoid violation of *COMPLEX without having to delete the final [t, d].

[18] In some pre-consonantal contexts re-syllabification is available. For instance, in an utterance such as *west rock* it is possible to re-syllabify the final [t] of *west* into the following syllable [wɛs.trɔk]. However, this is only possible for a small subset of consonants that could start the following word. [t, d] can only be followed by a small set of consonants in the onset of a syllable. Since final [t, d] can always re-syllabify in pre-vocalic position and can only re-syllabify in front of a small number of consonants, the assumption is that the small number of pre-consonantal re-syllabifications will not have an appreciable effect on the overall deletion pattern.

See also Labov (1997) who studied the speech of two English speakers in detail. He reports that there is very little evidence that these speakers re-syllabify across a word-boundary when the following word starts in a consonant.

The lower deletion rate in pre-vocalic position therefore crucially depends on the assumption that re-syllabification is allowed. If re-syllabification were not allowed, then deletion would be the only way to avoid a *COMPLEX-violation both in pre-vocalic and pre-consonantal contexts. Re-syllabification does not come for free. A form that re-syllabifies final [t, d] across a word boundary violates a constraint from the ALIGN family (McCarthy and Prince, 1993b). In a form such as [wɛs.tɛnd] the right edge of the morphological word is not aligned with the right edge of any prosodic category.[19] In order for a re-syllabification candidate like [wɛs.tɛnd] to be available as a variant pronunciation of *west end* it is therefore necessary that the form [wɛs.tɛnd] is not disfavored by any constraint ranked higher than the critical cut-off. If ALIGN ranks above the critical cut-off, then [wɛs.tɛnd] would not be allowed as a pronunciation, and there would be no difference between pre-vocalic and pre-consonantal context. This is illustrated in the tableau in (22). This tableau represents a dialect with variable deletion in both pre-vocalic and pre-consonantal context. This requires the ranking ||Cut-off o {MAX, *COMPLEX}|| so that neither deletion nor retention is disfavored by a constraint ranked higher than the cut-off.

In pre-consonantal context there are two candidates that are not disfavored by any constraints ranked higher than the cut-off, namely the deletion candidate and the retention candidate. Of these, the retention candidate is rated better by EVAL and is therefore expected to be the more frequently observed variant. The same is true in pre-vocalic context. But now there is no difference between these two contexts – since the re-

[19] The exact formulation of this ALIGN constraint is not relevant here. It can be a constraint that requires the morphological word to be right-aligned with a syllable, a prosodic word or a foot. All that is relevant here is that the re-syllabification candidate violates some ALIGN constraint.

syllabification candidate is not available as a variant in pre-vocalic context. The retention candidates from both contexts are also both equally marked (since both violate only *COMPLEX), so that the drive to delete is equally strong in both contexts. Consequently, it is predicted that both contexts should show the same deletion rate.

(22) **No difference between pre-consonantal and pre-vocalic context**

			DEP	ALIGN	MAX	*COMPLEX
/Ct#C/	1	Ct.C				*
	2	C∅.C			*	
	3	CVt.C	*!			
/Ct#V/	1	Ct.V				*
	3	C.tV		*!		
	2	C∅.V			*	
	4	CVt.V	*!			

Output of EVAL

Pre-Consonantal	**Pre-Vocalic**
☞ Ct.C *COMPLEX	☞ Ct.V *COMPLEX
☞ C∅.C MAX	☞ C∅.V MAX
——— Cut-off ———	——— Cut-off ———
CVt.C DEP	C.tV ALIGN
…	…

Under the *COMPLEX-approach it is therefore predicted that dialects with equal variable deletion in pre-consonantal and pre-vocalic contexts are possible. This is a problematic prediction. No such dialects have been reported in the literature, and the standard assumption is that pre-consonantal context will always show higher deletion rates than pre-vocalic context. There is a way in which to prevent the *COMPLEX-analysis form allowing dialects like those in (22). What we want to exclude are dialects with variable deletion in pre-consonantal and pre-vocalic contexts, but that do not allow re-syllabification. Variable deletion implies that both MAX and *COMPLEX rank below the cut-off, and the non-availability of re-syllabification implies that ALIGN ranks above the cut-off. What we need is to stipulate that the ranking ||Cut-off o {MAX, *COMPLEX}|| implies the ranking ||Cut-off o ALIGN||. This stipulation would successfully exclude a grammar like that in (22). However, this is a very arbitrary stipulation without any conceivable substantive motivation.

The cue-based analysis that I developed in §1.2 above is fundamentally different. Under this analysis any dialect with variable deletion in both pre-consonantal and pre-vocalic contexts will necessarily show more deletion in pre-consonantal context. The reason for this is that non-deletion in pre-consonantal and pre-vocalic contexts violates different constraints, and that there is a universal ranking between these two constraints such that non-deletion in pre-consonantal context will always be more marked than non-deletion in pre-vocalic context, i.e. ||*Ct#C o *Ct#V||. The ranking ||*Ct#C o *Ct#V|| precludes the existence of a dialect with equal variable deletion in pre-consonantal and pre-vocalic context. Non-deletion in a pre-consonantal context violates a higher ranking markedness constraint, so that the drive to delete is stronger in this context than in pre-vocalic context. If both pre-consonantal and pre-vocalic contexts show variable deletion, pre-consonantal context will always have a higher deletion rate.

2. The preceding phonological context

The nature of consonant preceding the [t, d] also influences the rate of [t, d]-deletion. The general finding is that certain preceding consonants (such as the sibilants) are associated with higher [t, d]-deletion rates than other segments (such as the liquids). In this section I will analyze the effect of the preceding segment on [t, d]-deletion within the rank-ordering model of EVAL. The analysis that I develop builds on the claims by Guy (1994) and Guy and Boberg (1997) that we are dealing with an Obligatory Contour Principle (OCP) effect. The idea is that [t, d] deletes in order to avoid two contiguous consonants that are too similar. The more similar the preceding consonant is to [t, d], the more likely [t, d] is to delete.

The rest of this section is structured as follows: In §2.1 I present the data on the influence of the preceding consonant on the rate of [t, d]-deletion. Section §2.2 then contains the actual analysis of these data within the rank-ordering model of EVAL.

2.1 The data

In the literature on [t, d]-deletion the consonants that precede the [t, d] are usually classified in terms of gross manner features – i.e. we find different combinations of sound classes such as sibilants, non-sibilant fricatives, stops, nasals, and liquids. There is some variation between dialects, but the general finding is that these consonant classes can be ordered as follows in terms of declining [t, d]-deletion rates: sibilants > stops > nasals > non-sibilant fricatives > liquids (Labov, 1989:90). No completely satisfactory explanation could ever be given for this specific pattern. Most often it was interpreted as a sonority effect – the less sonorous the segment preceding the [t, d], the more likely [t, d] is to delete. Although this is generally true, there are several exceptions to this generalization.

The sibilants (as fricatives) are certainly more sonorous than the stops – why then are they associated with higher deletion rates than the stops? The nasals are also more sonorous than the fricatives – why do nasals then show higher deletion rates than the non-sibilant fricatives?

Labov classifies the preceding context as “a relatively weak constraint” (Labov, 1989:90). This classification is intended to show that the preceding context is a less accurate predictor of the likelihood of [t, d]-deletion than the following context. If we know that the mean [t, d]-deletion rate before all vowels is *x* percent, then we can expect that the mean [t, d]-deletion rate before some specific vowel will also be roughly *x* percent. However, this is not true with regard to the preceding context. If we knew that the mean [t, d]-deletion rate after all nasals is *y* percent, then we cannot necessarily assume that the mean [t, d]-deletion rate after any specific nasal will be *y* percent. There is more scatter in the data on the preceding context than in the data on the following context.

Rather than interpreting this as a consequence of the fact that the preceding context has a weaker influence on the likelihood of [t, d]-deletion relative to the following context, Guy (1994) and Guy and Boberg (1997) argue that the greater degree of scatter in the data on the preceding context should be taken as an indication of the fact that the preceding context has not been partitioned correctly. We should define different groupings of consonants than those traditionally used in the literature. They argue that the relevant classes should be consonants that share the same features with [t, d]. [t, d] is uniquely identified by the three features [+coronal, -continuant, -sonorant]. The consonants that precede [t, d] should therefore be classified according to which of these features they share with [t, d]. Guy and Boberg analyze a corpus based on the speech of three Philadelphians according to the classes defined by this metric.[20] The results of this analysis are given in (23) (Guy, 1994:145, Guy and Boberg, 1997:155).

(23) **The influence of the preceding context on [t, d]-deletion rates in the Guy and Boberg (1997) corpus**

Shared features	**Consonants**	***n***	**% deleted**
?	[r]	86	7
[-cont]	[m, ŋ]	9	11
[-son]	[f, v]	45	29
[+cor]	[l]	182	32
[-cont, -son]	[k, g, p, b]	136	37
[+cor, -cont]	[n]	337	46
[+cor, -son]	[s, š, z, ž]	276	49
[+cor, -cont, -son]	[t, d]	–	–

In the table in (23) the contexts are ordered such that contexts with higher deletion rates occur lower in the table. The deletion rates between some contexts are clearly different – for instance, after [s, š, z, ž] 49% of [t, d] deletes but after [f, v] only 29% of [t, d] deletes. However, for some contexts it is not so clear whether their deletion rates are really different – for instance, is the 49% deletion rate after [s, š, z, ž] really different from the 46% deletion rate after [n]? In order to answer these questions, I calculated a χ^2-statistic for every pair of contexts. The results of this calculation are given in (24). The

[20] Unfortunately, Guy and Boberg report no further details about their corpus. We therefore do not know anything more about the three individuals on whom this corpus is based.

top number for every context is the $\chi^2(1)$ statistic for that pair of contexts, and the bottom number is the *p*-value. Pairs with *p*-values smaller than 0.05 are italicized, and pairs with larger *p*-values are underscored.

(24) **χ^2(1) and *p*-values for context pairs in the Guy and Boberg corpus**[21]

	[+cor, -son] **[s, š, z, ž]**	**[+cor, -cont]** **[n]**	**[-cont, -son]** **[k, g, p, b]**	**[+cor]** **[l]**	**[-son]** **[f, v]**	**[-cont]** **[m, ŋ]**	**?** **[r]**
[+cor, -son] **[s, š, z, ž]**							
[+cor, -cont] **[n]**	0.94 0.33						
[-cont, -son] **[k, g, p, b]**	*16.8* *< 0.000*	*11.69* *< 0.000*					
[+cor] **[l]**	$> 10^{307}$ *< 0.000*	$> 10^{307}$ *< 0.000*	1.42 0.23				
[-son] **[f, v]**	$> 10^{307}$ *< 0.000*	$> 10^{307}$ *< 0.000*	*3.98* *0.046*	0.73 0.394			
[-cont] **[m, ŋ]**	$> 10^{307}$ *< 0.000*	$> 10^{307}$ *< 0.000*	$> 10^{307}$ *< 0.000*	$> 10^{307}$ *< 0.000*	*14.71* *< 0.000*		
? **[r]**	$> 10^{307}$ *< 0.000*	$> 10^{307}$ *< 0.000*	$> 10^{307}$ *< 0.000*	$> 10^{307}$ *< 0.000*	$> 10^{307}$ *< 0.000*	0.23 0.629	

[21] The $\chi^2(1)$ statistic for a pair of contexts was calculated as follows: Let the two contexts be $Cont_1$ and $Cont_2$, such that $Cont_1$ has a higher deletion rate than $Cont_2$. The observed values were taken to be the actual number of deletions and preservations of $Cont_1$. The expected values were the deletion and preservation rates that would be observed in $Cont_1$ had $Cont_1$ shown the same deletion rate as $Cont_2$. Consider the [s, š, z, ž] and [n] contexts as an example. [s, š, z, ž] has a deletion rate of 49%, and [n] has a deletion rate of 46%. The observed values were therefore taken to be the actual deletion and retention values of [s, š, z, ž], while the expected values were calculated assuming that [s, š, z, ž] had also shown a 46% deletion rate.

	Observed (49% deletion)	Expected (46% deletion)
Deletion	135	126.96
Retention	141	149.04

What can we conclude based on these comparisons? First consider the contexts that share only one feature with [t, d]. [t, d] deletes more after both [+coronal] and [-sonorant] than after [-continuant] – i.e. more deletion after [l, f, v] than after [m, ŋ]. Co-occurrence of two sounds that agree in place or sonorancy is therefore avoided more strongly than co-occurrence of two sounds that agree in continuancy.[22] Based simply on comparison of [+coronal] and [-sonorant] contexts, it is not possible to order these two contexts in terms of deletion rates – i.e. it is not possible to determine whether [t, d] deletes more following [l] or following [f, v]. Although [+coronal] context has a numerically higher deletion rate, the difference in deletion rate between these two contexts is not statistically significant. However, based on universal tendencies we would expect that co-occurrence of two homorganic consonants will be avoided more than co-occurrence of two consonants that agree in sonorancy. Consonantal co-occurrence patterns in the Semitic languages, for instance, are defined in terms of place of articulation – there are restrictions on the co-occurrence of homorganic consonants but heterorganic consonants co-occur freely (Frisch *et al.*, 2004, Greenberg, 1950, McCarthy, 1994, Pierrehumbert, 1993). There are also two bits of indirect evidence that [+coronal] does contribute more towards [t, d]-deletion than [-sonorant]. First, [t, d] deletes more frequently after [n] than after [k, g, p, b]. These two contexts share the [-continuant] feature, and differ only in that [n] is [+coronal] while [k, g, p, b] are [-sonorant].

[22] This is not unexpected. We know from consonantal co-occurrence patterns in other languages that co-occurrence of segments that agree in place is avoided more than co-occurrence of segments that do not agree in place of articulation. This is true at least for Arabic (Frisch *et al.*, 2004), English, French and Latin (Berkley, 1994a, 1994b, 2000). The fact that the [+coronal] context shows more deletion than [-continuant] context is therefore expected. Similarly, it is not unexpected that co-occurrence of two consonants that agree in sonorancy is avoided more than co-occurrence of two consonants that agree in continuancy. At least in Arabic, co-occurrence of coronals that agree in sonorancy is avoided more than co-occurrence of coronals that agree in continuancy.

Secondly, [k, g, p, b] have a significantly higher deletion rate than [f, v], but not than [l]. These two facts taken together with the fact that [l] has a numerically higher deletion rate than [f, v] suggests that [+coronal] does contribute more toward [t, d]-deletion than [-sonorant].

Now we can consider the contexts that share two features with [t, d]. The first observation that can be made is that both [s, š, z, ž] and [n] show higher deletion rates than [p, b, k, g]. Co-occurrence of consonants that share [+coronal] and either [-sonorant] or [-continuant] is avoided more than co-occurrence of two consonants that share [-sonorant] and [-continuant]. However, although [s, š, z, ž] has a numerically higher deletion rate than [n], this difference is not statistically significant. The expectation would be that [s, š, z, ž] will have a higher deletion rate – since these segments share both [+coronal] and [-sonorant] with [t, d], and we have seen just above that these two features contribute more to deletion than [-continuant]. Although there is no direct evidence that [s, š, z, ž] have a higher deletion rate than [n], there is some indirect evidence that suggests this to be the case. If we calculate the probability that the deletion rate in each of these two contexts differ from chance (i.e. from 50%), there is a strong indication that [s, š, z, ž] is associated with a higher deletion rate than [n]. Under the binomial distribution, the likelihood that the deletion rate after [s, š, z, ž] is really 50% is 0.38. However, the likelihood that the deletion rate after [n] is really 50% is only 0.08.

Now we can connect the contexts that share two features with [t, d] and the contexts that share only one feature with [t, d]. The first thing that can be noted is that [t, d] deletes more after both [s, š, z, ž] and [n] than after any of the consonants that share only one feature with [t, d]. All that we have to determine is the relationship of [k, g, p, b] to the segments that share only one feature with [t, d]. The [k, g, p, b] context has a higher numerical deletion rate than the [l] context. However, this difference is not significant. It is therefore not clear whether co-occurrence of two consonants that share both [-continuant] and [-sonorant] is avoided more or whether co-occurrence of two consonants that share only [+coronal] is avoided more. However, the [k, g, p, b] context has a higher deletion rate than both the [f, v] and [m, ŋ] contexts. This makes sense – sharing both [-continuant] and [-sonorant] is avoided more than sharing only one of these features.

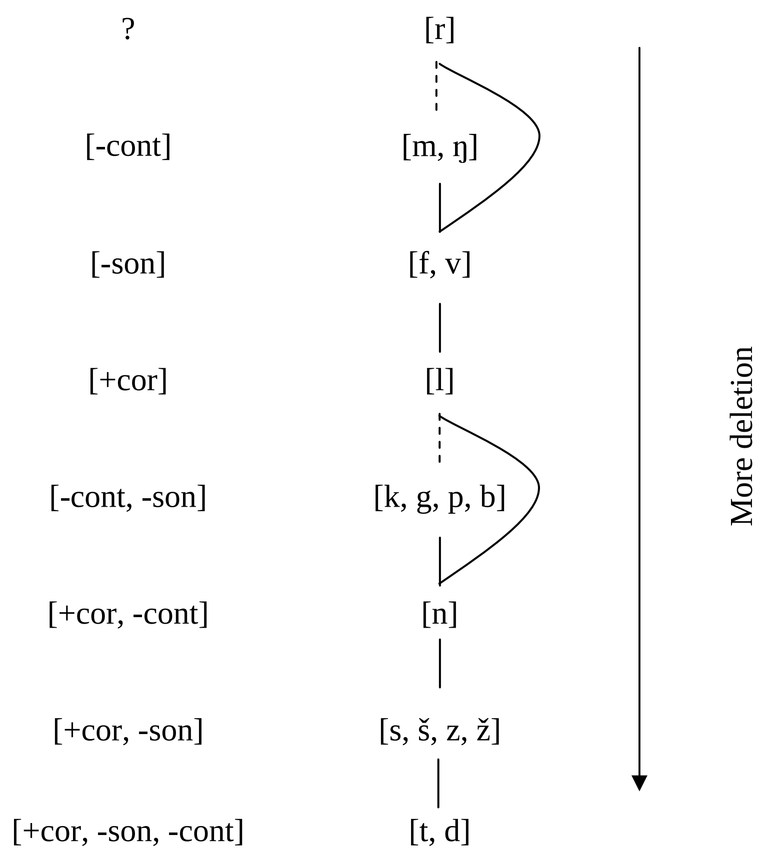
What remains now is to consider preceding [t, d] and preceding [r]. There are no monomorphemes in the English lexicon that end in one of the sequences [-tt], [-td], [-dd], or [-dt]. There are also no such bi-morphemic forms – the past tense suffix used with verbs that end in /t, d/ is [-əd]. It is therefore not possible to determine the [t, d]-deletion rate after [t, d]. However, the fact that such forms are completely absent from English suggests that English does not tolerate them at all. Had such forms existed, they would probably have been associated with the highest deletion rate, most likely a 100% deletion rate. This also makes sense in the general pattern of [t, d]-deletion observed in the table in (24). [t, d] deletes more after segments that share two features with [t, d] than after segments that share only one feature with [t, d]. We can therefore expect that [t, d] will delete even more after [t, d] with which it shares all three of the relevant features.

Lastly, consider the preceding [r] context. All contexts except for [m, ŋ] have higher deletion rates than [r]. If we take [r] to be a coronal liquid like [l], then [r] should show the same high deletion rate of [l]. Guy and Boberg take the low deletion rate after [r] as an indication that post-vocalic [r] is usually not pronounced at all or is realized only as

[r]-coloring on the preceding vowel. When this happens the [t, d] is preceded by a vowel and we would expect a low [t, d]-deletion rate (see §1.2.4.1 and §2.2.4.1 for a discussion of [t, d]-deletion in a post-vocalic context). According to Guy and Boberg, the post-vocalic [r] in their data were at least sometimes pronounced as a consonant. In these contexts we would then expect higher deletion rates, similar to those in the [l]-context.

In (25) I give a graphic representation of the order between the preceding contexts. A context that appears higher is associated with a lower [t, d]-deletion rate. A solid line between two contexts means that there is either direct or indirect evidence that the deletion rates between the two contexts are different. A broken line means that the deletion rates differ, but that strong evidence for the difference is lacking.

(25) **Order between different preceding contexts in the Guy and Boberg corpus in terms of [t, d] deletion rates**



Overall we have pretty strong evidence that the contexts are actually ordered as shown in (25). The two orderings that are less sure, are those between [k, g, p, b] and [l], and that between [m, ŋ] and [r]. About the latter of these two, we cannot conclude much. Guy and Boberg do not distinguish between [r] that is pronounced consonantally and [r] that is either not pronounced or that is pronounced as [r]-coloring on the preceding vowel. It is therefore really only about the order between [k, g, p, b] and [l] that the available data are not conclusive. Abstracting away from the uncertainties about these two orderings, I will assume that (25) represents the actual order between preceding contexts in terms of [t, d]-deletion rates, and the analysis that I will develop in §2.2 below will account for this order.

As mentioned at the beginning of this section, the preceding context has traditionally been treated differently in the literature. The context was partitioned differently, usually into the classes sibilants, stops, nasals, non-sibilant fricatives, and liquids, and the standard finding was that these contexts are ordered as follows in terms of descending [t, d]-deletion rates: sibilants > stops > nasals > non-sibilant fricatives > liquids. This particular order was most often claimed to be an effect of sonorancy – the less sonorous the preceding consonant the more likely [t, d] is to delete. However, there are several problems with this explanation.

Why would the sibilants that are more sonorous than the stops show higher deletion rates than the stops? This is no longer a mystery under the alternative view of the preceding context. The sibilants agree with [t, d] in place but differ from it in sonorancy. The stops agree with [t, d] in sonorancy, but differ from it in place. However, we have seen above that co-occurrence of homorganic consonants are avoided more than co-occurrence of consonants that agree in sonorancy features.

The distinction between the sibilants and the non-sibilant fricatives are also no longer problematic. Although both of these groups have the same level of sonorancy, the sibilants also agree with [t, d] in place. Since the sibilants share more features with [t, d], [t, d] deletes more after the sibilants than after the non-sibilant fricatives.

The fact that the nasal context showed a higher [t, d]-deletion rate than the non-sibilant fricatives was also problematic. Nasals are certainly more sonorous than fricatives. An explanation can now also be offered for this. By far most of the nasals that precede [t, d] are [n]'s.[23] [n] shares two features with [t, d], while the non-sibilant fricatives share only one feature with [t, d]. We therefore expect higher [t, d]-deletion rates following [n] than following [f, v].

Overall, it seems that it is better to partition the preceding context following Guy and Boberg than the tradition in the literature. Unfortunately, since the literature generally partitions the preceding context differently than Guy and Boberg, it is not possible to determine beyond doubt whether the data from the rest of literature support the Guy and Boberg analysis. However, I have shown just above that the pattern claimed by Labov (1989:90) to be the standard (sibilants > stops > nasals > non-sibilant fricatives > liquids) is in general compatible with the Guy and Boberg analysis.[24]

---

[23] There are no monomorphemes that end in the sequence [-mt], [-md], [-ŋt] or [-ŋd]. And the number of bi-morphemes that end in these sequences are also much lower than the number of bi-morphemes that end in [-nd] or [-nt]. This is confirmed in the Guy and Boberg corpus. Their corpus contained 337 tokens with an [n] preceding a [t, d], and only 9 with an [m] or [ŋ] preceding [t, d].

[24] See §2.2.3.2 below for a more detailed discussion of other data from the literature.

2.2 The analysis

In this section I develop an analysis of the pattern in (25). The analysis will assume that constraints that are driving [t, d]-deletion are versions of the Obligatory Contour Principle (OCP) (Goldsmith, 1976, Leben, 1973, McCarthy, 1986, Yip, 1988). These constraints penalize contiguous identical features. The more features shared between [t, d] and a preceding consonant, the more severely it will be penalized by OCP-constraints. The rest of this section is structured as follows: In §2.2.1 I first discuss the constraints that are involved explaining the effect of the preceding context on [t, d]-deletion. Section §2.2.2 then contains the actual analysis within the rank-ordering model of EVAL. In section §2.2.3 I consider the typology of deletion patterns that are possible assuming the constraints formulated in §2.2.1. Finally, in §2.2.4 I consider two outstanding issues – the same issues that were also considered when I discussed the following context above (§1.2.4). First, I discuss the deletion of stops other than [t, d]. Secondly, I discuss the deletion of [t, d] preceded by a vowel.

2.2.1 The constraints

Since the phenomenon we are dealing with is one of deletion, the relevant faithfulness constraint is the anti-deletion constraint MAX. In order to explain why MAX is sometimes violated, we need markedness constraints that will be violated by the non-deletion candidates. These markedness constraints are specific instantiations of the OCP.

There is a long tradition in phonology of constraining the occurrence of contiguous identical elements. This idea was first implicated by Leben (1973) in order to explain the avoidance of contiguous identical tones. Goldsmith (1976) later termed the constraint the "Obligatory Contour Principle" to capture the fact that forms were required to have tonal contours (i.e. no tonal plateaus). McCarthy (1986) and Yip (1988) showed that a similar principle also applies to segmental phonology – i.e. identical adjacent segments and identical features that are adjacent on some level of representation are also avoided.

Following Guy and Boberg (1997) I will assume that the markedness constraints that are responsible for the [t, d]-deletion pattern in (25) above are OCP-constraints against contiguous identical features, specifically against the three features that distinguish [t, d] from other consonants. The set relevant markedness constraints are defined in (26a) below. I am assuming the universal ranking in (26b) between these constraints. On this ranking, see below (26).

(26) a. **Markedness constraints**

*[+cor][+cor]:	Do not allow two contiguous segments that are both specified as [+coronal].
*[-son][-son]:	Do not allow two contiguous segments that are both specified as [-sonorant].
*[-cont][-cont]:	Do not allow two contiguous segments that are both specified as [-continuant].

b. **Ranking**

||*[+cor][+cor] o *[-son][-son] o *[-cont][-cont]|| [25]

---

[25] The formulation of these OCP-constraints is different from the way in which Alderete (1996, 1997) and Itô and Mester (1997, 2003) formulate OCP-constraints. They define OCP-constraints as the local self-conjunction of markedness constraints (Smolensky, 1995) – i.e. if *M* is a markedness constraint, then $*M_{\delta}^{2}$ is an OCP-constraint that is violated whenever *M* is violated twice in domain δ. The existence of the OCP-constraint therefore depends on the existence of the un-conjoined markedness constraint *M*.

The motivation for the ranking in (26b) comes from cross-linguistic patterns of consonantal co-occurrence restrictions. We know for Arabic (Frisch *et al*., 2004, Greenberg, 1950, Pierrehumbert, 1993), Hebrew (Greenberg, 1950), English, French and Latin (Berkley, 1994a, 1994b, 2000) that the co-occurrence of homorganic consonants is avoided more than the co-occurrence of consonants that agree in other features. Since *[+cor][+cor] penalizes co-occurrence of homorganic consonants, we can expect that it will outrank constraints on the co-occurrence of consonants agreeing in non-place features. We also know for Arabic that, within the class of coronals, those that agree in sonorancy are avoided more than those that agree in other features such as continuancy. Based on this, it can expected that *[-son][-son] outranks *[-cont][-cont].

In addition to the constraints in (26) that penalize contiguous segments that share one of the three features [+coronal, -sonorant, -continuant], there are also constraints that penalize contiguous segments that share two or three of these features. The motivation for these constraints again comes from cross-linguistic consonantal co-occurrence patterns. Pierrehumbert (Pierrehumbert, 1993), Frisch *et al.* (Frisch et al., 2004) and Berkley (Berkley, 1994a, 1994b, 2000) have all illustrated that consonantal co-occurrence restrictions are gradient – the more similar two consonants are, the less likely they are to

---

Gouskova (2003) has recently shown that assuming the existence of markedness constraints against "unmarked" features or segments results in incorrect typological predictions. The features [+coronal], [-sonorant] and [-continuant] are probably the most unmarked consonantal features. The unmarkedness of coronal place is generally accepted (de Lacy, 2002, 2003, Gnanadesikan, 1996, Jakobson, 1968, Paradis and Prunet, 1991, Prince, 1998). Assuming that the least marked consonants are as different from vowels as possible implies that stops are the least marked consonants. The features that select the stop consonants [-sonorant, -continuant] can therefore also be accepted as being unmarked features. If no markedness constraints against [+coronal] exists, then an OCP-constraint against two [+coronal] features can obviously not be formed via the local self-conjunction of a markedness constraint. The same is true of the features [-continuant] and [-sonorant]. There are therefore no *[+coronal], *[-continuant] or *[-sonorant] constraints that can be conjoined to form OCP-constraints. This is the why I do not define the constraints in (26) as locally self-conjoined markedness constraints.

co-occur in some domain. Consonants that share two of the features [+coronal, -sonorant, -continuant] with [t, d] are obviously more similar to [t, d] than consonants that share only one of these features with [t, d].[26] In order to capture these generalizations I assume the existence of the constraints in (27a) and (27b). I also assume that these constraints are ranked as shown in (27c) – a motivation of this ranking follows.

(27) **More markedness constraints**

a. **Sharing all three features**

***[+cor, -son, -cont][+cor, -son, -cont]**

Do not allow two contiguous segments that are both specified as [+coronal, -sonorant, -continuant].

b. **Sharing two of the features**

***[+cor, -son][+cor, -son]**

Do not allow two contiguous segments that are both specified as [+coronal, -sonorant].

***[+cor, -cont][+cor, -cont]**

Do not allow two contiguous segments that are both specified as [+coronal, -continuant].

***[-son, -cont][-son, -cont]**

Do not allow two contiguous segments that are both specified as [-sonorant, -continuant].

c. Ranking between the constraints in (26b)

||*[+cor, -son][+cor, -son] o *[+cor, -cont][+cor, -cont] o *[-son, -cont][-son, -cont]||

---

[26] Pierrehumbert (1993) calculates similarly between two consonants in terms of the number of shared features between the consonants. However, Frisch *et al*. (2004) show the number of natural classes shared by two consonants to be a better index of the similarity between the two consonants. Irrespective of which of these two measures of similarity is used, consonants that share two of the features [+coronal, -sonorant, -continuant] with [t, d] will be more similar to [t, d] than consonants that share only one of these features with [t, d].

Based on the fact that the co-occurrence of consonants is more restricted the more similar they are, I assume that all of the constraints in (27) rank higher than those in (26). On the same grounds, I also assume that the constraint in (27a) against sharing all three features ranks higher than the constraints in (27b) against sharing only two of the features.

The motivation for the ranking in (27c) comes again from the consonantal co-occurrence patterns in Arabic, English, French and Latin mentioned just above. In all of these languages co-occurrence of consonants that agree in place of articulation is avoided more than co-occurrence of consonants that do not agree in place of articulation. This motivates the ranking of the two constraints that include a reference to [+coronal] over the third constraint. At least for Arabic we know that within the set of coronals consonants that also agree in sonorancy are avoided more than those that do not agree in sonorancy. This is the motivation for the ranking between the first two constraints – since *[+cor, -son][+cor, -son] refers also to sonorancy, it outranks *[+cor, -cont][+cor, -cont].

In (28) I give a graphic representation of how all the markedness constraints that I assume are ranked.

(28) **The ranking between the markedness constraints in (26) and (27)**

Constraints	**Penalizes [t, d] preceded by …**
*[+cor, -son, -cont][+cor, -son, -cont]	[t, d]
|	
*[+cor, -son][+cor, -son]	[s, š, z, ž]
|	
*[+cor, -cont][+cor, -cont]	[n]
|	
*[-son, -cont][-son, -cont]	[k, g, p, b]
|	
*[+cor][+cor]	[l]
|	
*[-son][-son]	[f, v]
|	
*[-cont][-cont]	[m, ŋ]

2.2.2 Accounting for the observed patterns

Now that the relevant constraints have been identified, we can consider how these constraints interact to determine the variable [t, d]-deletion pattern shown in (23) and (25). As before, there are two aspects of the variation that need to be accounted for, namely the intra-contextual and the inter-contextual variation. The intra-contextual variation is discussed first in §2.2.2.1. Section §2.2.2.2 then deals with the inter-contextual variation.

2.2.2.1 Intra-contextual variation

The data in (23) show that, with the exception of the post [t, d] context, all contexts have variation between deletion and retention. In this section I first discuss the contexts that do show variation, and then return to the post [t, d] context.

There are two variants that are observed in the [t, d]-deletion phenomenon – the retention candidate that preserves [t, d], and the deletion candidate (indicated with the symbol ∅). In contexts where the deletion candidate is the more frequently observed variant, EVAL has to impose the harmonic ordering |∅ ™ t/d| on the candidate set. In contexts where the retention candidate is the more frequent variant, the opposite ordering has to be imposed on the candidate set, i.e. |t/d ™ ∅|. A glance back at (23) confirms that all the contexts that show variation are associated with deletion rates of lower than 50% – i.e. for all contexts we need the harmonic ordering |t/d ™ ∅|.[27]

---

[27] The deletion rate after sibilants is very close to 50%. However, in the discussion here I will assume that this context does actually show more retention than deletion. The fact that the deletion rate in this context is so close to chance indicates that this dialect of English is on the verge of changing from a dialect that prefers retention to a dialect that prefers deletion in this context. During this stage it might be that the second best candidate (the deletion candidate) is highly accessible – i.e. the deletion and the retention candidate do no differ much in their relative accessibility, so that individual speakers will show near chance deletion. It is also possible that individual speakers differ from each other. Some might have the ranking ||MAX o *[+cor, -son][+cor, -son]|| and therefore show more retention, while

In order to get the ordering |t/d ™ ∅| for these contexts, it is necessary that the deletion candidate always violate a higher ranked constraint than the retention candidates. Since the deletion candidate violates only MAX, we need MAX to outrank all of the markedness constraints that refer to these contexts. In order to assure that variation is observed in all contexts, it is also necessary that neither the deletion candidate nor the retention candidate be disfavored by any constraint ranked higher than the critical cut-off. This implies that the cut-off should be ranked higher than MAX and the markedness constraints. Lastly, we need to account for the fact that only two variants are observed, namely retention of [t, d] and deletion of [t, d]. In addition to deletion of [t, d], there are several other ways in which violation of the markedness constraints can be avoided. Consider an input such as /-Vlt/. The retention candidate for this input [-Vlt] violates *[+cor][+cor]. This violation can be avoided by deletion of the [t], i.e. [-Vl] (an actually observed variant), or by epenthesis of a vowel between the two consonants, i.e. [-VlVt]. In order to prevent [-VlVt] from surfacing as a variant, it is necessary that this candidate be disfavored by a constraint ranked higher than the cut-off. This candidate violates the anti-epenthesis constraint DEP. If we rank DEP higher than the cut-off, we can explain why [-VlVt] is never observed as a variant output for /-Vlt/. In the discussion below, I will use this candidate as an example of a non-observed variant. All other non-observed variants are ruled out in the same manner – i.e. they all are disfavored by constraints ranked higher than the cut-off.

---

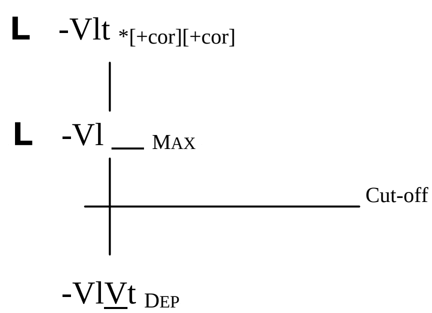
others have the opposite ranking ||*[+cor, -son][+cor, -son] o MAX|| and therefore show more deletion. Guy and Boberg (1997, see also Guy, 1994) report only the mean deletion rates for all the speakers together. It is therefore not possible to decide between these two possibilities.

Tableau (29) considers the evaluation of the relevant candidates for an input like /-Vlt/. In this tableau I include only one markedness constraint, namely *[+cor][+cor] – the constraint violated by the retention candidate [-Vlt]. Since all contexts with variation show the same variation pattern (more retention than deletion), this one tableau serves as an example for all these contexts. The variation pattern in other contexts can be explained in exactly the same way by replacing *[+cor][+cor] by the markedness constraint relevant to the particular context.

(29) **Variation for a /-Vlt/ input**

/-Vlt/	DEP	MAX	*[+cor][+cor]
1 -Vlt			*
2 -Vl ___		*	
3 -VlVt	*!		

Output of EVAL



Neither the retention candidate nor the deletion candidate violates any constraints ranked higher the cut-off. Both of these candidates are therefore predicted as possible outputs. Since EVAL rates the retention candidate better than the deletion candidate, the prediction is that the retention candidate will be the more frequently observed variant. The epenthetic candidate violates DEP which is ranked higher than the critical cut-off. Since there are candidates available that violate no constraints ranked higher than the cut-off, the epenthetic candidate will never be selected as an output variant.

Now we can consider the post [t, d] context. As explained when the data were discussed in §2.1, there are no forms in which a final [t, d] can actually be preceded by [t, d]. There are no monomorphemes in English with this sequence, and the past tense suffix used with verbs that end on [t, d] is /-əd/ rather than /-d/. However, because of "richness of the base" (Smolensky, 1996) we have to consider what the grammar would have done with inputs that contained one of the sequences /-td, -dd, -dt, -tt/. Since no forms like these exist in English, the assumption is that English does not tolerate sequences like these. Had such input sequences existed, they would then not be allowed to surface faithfully at all. Based on these considerations, I am assuming that a final [t, d] would have deleted 100% of the time from such sequences.

Unlike in the other contexts, the deletion candidate is therefore preferred over the retention candidate in the post [t, d] context. This means that for this context EVAL has to impose the ordering |∅ ™ t/d| on the candidate set. This is possible only if the retention candidate is disfavored by a constraint ranked higher than MAX. The markedness constraint that refers specifically to the post [t, d] context therefore outranks MAX, i.e. ||*[+cor, -son, -cont][+cor, -son, -cont] o MAX||. In order to assure that the deletion candidate is the only candidate that is accessed as output in this context, it is necessary that the retention candidate be disfavored by a constraint ranked higher than the cut-off, i.e. ||*[+cor, -son, - cont][+cor, -son, -cont] o Cut-off||. When the other contexts were discussed just above, I have argued that the Cut-off ranks higher than MAX. Combing these rankings therefore gives us ||*[+cor, -son, - cont][+cor, -son, -cont] o Cut-off o MAX||. Under this ranking a final [t, d] will always delete when it is preceded by [t, d]. This is shown in tableau (30).

(30) **Categorical deletion after [t, d]**

/-Vtt/	*[+cor, -son, - cont] [+cor, -son, -cont]	DEP[28]	MAX
3 -Vtt	*!		
1 -Vt __			*
2 -VtVt		*!	

Output of EVAL

L -Vt __ MAX

Cut-off

-VtVt DEP

-Vtt *[+cor, -son, - cont][+cor, -son, -cont]

With the exception of the deletion candidate, all candidates are disfavored by a constraint ranked higher then cut-off. The deletion candidate violates only MAX, a constraint ranked lower than the cut-off. Since there is a candidate available that is not disfavored by any constraint ranked higher than the cut-off, the candidates that are disfavored by constraints ranked higher than the cut-off will not be accessed as outputs. The prediction is therefore that the deletion candidate will be the only observed output.

2.2.2.2 Inter-contextual variation

What remains to be accounted for is the difference between different contexts. Although all of the contexts show less than 50% deletion, the actual deletion rates in the different contexts are not the same. In (25) the contexts are listed in ascending order of [t, d]-deletion rate. In the rank-ordering model of EVAL such inter-contextual variation is

[28] We do not have evidence for the ranking between DEP and *[+cor, -son, - cont][+cor, -son, -cont]. Following the principle of ranking conservatism I rank the markedness constraint higher than the faithfulness constraint. On ranking conservatism, see the discussion in Chapter 4 §2.2.1.

accounted for by considering non-generated comparison sets – i.e. we compare the retention candidates from different input contexts with each other rather than different output candidates for a single input. This comparison is done in (31).

(31) **Comparison between retention candidates from different contexts**

Context			*[+cor, -son, -cont][+cor, -son, -cont]	MAX	*[+cor, -son][+cor, -son]	*[+cor, -cont][+cor, -cont]	*[-son, -cont][-son, -cont]	*[+cor][+cor]	*[-son][-son]	*[-cont][-cont]
[t, d]	7	-tt	*							
[s, š, z, ž]	6	-st			*					
[n]	5	-nt				*				
[k, g, p, b]	4	-kt					*			
[l]	3	-lt						*		
[f, v]	2	-ft							*	
[m, ŋ]	1	-mt								*

Output of EVAL

Context

[m, ŋ] -mt *[-cont][-cont]
|
[f, v] -ft *[-son][-son]
|
[l] -lt *[+cor][+cor]
|
[k, g, p, b] -kt *[-son, -cont][-son, -cont]
|
[n] -nt *[+cor, -cont][+cor, -cont]
|
[s, š, z, ž] -st *[+cor, -son][+cor, -son]
|
[t, d] -tt *[+cor, -son, -cont][+cor, -son, -cont]

The more marked the retention candidate is, the more can be gained by deletion of the [t, d]. The prediction is therefore that the deletion rates should steadily increase as we move down the rank-ordering that EVAL imposes on these candidates. In (25) the contexts were also arranged in terms of increasing [t, d]-deletion rate. Comparison between the ordering in (31) and the ordering in (25) will confirm that these two are the same. The predicted and observed relations between the contexts therefore agree. By allowing EVAL to compare the retention candidates from the different input contexts, we can account for the difference in deletion rates between the contexts.

This is a significant result. When I discussed the ranking between the different markedness constraints in §2.1 above, I showed that each of the rankings was motivated by consonantal co-occurrence restrictions in several languages. The constraints were therefore not ranked primarily based on the [t, d]-deletion patterns. The fact that this particular ranking correctly accounts for the inter-contextual variation can therefore be taken as strong evidence in favor of the analysis presented here.

2.2.3 Factorial typology – what are the possible dialects?

I have argued above that we need seven markedness constraints, one faithfulness constraint and the critical cut-off to account for the [t, d]-deletion pattern discussed in §2.2.1 and §2.2.2. We have to consider the factorial typology that follows from this – i.e. what are all the possible rankings between these constraints and the cut-off and what are the deletion patterns that would result from each of these rankings? These and only these patterns are predicted as possible.

Since no dialect of English ever allows a word to end on two coronal stops, I will assume that the post [t, d] context will always be associated with categorical deletion, and will not consider this context here. I will therefore consider only six of the markedness constraints here. Although there are six markedness constraints, I have argued that the ranking between these constraints are universally fixed as in (28). All that we have to consider is how the critical cut-off and MAX can be ranked relative to this fixed ranking. There are seven positions on the ranking in (28) where MAX can be ranked. In each of these seven rankings there are eight positions where the critical cut-off can be located. This means that there is a total of 56 possible rankings to consider. I will not discuss each of these 56 grammars. However, I will point out all the deletion patterns that are predicted as possible (that result from at least one of these rankings), and also some of the deletion patterns that are predicted as impossible (that would not result from any of the possible rankings).

The rest of this section is structured as follows: I begin by considering what the conditions are that must be satisfied for any variation to be observed (§2.2.3.1). After that has been established, I will first discuss the deletion patterns that are predicted as possible (§2.2.3.2), and then the patterns that are predicted as impossible (§2.2.3.2).

2.2.3.1 Conditions for variation

Variation is only possible if there is more than one candidate that is not disfavored by any constraint ranked higher than the critical cut-off. In the [t, d]-deletion phenomenon the observed variants are the retention and the deletion candidates. For some context to show variation, it is therefore necessary that neither the deletion candidate nor the retention candidate for that context be disfavored by a constraint ranked higher the cut-off. The deletion candidate will always violate MAX. The first requirement is therefore that MAX should rank below the cut-off. The retention candidate in each context will violate one or more of the six markedness constraints assumed here.[29] In order for the retention candidate to be one of the observed variants, it is also necessary that all the markedness constraints that it violates rank lower than the cut-off. These requirements are stated in a general form in (32).

(32) **Necessary conditions for variation in each context**

a. **General condition**

||Cut-off o MAX||

b. **Context specific conditions**

Let 𝕄 stand for the set of markedness constraints violated by the retention candidate in some context. Then variation in this context can be observed only if:

For all M ∈ 𝕄: ||Cut-off o M||

2.2.3.2 Possible deletion patterns

I list the deletion patterns that are predicted as possible in (33). I do not show here why these are all and only the possible patterns. This discussion can be found in the Appendix at the end of this chapter. In the tables in (33) "D" stands for "categorical deletion", "R" for "categorical retention", "D > R" for "more deletion than retention" and "R > D" for "more retention than deletion". In order to make it easier to identify patterns, I also shade all cells in which more deletion than retention is observed – i.e. both "D" and "D > R"

[29] Whenever the retention candidate violates one of the constraints that refer to more than one feature, it will also violate the constraints that refer to each of these features individually.

cells. The different contexts that can precede a final [t, d] are listed in the top row in the order of decreasing markedness.

(33) **Possible deletion patterns**

a. **No-variation**

[s, š, z, ž]	[n]	[k, g, p, b]	[l]	[f, v]	[m, ŋ]
R	R	R	R	R	R
D	R	R	R	R	R
D	D	R	R	R	R
D	D	D	R	R	R
D	D	D	D	R	R
D	D	D	D	D	R
D	D	D	D	D	D

b. **Variation in all contexts**

[s, š, z, ž]	[n]	[k, g, p, b]	[l]	[f, v]	[m, ŋ]
R > D	R > D	R > D	R > D	R > D	R > D
D > R	R > D	R > D	R > D	R > D	R > D
D > R	D > R	R > D	R > D	R > D	R > D
D > R	D > R	D > R	R > D	R > D	R > D
D > R	D > R	D > R	D > R	R > D	R > D
D > R	D > R	D > R	D > R	D > R	R > D
D > R	D > R	D > R	D > R	D > R	D > R

c. **Variation only in some contexts**

[s, š, z, ž]	[n]	[k, g, p, b]	[l]	[f, v]	[m, ŋ]
D	R > D	R > D	R > D	R > D	R > D
D	D > R	R > D	R > D	R > D	R > D
D	D > R	D > R	R > D	R > D	R > D
D	D > R	D > R	D > R	R > D	R > D
D	D > R	D > R	D > R	D > R	R > D

((33c) continued)

[s, š, z, ž]	[n]	[k, g, p, b]	[l]	[f, v]	[m, ŋ]
D	D > R	D > R	D > R	D > R	D > R
D	D	R > D	R > D	R > D	R > D
D	D	D > R	R > D	R > D	R > D
D	D	D > R	D > R	R > D	R > D
D	D	D > R	D > R	D > R	R > D
D	D	D > R	D > R	D > R	D > R
D	D	D	R > D	R > D	R > D
D	D	D	D > R	R > D	R > D
D	D	D	D > R	D > R	R > D
D	D	D	D > R	D > R	D > R
D	D	D	D	R > D	R > D
D	D	D	D	D > R	R > D
D	D	D	D	D > R	D > R
D	D	D	D	D	R > D
D	D	D	D	D	D > R

The most striking characteristic of these tables is that if a cell is shaded, then all cells to its left are also shaded. This means that if some context is associated with more deletion than retention, then so are all contexts in which retention would be more marked. This is a very reasonable prediction. If the markedness of the retention candidate in some context is severe enough that deletion is preferred over retention for that context, then the same should be true of contexts in which the retention candidate is even more marked.

A prediction that is not shown in the tables in (33) is that the deletion rate should steadily fall across the contexts from left to right – that is, the highest deletion rate is expected for the most marked sequence, and lower deletion rates for less marked sequences. This is clearly shown in (31) above. In tableau (31) I compared the retention candidates from the different contexts for the Guy and Boberg (1997) corpus. Although the comparison there was done specifically for their corpus, it can stand in for any possible grammar. Since the ranking between the markedness constraints is fixed, the comparison between the retention candidates will always result in the same rank-ordering between the retention candidates, irrespective of where MAX and the critical cut-off rank amongst the markedness constraints.

The only one of the patterns in (33) that we know for certain to exist is that represented by the first line of table (33b) – variation in all contexts with more retention than deletion in all contexts. This is the pattern that is observed in the speech of the three Philadelphians that Guy and Boberg (1997, see also Guy, 1994) report on and that was discussed in detail in §2.1 and §2.2.2 above. There is no other dialect of English for which we have adequate information to determine whether it exemplifies one of the other patterns. The reason for this is, of course, that the other studies of [t, d]-deletion partitions the preceding context differently – see the discussion in §2.1 about this. However, it is at least possible to determine for some dialects discussed in the literature whether they are likely to fit into one of these patterns. The tables in (34) are a representative sample of the data from the literature on the influence of the preceding context. The classes are listed in order of descending deletion rate from left to right.[30]

---

[30] Labov *et al.* (1968) report on the English of African American and Puerto Rican speakers in New York City. Unfortunately they do not report the actual deletion rates associated with different preceding contexts. However, they do state that [t, d] deletes most often after [s], and very infrequently after [l] (which they ascribe to the fact that post-vocalic [l] is most often “non-consonantal”) (p. 129).

(34) **Influence of the preceding context on the [t, d]-deletion rate**

(a) Neu data (1980:49)

Class	**[s, š, z, ž]**	**[p, b, k, g]**	**[n, m, ŋ]**	**[l]**	**[f, v]**
n	306	123	693	117	70
% deleted	37	31	30	5	3

(b) Jamaican English (Kingston) (Patrick, 1991:178)

Class	**[s, š, z, ž]**	**[p, b, k, g]**	**[f, v]**	**[n, m, ŋ]**	**[l]**
n	462	162	73	907	168
% deleted	85	80	75	67	58

(c) Tejano English (San Antonio) (Bayley, 1997:310)

Class	**[s, š, z, ž]**	**[m, n, ŋ]**	**[p, b, k, g]**	**[l]**	**[f, v]**
n	1,288	1,073	334	375	206
% deleted	72	40	33	21	16

(d) Trinidadian English (Kang, 1994:157)

Class	**[s, š, z, ž, k, g, p, b, n, m, ŋ]**	**[f, v, l]**
n	51	30
% deleted	45	30

(e) African American English (Washington, DC) (Fasold, 1972:70)

Class	**[n, m, ŋ, l]**	**[s, š, z, ž, f, v]**	**[p, b, k, g]**
n	147	112	123
% deleted	63	49	37

(f) Chicano English (Los Angeles) (Santa Ana, 1991:92)

Class	**[m, n, ŋ]**	**[s, š, z, ž]**	**[l]**	**[f, v]**	**[r]**	**[p, b, k, g]**
n	1,779	777	354	83	475	21
% deleted	67	60	34	16	14	5

With the exception of the Chicano English in (34f), all of these dialects are compatible with the predictions of the analysis developed above. Consider first the Neu data from (34a). As predicted by the analysis, post-sibilant context shows the highest deletion rate. Since this context still shows less than 50% deletion, it means that these data represent a dialect that fall in the first line of (33b) – i.e. more retention than deletion everywhere. The prediction of the analysis here is that [n] should show more deletion than the stops, and the stops again more than [m, ŋ]. Since Neu groups all three nasals together it is not possible to determine whether this particular prediction is confirmed by her data. She reports near equal deletion after the nasals and after the stops. It is possible that a higher deletion rate after [n] and the lower deletion rate of [m, ŋ] average out to a deletion rate that is about equal to the deletion rate after the stops. My analysis predicts a higher deletion rate after [l] than after the non-sibilant fricatives. This is confirmed in Neu's data. Since Neu groups [m, ŋ] together with [n], it is not possible to determine what the deletion rate is that is associated with [m, ŋ] alone. We can therefore not determine whether post [m, ŋ] context shows a lower deletion rate than post [f, v] context.

The Jamaican English data in (34b) would fall in the last of the possible patterns in (33b) – with more deletion than retention everywhere. As predicted, it has the highest deletion rate after sibilants. Next we would expect [n]. However, since [m, ŋ] is lumped together with [n], it is very likely the case that the low deletion rate after [m, ŋ] pulls down the mean rate for nasals. The most unexpected result is that [l] shows less deletion than [f, v]. However, it is possible that the [l] of Jamaican English is often vocalized, in which case we would expect a low deletion rate after [l] – see for instance Labov *et al*. (1968:129) who use this as explanation for the low deletion rate after [l] in the AAE of Harlem.

Tejano English (34c) represents a dialect from the second pattern in (33b) – more deletion than retention in the most marked post-sibilant context, more retention than deletion everywhere else.

For Trinidadian English (34d) it is not possible to decide which pattern it would represent – both since the preceding context is partitioned into only two groups, and because the number of tokens in this corpus is very small.

Washington, DC AAE (34e) is most likely representative of the pattern in the third line of (33b) – more deletion than retention after sibilants and [n], but more retention than deletion elsewhere. Fasold reports a 63% deletion rate after [n, m, ŋ, l]. Since [l] and [m, ŋ] are expected to have low deletion rates, it means that the actual deletion rate after [n] is probably even higher. For the class of fricatives [s, š, z, ž, f, v] Fasold reports a 49% deletion rate. The actual rate after sibilants is almost certainly higher, and is pulled down by a relatively low deletion rate after [f, v]. Fasold reports a rate below 50% for the stops, and we would therefore expect [l], [f, v] and [m, ŋ] also to show less than 50% deletion – since retention in all of these contexts are less marked than retention after a stop, and these contexts should therefore show even less deletion than the post-stop context.

The data for Chicano English in (34f) are problematic. The deletion pattern in these data goes against the predictions of the analysis above in several respects. First, the nasals show a higher deletion rate than the sibilants. Secondly the stops show a lower deletion rate than [l], [f, v] and [r]. These data do not only counter predictions of the analysis that I developed above, but also the statement of Labov about how the preceding context in general influences [t, d]-deletion. Labov (1989:90) summarizes the results of studies on [t, d]-deletion, and notes that preceding consonants can be ordered as follows in terms of decreasing deletion rates: sibilants > stops > nasals > non-sibilant fricatives > liquids. Santa Ana (1996:72) also acknowledges that his data on Chicano English counter all other data reported in the literature. The Chicano data therefore represent a truly unexpected pattern.[31]

To the best of my knowledge no dialect has been reported with one of the patterns from (33a) (variation in no context) or from (33c) (variation only in some contexts). Even so, all of these patterns seem reasonably possible – they all show at least as much deletion in the more marked than in the less marked contexts.

2.2.3.3 Impossible deletion patterns

We also have to consider deletion patterns that are predicted as impossible. These are probably even more instructive. If a deletion pattern that is predicted as impossible does actually exist, it would count as rather strong evidence against the analysis.

A group of deletion patterns that are predicted as impossible are patterns in which a more marked sequence is associated with lower deletion rates than a less marked sequence. I list a few of these patterns as examples in (35).

(35) **Impossible patterns: More retention in more marked context than in less marked context**

[s, š, z, ž]	[n]	[k, g, p, b]	[l]	[f, v]	[m, ŋ]
R	R	R	D	D	D
R	R	R	R > D	R > D	R >D
D > R	D > R	D > R	D	D	D
R > D	R > D	R > D	D	D	D
R > D	R > D	R > D	D > R	D > R	D > R

31 See the next section for more discussion of the Chicano deletion pattern.

The patterns in (35) represent only a portion of the large number of patterns like these that are predicted as impossible. To make the discussion more concrete, consider the deletion rates after [n] and after [m, ŋ] in the patterns in (35). In all of these examples [t, d] would delete less after [n] than after [m, ŋ]. All of these patterns are predicted as impossible under the analysis developed above. This prediction follows straightforwardly from the universal ranking between the markedness constraints in (28). Because *[+cor, -cont][+cor, -cont] universally outranks *[-cont][-cont], retention after an [n] will always be more marked than retention after [m, ŋ]. With the exception of the deletion pattern of Chicano English (see (34f) above), I know of no dialect of English that counters this prediction.

The Chicano English data do counter this prediction, and therefore represent a potential problem for the analysis that I developed above. For instance, in Chicano English [t, d] deletes more after nasals than after sibilants. However, we should remember that factorial typology predictions assume that the constraints being considered are the only relevant constraints. It is possible that there are other constraints that could also have an influence on [t, d]-deletion. Santa Ana (1996) suggests that the Chicano English pattern is governed not by OCP-constraints, but by constraints on syllabic well-formedness. Following Clements (1988), Santa Ana claims that a high sonority coda is more well-formed than a low sonority coda. Deletion of a final [t, d] after a segment that is high in sonority will therefore result in a syllable with a highly desirable coda. However, deletion after a consonant that is low in sonority will result in a syllable with a coda that is less desirable. This could explain why [t, d] deletes more after nasals than sibilants. Deletion after a nasal results in a syllable with a highly desirable nasal coda.

Deletion after a sibilant results in a syllable with a less desirable sibilant coda. It therefore seems to be the case that in Chicano English the constraints on the well-formedness of codas outrank the OCP-constraints that were formulated above in §2.1.1. As a result, these syllabic well-formedness constraints would take precedence in deciding the deletion pattern.[32] Even if this could account for the Chicano pattern, it would still be hard to explain why Chicano English differs from all other dialects. Currently I can offer no explanation for this.

There is another group of patterns that are predicted as impossible, namely patterns in which some context shows variable deletion and some less marked context shows categorical retention. I list a few of these patterns as examples in (36).

(36) **Impossible patterns: Variable deletion in some context, and categorical retention in a less marked context**

[s, š, z, ž]	[n]	[k, g, p, b]	[l]	[f, v]	[m, ŋ]
R > D	R > D	R > D	R	R	R
D > R	D > R	D > R	R	R	R
D > R	D > R	R > D	R > D	R	R

All of the examples in (36) show variable deletion at the more marked end of the spectrum, and categorical retention at the less marked end. To make the example more concrete, consider only the post [n] and post [f, v] contexts. In the patterns in (36) there is

[32] Let OCP stand for the OCP-constraints defined in §2.2.1 above, and SWF stand for the syllabic well-formedness constraints that determine the Chicano deletion patterns. In particular let SWF_{Nasal} stand for the constraint on nasal codas, SWF_{Sib} for the constraint on sibilants, and SWF_{Rest} for all the other coda constraints grouped together. Chicano English would then need the following ranking: ||Cut-off o SWF_{Nasal} o SWF_{Sib} o MAX o SWF_{Rest} o OCP||. Since the cut-off ranks above both MAX and the SWF constraints, it follows that there will be variation between deletion and retention. Since SWF_{Nasal} and SWF_{Sib} both outrank MAX, EVAL will order the candidates in these contexts as follows: |∅ ™ t/d| – i.e. we expect more deletion than retention here. Since MAX outranks the rest of the SWF constraints, EVAL will impose the opposite order on the candidate set for these contexts, i.e. |t/d ™ ∅|. For these contexts we would then expect more retention than deletion. The OCP-constraints have to rank relatively low – so that they cannot override the effects of the SWF constraints.

variable deletion after [n] and categorical retention after [f, v]. The impossibility of these patterns is a somewhat unexpected prediction. Retention after [f, v] violates *[-son][-son] and retention after [n] violates *[+cor, -cont][+cor, -cont]. Because of the universal ranking ||*[+cor, -cont][+cor, -cont] o *[-son][-son]|| (see (28)), retention after [n] will always be more marked than retention after [f, v]. From this we expect that [t, d] will always delete more after [n] than after [f, v]. Why is it then not possible for [t, d] to be categorically retained after [f, v] and to delete variably after [n]?

To see how this prediction follows from the analysis developed above, consider what the conditions are that have to be met for the [n] context to show variable deletion. Both of the variation conditions from (32) have to be met for this context, i.e. we need the ranking ||Cut-off o {MAX, *[+cor, -cont][+cor, -cont]}||. However, the universal ranking ||*[+cor, -cont][+cor, -cont] o *[-son][-son]|| (see (28)) entails through transitivity of constraint ranking that we also have ||Cut-off o {MAX, *[-son][-son]}||. Both variation conditions are therefore also met for the post [f, v] context, so that it is not possible to have categorical retention in this context.[33] In general then, if some context shows variation, then so will all less marked contexts. Although this prediction of my analysis seems potentially problematic, to the best of my knowledge no dialect has been reported that shows any of these patterns. For now, I therefore only acknowledge this as a falsifiable prediction of the analysis.

---

[33] Categorical deletion is also excluded in the same manner. However, this is not a problem. If post [n] context had variable deletion and post [f, v] context had categorical deletion, then the less marked post [f, v] context would have had more deletion than the more marked post [n] context. See the discussion earlier in this section about cases like these.

2.2.4 Two outstanding questions

When I discussed the influence of the following context, I showed that the other stops of English [p, b, k, g] also delete, and that a [t, d] deletes also when it is preceded by a vowel (§1.2.4). I will therefore not again show that this is true. However, I will briefly consider the implication of these facts for the analysis of the influence of the preceding context developed above.

2.2.4.1 What about [p, b] and [k, g]?

I have already shown in §1.2.4.1 that the labial and velar stops of English are also subject to variable deletion when they occur as final member of a word-final consonant cluster. As I also mentioned then, there are no data available on the deletion patterns associated with the non-coronal stops. The discussion in this section is therefore necessarily speculative.

The most straightforward assumption would be that the deletion of the non-coronal stops is influenced by the same factors that influence the deletion of the coronal stops. I argued above that the constraints that drive the deletion of the coronal stops are constraints of the OCP-family – constraints against contiguous segments that share certain features. In order to determine what the constraints are that influence the deletion of the labial and the velar stops, it is first necessary to determine what the features are that uniquely identify these two classes of stops. This is shown in (37).

(37) **Distinctive features of the non-coronal stops**

[p, b]	=	[+labial, -sonorant, -continuant]
[k, g]	=	[+velar, -sonorant, -continuant]

From these features we can now form OCP-constraints similar to the constraints that were formulated above for the coronals. The relevant constraints are listed in (38).

(38) **Markedness constraints that influence the deletion of non-coronal stops**

a. **Applying to both labials and velars**

*[-son][-son]:	Do not allow two contiguous segments that are both specified as [-sonorant].
*[-cont][-cont]:	Do not allow two contiguous segments that are both specified as [-continuant].
*[-son, -cont][-son, -cont]:	Do not allow two contiguous segments that are both specified as [-sonorant, -continuant].

b. **Specific to labials**

*[+lab][+lab]:	Do not allow two contiguous segments that are both specified as [+labial].
*[+lab, -son][+lab, -son]:	Do not allow two contiguous segments that are both specified as [+labial, -sonorant].
*[+lab, -cont][+lab, -cont]:	Do not allow two contiguous segments that are both specified as [+labial, -continuant].

c. **Specific to velars**

*[+vel][+vel]:	Do not allow two contiguous segments that are both specified as [+velar].
*[+vel, -son][+vel, -son]:	Do not allow two contiguous segments that are both specified as [+velar, -sonorant].
*[+vel, -cont][+vel, -cont]:	Do not allow two contiguous segments that are both specified as [+velar, -continuant].

Velar and labial stops share the features [-sonorant, -continuant] with coronals, so that the constraints in (38a) apply to stops at all three places of articulation. The constraints in (38b) and (38c) refer specifically to place and therefore apply only to some stops. In the discussion on coronals, I argued that agreement in place is avoided most, then in sonorancy, then in continuancy. Based on this I list I list the rankings for labials and velars in (39). Next to each constraint I list the contexts in which it applies. Labial and velar stops occur only after sibilants and homorganic nasals (Fudge, 1969:268). I indicate contexts in which they do not occur by striking out the segments representing these contexts.[34]

(39) **Ranking of the constraints for labials and velars**

Labials		**Velars**	
Constraints	**Penalizes [p, b] preceded by …**	**Constraints**	**Penalizes [k, g] preceded by …**
*[+lab,-son][+lab,-son]	[~~f, v~~]	*[+vel,-son][+vel,-son]	–[35]
*[+cor,-cnt][+cor,-cnt]	[m]	*[+vel,-cnt][+vel,-cnt]	[ŋ]
*[-son,-cnt][-son,-cnt]	[~~t, d, k, g~~]	*[-son,-cnt][-son,-cnt]	[~~t, d, p, b~~]
*[+lab][+lab]	–[36]	*[+vel][+vel]	–[37]
*[-son][-son]	[s, ~~š, z, ž~~]	*[-son][-son]	[s, ~~š, z, ž, f, v~~]
*[-cont][-cont]	[~~n, ŋ~~]	*[-cont][-cont]	[~~n, m~~]

---

[34] An example of a non-occurring sequence with a labial stop is [-fp]. Since this sequence is not allowed in English, there are no monomorphemes with this sequence. Since English does not have a labial stop suffix, /-p/ or /-b/, no bi-morphemes with this sequence is possible either. All of these non-occurring sequences must be ruled out by different markedness constraints that are ranked higher than the cut-off.

[35] This cell would have contained segments with the feature combination [+velar, -sonorant, +continuant], i.e. velar fricatives. English does not have any velar fricatives, so that this cell is empty.

[36] This cell would have contained [+labial, +sonorant, +continuant] segments, i.e. a labial counterpart of [l]. Since the English consonantal inventory does not contain any such sounds, this cell is empty.

[37] This cell would have contained segments with the features combination [+velar, +sonorant, +continuant], i.e. a velar counterpart of [l]. Since the English consonantal inventory does not contain any such sounds, this cell is empty.

From these rankings it is easy to predict which contexts would be associated with higher deletion rates. The higher ranked the markedness constraints that would be violated by a retention candidate, the more marked retention in that context would be, and the more deletion we would expect.[38] In (40) I list for each of the places of articulation the different preceding contexts in descending order of predicted deletion rate. The order for labials and velars comes from (39), while the order for the coronals is from (31).

(40) **Predicted order in deletion rate for different places of articulation**

[t, d] after …	**[p, b] after …**	**[k, g] after …**
[s, š, z, ž]	[~~f, v~~]	–
[n]	[m]	[ŋ]
[k, g, p, b]	[~~t, d, k, g~~]	[~~t, d, p, b~~]
[l]	–	–
[f, v]	[s, ~~š, z, ž~~]	[s, ~~š, z, ž, f, v~~]
[m, ŋ]	[~~n, ŋ~~]	[~~n, m~~]

↑ **More deletion**

The prediction is therefore that the deletion pattern after velar and labial stops would be quite different from the pattern after coronal stops. For coronals we expect the highest deletion rate after sibilants and [n]. For labials and velars these contexts are predicted to have the lowest deletion rates. Of course, since labial and velar stops do not occur after heterorganic nasals, the prediction about [n] is not testable. However, the

[38] Refer to the inter-context comparison for coronals in (31) above for an illustration of how this prediction can be derived from an OT tableau.

labial and velar stops do occur after [s]. In principle this prediction could be tested – does [t, d] delete much more frequently after [s] than either [p, b] or [k, g] does?

Another prediction is that [t, d] should delete relatively infrequently after [m], while [p, b] should delete much more after [m]. Similarly, [t, d] should delete infrequently after [ŋ] while [k, g] should delete much more after [ŋ]. Since labial stops can be preceded by [m] and velar stops by [ŋ], these two predictions are also in principle testable.

The analysis developed above for [t, d]-deletion makes interesting testable predictions about the deletion of velar and labial stops. This suggests worthwhile ways in which to expand the research on variable stop deletion in English.

2.2.4.2 What about [t, d] preceded by a vowel?

In §1.2.4.2 I have already shown that word-final [t, d] also deletes when it is preceded by a vowel. Since vowels do not share any of the features [+coronal, -sonorant, -continuant] with [t, d], a [t, d] preceded by a vowel will be unmarked relative to a [t, d] preceded by any consonant. The prediction is therefore that this context will show the lowest deletion rate of all contexts. This prediction is confirmed in Guy and Boberg's (1997) corpus. They do not list the actual deletion rate of [t, d] after vowels. However, they do state that this context shows "nearly categorical retention" (p. 155).

3. Considering alternatives

There are three alternative proposals for dealing with variable data in OT, namely crucially unranked constraint grammars (Anttila, 1997, Anttila and Cho, 1998, Anttila and Revithiadou, 2000, Anttila and Fong, 2002), floating constraint grammars (Nagy and Reynolds, 1997, Reynolds, 1994, Reynolds and Sheffer, 1994), and stochastic grammars (Boersma, 1998, Boersma and Hayes, 2001, Zubritskaya, 1997). In this section I will compare these alternatives to the rank-ordering model of EVAL, showing that they face certain conceptual and practical problems in explaining the kind of variable data that were discussed in this and the preceding chapters. This section therefore serves as a part not only of this chapter, but also of Chapter 3 on Latvian and of Chapter 4 on Portuguese. Before discussing the problems associated with these alternative models, I will first give a very brief review of how variation is accounted for in each of these models.

Crucially unranked constraints. Anttila (Anttila, 1997) proposed an extension to the classic OT grammar that could account for variable phenomena. He assumes that the constraint hierarchy of some language can contain a set of crucially unranked constraints. On every evaluation occasion one total ordering of the constraints is chosen from among the different total orderings possible between the crucially unranked constraints. Each of the possible total orderings is equally likely to be chosen on any evaluation occasion. Variation arises if different rankings between these crucially unranked constraints select different candidates as optimal. This theory not only explains how variation can arise, but it also makes predictions about the absolute frequency with which each variant for some input will be observed. Assume that there are n crucially unranked constraints. There are then $n!$ possible rankings between these n constraints. Suppose that there are two variants, and that m of the $n!$ rankings select $variant_1$ as optimal and $(n! – m)$ rankings select $variant_2$ as optimal. The prediction is then that $variant_1$ will be observed $m/n!$ of the time, and that $variant_2$ will be observed $(n! – m)/n!$ of the time.

Floating constraints. Independently from Anttila, Reynolds proposed a very similar extension to classic OT (Reynolds, 1994). Rather than having a set of crucially unranked constraints, Reynolds assumes that there are "floating constraints". A floating constraint is a constraint that is crucially unranked relative to a span of the (ranked) constraint hierarchy (this span is known as the "floating range" of the floating constraint). On every evaluation occasion the floating constraint is ranked in one specific location along its floating range. Variation arises if different docking sites for the floating constraint results in different candidates being selected as output. As in the Anttila model, the Reynolds model also makes predictions about the absolute frequency with which different variants will be observed. If there is one floating constraint with a floating range that is n constraints long, then there are $(n + 1)$ docking sites for the floating constraint along its floating range. Suppose that there are two variants, and that m of the docking sites for the floating constraint result in $variant_1$ being selected as optimal and $(n + 1 - m)$ of the docking sites result in $variant_2$ being selected as optimal. The prediction is then that $variant_1$ will be observed $m/(n + 1)$ of the time, and that $variant_2$ will be observed $(n + 1 - m)/(n + 1)$ of the time.

Stochastic OT grammars. In a stochastic OT grammar (Boersma, 1998, Boersma and Hayes, 2001) constraints are ranked along a continuous ranking scale. Every constraint has a basic ranking value along this scale. The actual point where a constraint is ranked along the continuous ranking scale is not equivalent to its basic ranking value.

A stochastic OT grammar includes a noise component – on every evaluation occasion a (positive or negative) random value is added to the basic ranking value of every constraint. This noise has a normal distribution with zero as its mean and some arbitrarily chosen standard deviation that is set at the same value for all constraints. Since the actual ranking value for some constraint is the result of adding this noise to the basic ranking of the constraint, the actual ranking values of a constraint will also be normally distributed around its basic ranking value. Since the ranking of a constraint is not fixed on the continuous ranking scale two constraints C_1 and C_2 can be ranked $\|C_1 \text{ o } C_2\|$ on one evaluation occasion but $\|C_2 \text{ o } C_1\|$ on the next evaluation occasion. Variation arises when one of these rankings selects one candidate as optimal, while the other ranking selects another candidate as optimal. The likelihood of either $\|C_1 \text{ o } C_2\|$ or $\|C_2 \text{ o } C_1\|$ being observed can be controlled very precisely by varying the distance between the basic ranking values of C_1 and C_2. In this way a stochastic OT grammar also makes predictions about the absolute frequencies with which different variants are observed. In fact, by controlling the distance between the basic ranking values of C_1 and C_2, any frequency distribution between the two rankings can be modeled.

There are two obvious differences between these alternatives and the rank-ordering model of EVAL that I am proposing. The first is a more conceptual difference about the locus of variation – is variation situated in the grammar or outside of the grammar? The second difference has to do with the question of whether grammar should account for absolute frequencies or only for relative frequencies.

A basic conceptual difference between the rank-ordering model of EVAL and the other models is where variation is seated. In OT the grammar of some language can be equated with a ranking of the constraint set. In the other three models variation is then seated directly in the grammar. Variation arises because the constraints are ranked differently at different evaluation occasions. Consider a language where one input can have two outputs, $variant_1$ and $variant_2$. On one evaluation occasion the grammar of this language will rate these candidates as follows: |$variant_1$ ™ $variant_2$|. In this situation variant_1 will be the observed output. On the next evaluation occasion, the ranking between the constraints can be different and the grammar can then rate the candidates differently, i.e. |$variant_2$ ™ $variant_1$|. In this situation $variant_2$ will be the output. Variation arises because the grammar is different and imposes a different information structure on the candidate set at different evaluation occasions. The source of variation is therefore situated directly in the grammar.

The rank-ordering model of EVAL is very different in this regard. For any language there is only one ranking between the constraints and therefore only one grammar. The grammar will impose exactly the same information structure on the candidate set at every evaluation occasion. If there are two variants, $variant_1$ and $variant_2$, and $variant_1$ is observed more frequently than $variant_2$, then the grammar will on every evaluation occasion impose the rank-ordering |$variant_1$ ™ $variant_2$| on the candidate set. Variation arises in the way in which the language user interacts with this invariant output of the grammar. The locus of variation is then situated outside of grammar proper. Grammar specifies the limits within which variation will be observed – it specifies which candidates are possible variants (by the critical cut-off) and it specifies the relative frequency between the variants. But the actual output of the grammar is invariant.

A second difference between the alternatives and the rank-ordering model of EVAL is that the alternatives attempt to account for the absolute frequency with which different variants are observed, while the rank-ordering model of EVAL only accounts for the relative frequencies of the different variants. If there are two variants and they are ranked as |*variant*$_1$ ™ *variant*$_2$| by EVAL, then the prediction is that *variant*$_1$ will be observed more frequently than *variant*$_2$. However, no prediction is made about how much more frequent *variant*$_1$ will be. The other three models account for absolute frequencies, while the rank-ordering model of EVAL accounts only for relative frequencies. It seems that these models account for more aspects of the variable data and that they are therefore better. This is only an apparent advantage of these models over the rank-ordering model of EVAL. In the rest of this section I will show that these models face certain conceptual and practical problems precisely because they make predictions about absolute frequencies. The rank-ordering model of EVAL avoids all of these problems.

3.1 Conceptual problems

I will discuss two conceptual problems. The first I will call the "which-frequency" problem, and the second the "grammar-alone" problem.

The data on variation that are reported in the literature usually represent the average pattern associated with some speech community. However, it is highly unlikely that all (or even any) of the individuals that make up that speech community will have exactly the same variation pattern as the community average. As an example, consider again the Latvian example discussed in Chapter 3. In Latvian, unstressed vowels are variably deleted from final unstressed syllables. The data that we have on this process were collected by Karinš (1995a) from eight individual speakers of the Riga dialect of Latvian. Karinš found that his eight subjects deleted the vowel on average 86% of the time. However, there was considerable variation between the eight subjects. The standard deviation is his data was 9.9%, and the subject with the lowest deletion rate deleted only 67% of the time while the subject with the highest deletion rate deleted 97% of the time.

In this dataset we therefore have the average deletion rate of 86%, but we also have the deletion rates of the eight individual subjects that differ from each other and from the community average. Of all these different absolute deletion rates, which one should be modeled by the grammar? One possibility is to model the average of 86%. However, it is debatable how real this average actually is. The grammar that we are then modeling is not the actual grammar of any individual member of the community. As an alternative we can model the grammars of the different individual members separately. But this tips the scale too far in the other direction. We then lose the concept that the members of the speech community do share a grammar.

What is it that the eight individuals studied by Karinš have in common? All of them show the same *relative* variation pattern. All eight subjects have two variants, deletion and retention. And for all eight the deletion variant is the more frequent variant. This is what exemplifies the grammar that the community shares – a relative preference for one variant over another. It is this relative preference that is modeled in the rank-ordering of EVAL. Under this model the claim is that the members of some community will all have the same grammar, and that this grammar will simply stipulate the relative frequency of the variants. In the Latvian case at hand, the community grammar will rank-order the two variants as follows: |deletion ™ retention|. All members of the community are therefore predicted to prefer deletion over retention, but there can be differences among individuals in how likely they are to select candidates beneath the best candidate as output. This variation between members of the community is, however, not part of their grammar. This is the result of how different individuals interact with the same grammar. By not attempting to model absolute frequencies the rank-ordering of EVAL is not faced with the "which-frequency" problem. In this model it is very clear which frequency to model – the average *relative* frequency that exemplifies the speech community.

The second conceptual problem faced by the three alternative models is the "grammar-alone" problem, and is closely related to the "which-frequency" problem. The alternative models attempt to account through the grammar for the *absolute* frequency with which different variants are observed. An implicit assumption that underlies this is that grammar alone is responsible for the variation pattern. If grammar accounts for all of the variation in the data, then there is no room for other extra-grammatical factors. This goes against a large body of evidence that there are many extra-grammatical factors that significantly interact with variation. It is known, for instance, that factors such as gender, age, socio-economic class, speech situation, individual preferences, *etc*. do contribute towards variation. In the rank-ordering model of EVAL the assumption is that grammar only determines the relative frequency of different variants. The extra-grammatical factors are then responsible for determining the specific absolute frequency with which different variants are observed. Grammar does not account for all aspects of variation, but provides only the limits within which extra-grammatical factors can interplay to determine the absolute patterns of variation.

3.2 Practical problems

In this section I show that crucially unranked constraint grammars and floating constraint grammars are faced with certain practical problems that are avoided by the rank-ordering model of EVAL. The claim of this section is not that the alternatives cannot account for variation data. I will rather show that there are aspects of the variation data that will force the alternatives to construct some unlikely/ad hoc accounts.

The stochastic OT grammars are very powerful and can probably model any variation frequency – since the distance between the basic ranking values of constraints can be specified arbitrarily. However, this is not the case with the crucially unranked constraint grammars and the floating constraint grammars. In order to model a wide array of variation frequencies these kinds of grammars are forced to rely on a large number of constraints. I will illustrate this point here with the example of [t, d]-deletion discussed earlier in this chapter. However, this is a general problem faced by these kinds of grammars and can be illustrated with any variable phenomenon studied in enough different dialects. I use only the deletion rate in pre-consonantal context in the different dialects discussed in §1 above. I list the deletion and retention rates in this context for the different dialects in (41). These data are extracted from the table in (1) in §1.1.

Consider first how these data might be accounted for in a grammar with crucially unranked constraints. In all of the dialects, except for that represented by the Neu data, the deletion variant is the more frequent variant. Excluding the Neu data, it is therefore necessary that the deletion variant be selected as optimal by more of the rankings possible between the crucially unranked constraints than the retention candidate. This means that out of the crucially unranked constraints there should be more constraints that favor deletion than constraints that favor retention. For the dialects represented by the Neu data, the opposite is true. In these dialects the retention candidate is the more frequent variant. More of the rankings possible between the crucially unranked constraints should therefore favor retention than deletion, implying that out of the crucially unranked constraints there should be more constraints that favor retention than constraints that favor deletion. This implies that it cannot be the same set of constraints that is responsible for the deletion~retention variation in the Neu data and in the other dialects.

(41) **[t, d]-deletion and retention rates in pre-consonantal context in different dialects of English**

	Deletion	**Retention**
Chicano English (Los Angeles)	62	38
Tejano English (San Antonio)	62	38
Black English (Washington, DC)	76	24
Jamaican mesolect (Kingston)	85	15
Trinidadian English	81	19
Neu data	36	64

The picture is more complicated than this, however. Not even for the dialects that all show more deletion than retention can the variation pattern be governed by the same set of crucially unranked constraints. In Chicano and Tejano English the deletion variant is observed 62% of the time. This means that 62% of the rankings possible between the crucially unranked constraints should select the deletion candidate as optimal. However, in Washington, DC AAE deletion is observed 76% of time, so that 76% of the rankings should select the deletion candidate as optimal. In Jamaican English 85% of the rankings should select the deletion candidate, and in Trinidadian English 81% of the rankings should select deletion. In order to account for all of these different variation patterns, it will be necessary that the set of crucially unranked constraints be different for each of these dialects.

There are two reasons why this situation seems less than ideal. First, it would be very hard to find sets of constraints that would result in exactly the correct variation pattern associated with each dialect. If we take into account that there are many more dialects of English and therefore very likely many more variation patterns, this situation gets just more difficult. It is not in principle impossible to model all of these different variation patterns. However, since so many different sets of constraints would be required, it seems likely that the constraints necessary would be of an ad hoc nature and not very well motivated.

Secondly, we are dealing here with the same phonological process in different dialects of the same language. It is also clear from the data that the grammatical factors that influence the likelihood of application of the process are the same in all of the dialects. If we have to use a different set of constraints to model this process in each dialect, we do not capture the fact that it is the same process applying in each dialect. A significant generalization is then not captured by our analysis.

In a grammar with floating constraints we are faced with much the same problems. There are five different variation patterns represented in the table in (41). One option for modeling this data is to accept that the floating constraint is the same in each of the dialects. Since there are five different patterns, it means that the floating range of the floating constraint will have to be different in each of the five different kinds of dialects.

The floating ranges of different dialects will have to contain different constraints and/or will have to be of different length. Another option is that the floating ranges of different dialects are the same but that the dialects differ in which constraint is the floating constraint. Finally, it is possible that both the floating constraints and the floating ranges are different between dialects. It is probably not in principle impossible to define the constraints that will be necessary to model the different variation patterns. However, in order to model exactly the variation patterns observed it will very likely be necessary to stipulate some rather ad hoc constraints. It will also be the case that the same phenomenon ([t, d]-deletion in pre-consonantal position) is governed by a different set of constraints in different dialects.

These problems are all avoided in the rank-ordering model of EVAL. As shown in the discussion in §1 above, we can use exactly the same two constraints (*Ct#C and MAX) to account for all of the different variation patterns associated with pre-consonantal context. In dialects with more deletion than retention, the ranking ||*Ct#C o MAX|| is observed. EVAL then rank-orders the candidate set as |deletion ™ retention| so that the deletion candidate is the more frequent variant. In dialects represented by the Neu data the constraints are ranked as ||MAX o *Ct#C || so that EVAL imposes the ordering |retention ™ deletion| on the candidate set. Retention is then predicted to be more frequent than deletion.

In the rank-ordering model of EVAL we can model both kinds of dialects with exactly the same constraints – both dialects with more deletion and dialects with more retention. Since the rank-ordering model of EVAL models only relative frequency, all dialects that show more deletion than retention can also be modeled by the same constraints – it is not necessary to discriminate grammatically between dialects with different absolute preferences for deletion. These differences are the result of how grammar interacts with several extra-grammatical factors. The rank-ordering model of EVAL can therefore account for the variation pattern easily with a small set of well motivated constraints. It can also account for the variation using exactly the same set of constraints in each of the dialects, thereby capturing the fact that it is the same process applying in each of the dialects.

This point has been illustrated here with one specific example. However, it is a general problem that the crucially unranked constraints grammars and floating constraint grammars will be faced with. Any variable phenomenon that applies with different absolute frequencies in different dialects of the same language (or in different languages for that matter), will present these accounts of variation with this same problem. For each dialect a different set of constraints will be necessary to model the variation. The fact that it is the same process conditioned by the same grammatical factors is then not captured. If there happen to be many different dialects with many different absolute variation patterns, the result will be that the same phenomenon has to be governed by many different and distinct sets of constraints. It will then also start becoming increasingly difficult to find exactly the right set of constraints to model each variation pattern.

Appendix: Factorial typologies

A.1 The following phonological context

In 1.2.3.2 I discussed the possible deletion patterns associated with the following phonological context. In this section of the Appendix, I will show that the patterns mentioned there are indeed all and only the patterns predicted under the analysis that I developed there.

A.1.1 No variation patterns

In the rank-ordering model there are two ways in which a categorical phenomenon can be modeled (see Chapter 1 §2.2.3): (i) When all candidates are disfavored by at least one constraint ranked higher than the cut-off, then only the single best candidate is selected as output. (ii) When all but one candidate are disfavored by a constraint ranked higher than the cut-off, then only this one candidate is selected as output.

Consequently, whenever all four constraints outrank the cut-off, no variation will be possible. When the markedness constraint against retention in some context outranks MAX, then that context will show categorical retention. On the other hand, if MAX outranks the markedness constraint against retention for some context, then that context will show categorical retention. In (42) I list all of the possible rankings with the cut-off at the bottom of the hierarchy, as well as the output that is associated with the ranking in each of the three contexts. In this table "D" stands for categorical deletion, and "R" for categorical retention. I indicate cells with more deletion than retention by shading.

(42) **Rankings with the cut-off at the bottom of the hierarchy**

					Pre-C	**Pre-V**	**Pre-P**
*Ct#C	*Ct#V	*Ct##	MAX	Cut-off	D	D	D
*Ct#C	*Ct#V	MAX	*Ct##	Cut-off	D	D	R
*Ct#C	MAX	*Ct#V	*Ct##	Cut-off	D	R	R
MAX	*Ct#C	*Ct#V	*Ct##	Cut-off	R	R	R
*Ct#C	*Ct##	*Ct#V	MAX	Cut-off	D	D	D
*Ct#C	*Ct##	MAX	*Ct#V	Cut-off	D	R	D
*Ct#C	MAX	*Ct##	*Ct#V	Cut-off	D	R	R
MAX	*Ct#C	*Ct##	*Ct#V	Cut-off	R	R	R

Now we can consider the situations in which only one of the candidates for some input is disfavored by a constraint ranked higher than the cut-off. Whenever both MAX and one of the markedness constraints violated by retention in some context ranks below the cut-off, then both retention and deletion for that context will violate no constraints ranked above the cut-off. This context will then show variation. There are therefore two ways in which to assure that only one candidate will violate no constraint ranked above the cut-off: (i) If MAX alone ranks below the cut-off, then only the deletion candidate will violate no constraint above the cut-off, and categorical deletion will be observed in all contexts. (ii) If MAX ranks above the cut-off, then all contexts for which the markedness constraint ranks below the cut-off will show categorical retention – for these contexts only the retention candidate will violate no constraint ranked above the cut-off. (Those contexts for which the markedness constraint also ranks above the cut-off will show either categorical deletion or categorical retention, depending on the ranking between MAX and the markedness constraint applying in the specific context.) In (43) I list all of the rankings that meet one of these two requirements. Comparison of the patterns in (42) and (43) with those listed in (19a) will confirm that these are indeed all and only the possible patterns with no variation.

(43) **Rankings under which for at least one context only one candidate does not violate a constraint ranked higher than the cut-off**

					Pre-C	**Pre-V**	**Pre-P**
*Ct#C	*Ct#V	*Ct##	Cut-off	MAX	D	D	D
*Ct#C	*Ct##	*Ct#V	Cut-off	MAX	D	D	D
*Ct#C	*Ct#V	MAX	Cut-off	*Ct##	D	D	R
*Ct#C	MAX	*Ct#V	Cut-off	*Ct##	D	R	R
MAX	*Ct#C	*Ct#V	Cut-off	*Ct##	R	R	R
*Ct#C	*Ct##	MAX	Cut-off	*Ct#V	D	R	D
*Ct#C	MAX	*Ct##	Cut-off	*Ct#V	D	R	R
MAX	*Ct#C	*Ct##	Cut-off	*Ct#V	R	R	R
*Ct#C	MAX	Cut-off	*Ct#V	*Ct##	D	R	R
*Ct#C	MAX	Cut-off	*Ct##	*Ct#V	D	R	R
MAX	*Ct#C	Cut-off	*Ct#V	*Ct##	R	R	R
MAX	*Ct#C	Cut-off	*Ct##	*Ct#V	R	R	R
MAX	Cut-off	*Ct#C	*Ct#V	*Ct##	R	R	R
MAX	Cut-off	*Ct#C	*Ct##	*Ct#V	R	R	R

A.1.2 Variation patterns

In (18) I stated the conditions that must be met for variation. Variation in some context can be observed only if both MAX and the markedness constraint that applies in that context rank below the cut-off. Whether the deletion or the retention candidate is the more frequent variant, depends on the ranking between MAX and the markedness constraint. Under the raking ||MAX o Markedness|| the retention candidate is the more frequent variant, and under the ranking ||Markedness o MAX|| the deletion candidate is the more frequent variant. When MAX ranks below the cut-off, then any context whose markedness constraint ranks above the cut-off will show categorical deletion. In (44) I list all rankings that will result in variation in at least one context. In this table "D" stands for categorical deletion, "R" or categorical retention, "D > R" for variation with more deletion than retention, and "R > D" for variation with more retention than deletion. As before I shade cells with more deletion than retention, i.e. both "D" and "D > R" cells. Comparison of the patterns in (44) with those in (19b) and (19c) will show that these are indeed all and only the patterns with variation in at least one context.

(44) **Rankings under which variation is observed in at least one context**

					Pre-C	**Pre-V**	**Pre-P**
*Ct#C	*Ct#V	Cut-off	*Ct##	MAX	D	D	D > R
*Ct#C	*Ct#V	Cut-off	MAX	*Ct##	D	D	R > D
*Ct#C	*Ct##	Cut-off	*Ct#V	MAX	D	D > R	D
*Ct#C	*Ct##	Cut-off	MAX	*Ct#V	D	R > D	D
*Ct#C	Cut-off	*Ct#V	*Ct##	MAX	D	D > R	D > R
*Ct#C	Cut-off	*Ct#V	MAX	*Ct##	D	D > R	R > D
*Ct#C	Cut-off	*Ct##	*Ct#V	MAX	D	D > R	D > R
*Ct#C	Cut-off	*Ct##	MAX	*Ct#V	D	R > D	D > R
*Ct#C	Cut-off	MAX	*Ct##	*Ct#V	D	R > D	R > D
*Ct#C	Cut-off	MAX	*Ct#V	*Ct##	D	R > D	R > D
Cut-off	*Ct#C	*Ct#V	*Ct##	MAX	D > R	D > R	D > R
Cut-off	*Ct#C	*Ct##	*Ct#V	MAX	D > R	D > R	D > R
Cut-off	*Ct#C	*Ct#V	MAX	*Ct##	D > R	D > R	R > D
Cut-off	*Ct#C	*Ct##	MAX	*Ct#V	D > R	R > D	D > R
Cut-off	*Ct#C	MAX	*Ct#V	*Ct##	D > R	R > D	R > D
Cut-off	*Ct#C	MAX	*Ct##	*Ct#V	D > R	R > D	R > D
Cut-off	MAX	*Ct#C	*Ct##	*Ct#V	R > D	R > D	R > D
Cut-off	MAX	*Ct#C	*Ct#V	*Ct##	R > D	R > D	R > D

A.2 The preceding phonological context

In 2.2.3.2 I discussed the possible deletion patterns associated with the preceding phonological context. In this section of the Appendix, I will show that the patterns mentioned there are indeed all and only the patterns predicted under the analysis that I developed there.

A.2.1 No variation patterns

There are two ways in which a pattern with no variation can be achieved (see Chapter 1 §2.2.3): (i) All candidates violate at least one constraint ranked higher than the cut-off (i.e. all constraints rank higher than the cut-off). (ii) Only one of the candidates violate no constraint ranked higher than the cut-off (i.e. either MAX alone ranks below the cut-off, or MAX ranks above the cut-off and some of the markedness constraints rank below the cut-off).

I begin by considering the first way for achieving a pattern with no variation. The ranking between MAX and the markedness constraint that applies to a specific context will determine whether that context shows categorical deletion or categorical retention. The ranking ||MAX o Markedness|| will result in categorical retention, and the ranking ||Markedness o MAX|| in categorical deletion. In (45) I give one example of such a ranking. Since all constraints rank higher than the cut-off, only the single best candidate for any input will be selected as output. This tableau can therefore be interpreted like a classic OT tableau – i.e. I use the pointing hand in the tableau to indicate the optimal candidate.

(45) **One grammar with the cut-off at bottom of hierarchy**

Context				*[+cor, -son] [+cor, -son]	*[+cor, -cont] [+cor, -cont]	*[-son, -cont] [-son, -cont]	MAX	*[+cor][+cor]	*[-son][-son]	*[-cont][-cont]
[s, š, z, ž]	/st/		-st	*!				*	*	
		L	-s∅				*			
[n]	/nt/		-nt		*!			*		*
		L	-n∅				*			
[k, g, p, b]	/kt/		-kt			*!			*	*
		L	-k∅				*			
[l]	/lt/	L	-lt					*		
			-l∅				*!			
[f, v]	/ft/	L	-ft						*	
			-f∅				*!			
[m, ŋ]	/mt/	L	-mt							*
							*!			

The three contexts for which the markedness constraints rank higher than MAX show categorical deletion. On the other hand, the three contexts for which the markedness constraints rank lower than MAX show categorical retention. The markedness constraints are in a fixed ranking (see (28) above). Since there are six markedness constraints, it follows that there are seven positions for MAX to be ranked into, and therefore that there are seven patterns possible with the cut-off at the bottom of the hierarchy. The seven possible patterns are listed in (46). For each pattern I also mention the highest ranking markedness constraint that is dominated by MAX for that specific pattern. In this table "D" stands for categorical deletion (all contexts whose markedness constraints outrank MAX), and "R" stands for categorical retention (all contexts whose markedness constraint ranks below MAX). As before, I also shade all cells that represent contexts with more deletion than retention – i.e. all "D" cells.

(46) **All deletion patterns with the cut-off at the bottom of the hierarchy**

MAX ranked above	**[s, š, z, ž]**	**[n]**	**[k, g, p, b]**	**[l]**	**[f, v]**	**[m, ŋ]**
Cut-off	D	D	D	D	D	D
*[-cont][-cont]	D	D	D	D	D	R
*[-son][-son]	D	D	D	D	R	R
*[+cor][+cor]	D	D	D	R	R	R
*[-son, -cont][-son, -cont]	D	D	R	R	R	R
*[+cor, -cont][+cor, -cont]	D	R	R	R	R	R
*[+cor, -son][+cor, -son]	R	R	R	R	R	R

Now we can consider the second source of patterns with no variation. These are rankings in which for some inputs one candidate violates only constraints ranked lower than the cut-off. There are two possibilities. If MAX alone ranks lower than the cut-off, then for all contexts the deletion candidate will violate no constraint ranked higher the cut-off while all other candidates will violate a constraint ranked higher than the cut-off. The deletion candidate will then be the only output observed in all contexts. This is illustrated by the tableau in (47). In this tableau I use the pointing hand like in a classic OT tableau – i.e. to indicate the single output for every input.

(47) **Only MAX below the cut-off = categorical deletion everywhere**

Context			*[+cor, -son] [+cor, -son]	*[+cor, -cont] [+cor, -cont]	*[-son, -cont] [-son, -cont]	*[+cor][+cor]	*[-son][-son]	*[-cont][-cont]	MAX
[s, š, z, ž]	/st/	-st	*!			*	*		
		☞ -s∅							*
[n]	/nt/	-nt		*!		*		*	
		☞ -n∅							*
[k, g, p, b]	/kt/	-kt			*!		*	*	
		☞ -k∅							*
[l]	/lt/	-lt				*!			
		☞ -l∅							*
[f, v]	/ft/	-ft					*!		
		☞ -f∅							*
[m, ŋ]	/mt/	-mt						*!	
		☞							*

There is a second way in which to achieve no variation with some constraints ranked lower than the cut-off, namely if MAX ranks higher than the cut-off and some markedness constraint (or constraints) ranks lower than the cut-off. For all those contexts where MAX ranks higher than the markedness constraint, categorical retention will be observed. This is irrespective of whether the markedness constraint is ranked above or below the cut-off. If the markedness constraint ranks lower than the cut-off, then the retention candidate is the only candidate that does not violate a constraint ranked higher than the cut-off and is therefore selected as only output. If the markedness constraint ranks higher than the cut-off then all candidates violate some constraint ranked above the cut-off and only the one best candidate is selected as output. If MAX ranks below the markedness constraint for some context, then all candidates again violate some constraint above the cut-off and only the best candidate is selected as output. In these contexts the deletion candidate is therefore selected. The tableau in (48) illustrates one of these grammars. The pointing hand is again used as in classic OT.

(48) **One grammar with some markedness constraint below the cut-off**

Context				*[+cor, -son][+cor, -son]	*[+cor, -cont][+cor, -cont]	MAX	*[-son, -cont][-son, -cont]	*[+cor][+cor]	*[-son][-son]	*[-cont][-cont]
[s, š, z, ž]	/st/		-st	*!				*	*	
		L	-s∅			*				
[n]	/nt/		-nt		*!			*		*
		L	-n∅			*				
[k, g, p, b]	/kt/	L	-kt				*		*	*
			-k∅			*!				
[l]	/lt/	L	-lt					*		
			-l∅			*!				
[f, v]	/ft/	L	-ft						*	
			-f∅			*!				
[m, ŋ]	/mt/	L	-mt							*
						*!				

For the first two contexts we have the ranking ||Markedness o MAX||. Both retention and deletion violate constraints above the cut-off, but deletion violates the lower ranking constraint. These contexts therefore have categorical deletion. In the third context we have ||MAX o Markedness||. Also here both candidates violate a constraint above the cut-off. Only the best candidate is then selected, which here is the retention candidate. In the last three contexts the markedness constraint ranks below the cut-off and therefore also below MAX. The retention candidate as the only candidate not violating a constraint ranked above the cut-off is selected as only output.

The markedness constraints are in a fixed ranking (see (28) above). Of the constraints that rank higher than the cut-off only MAX can therefore move. If there are *n* markedness constraints higher than the cut-off, then there are (*n* + 1) positions into which MAX can be ranked. In (49) I list all the patterns with no variation that are possible with at least one constraint below the cut-off. The first line represents a grammar in which MAX is the only constraint below the cut-off (see (47)). For each of the other lines I represent the highest ranking markedness constraint that is ranked lower than MAX, as well as the highest ranking markedness constraint ranked lower than the cut-off. In order the determine the output pattern, it is really only necessary to know the highest ranking markedness constraint ranked lower than MAX – if ||MAX o Markedness|| then we have categorical retention and if ||Markedness o MAX|| we have categorical deletion.

Comparison of the patterns in (46) and (49) with the patterns in (33a) will confirm that (33a) does indeed include all and only the no-variation patterns.

(49) **All patterns with no variation and with at least one constraint ranked below the cut-off**

	Constraint that applies	*[+cor, -son][+cor, -son]	*[+cor, -cont][+cor, -cont]	*[-son, -cont][-son, -cont]	*[+cor][+cor]	*[-son][-son]	*[-cont][-cont]
Cut-off above	**MAX ranked above**	**[s, š, z, ž]**	**[n]**	**[k, g, p, b]**	**[l]**	**[f, v]**	**[m, ŋ]**
MAX	–	D	D	D	D	D	D
*[-cont][-cont]	*[-cont][-cont]	D	D	D	D	D	R
	*[-son][-son]	D	D	D	D	R	R
	*[+cor][+cor]	D	D	D	R	R	R
	*[-son,-cont][-son,-cont]	D	D	R	R	R	R
	*[+cor,-cont][+cor,-cont]	D	R	R	R	R	R
	*[+cor,-son][+cor,-son]	R	R	R	R	R	R
*[-son][-son]	*[-son][-son]	D	D	D	D	R	R
	*[+cor][+cor]	D	D	D	R	R	R
	*[-son,-cont][-son,-cont]	D	D	R	R	R	R
	*[+cor,-cont][+cor,-cont]	D	R	R	R	R	R
	*[+cor,-son][+cor,-son]	R	R	R	R	R	R
*[+cor][+cor]	*[+cor][+cor]	D	D	D	R	R	R
	*[-son,-cont][-son,-cont]	D	D	R	R	R	R
	*[+cor,-cont][+cor,-cont]	D	R	R	R	R	R
	*[+cor,-son][+cor,-son]	R	R	R	R	R	R
*[-son, -cont][-son, -cont]	*[-son,-cont][-son,-cont]	D	D	R	R	R	R
	*[+cor,-cont][+cor,-cont]	D	R	R	R	R	R
	*[+cor,-son][+cor,-son]	R	R	R	R	R	R
*[+cor, -cont][+cor, -cont]	*[+cor,-cont][+cor,-cont]	D	R	R	R	R	R
	*[+cor,-son][+cor,-son]	R	R	R	R	R	R
*[+cor, -son][+cor, -son]	*[+cor,-son][+cor,-son]	R	R	R	R	R	R

A.2.2 Variation patterns

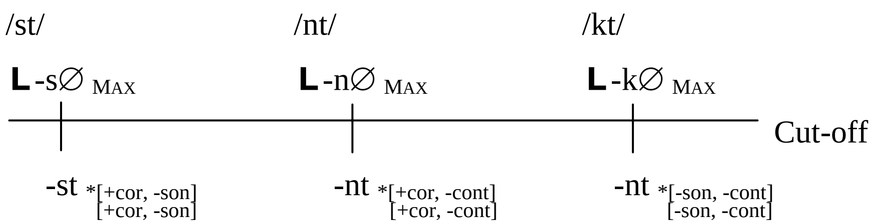
In (32) I listed the conditions that must be met for each context in order for variation to be observed in that context. These conditions can be summarized as follows: For some context to show variation, both the markedness constraints that apply in that context and MAX have to rank lower than the cut-off. The ranking between MAX and the markedness constraints will determine whether deletion or retention will be observed more frequently. Under the ranking ||MAX o Markedness|| more retention than deletion will be observed since the retention candidate violates the lower ranking constraint. Under the ranking ||Markedness o MAX|| more deletion will be observed since deletion violates the lower ranking constraint. Contexts whose markedness constraints rank higher than the cut-off will show categorical deletion – since MAX is below the cut-off the deletion candidate violates no constraint above the cut-off and therefore the retention candidate that does violate a constraint ranked higher than the cut-off will not be accessed as output. The tableau in (50) shows one of these grammars as an example.

For the first three contexts in (50) the ranking ||Markedness o Cut-off o MAX|| holds. The retention candidate violates a markedness constraint ranked higher than the cut-off and the deletion candidate violates MAX ranked lower the cut-off. In these contexts we see categorical deletion. The rank-ordering imposed by EVAL on the candidate set for these three contexts are shown in (51).

(50) **One grammar with variation in at least some contexts**

Context				*[+cor, -son][+cor, -son]	*[+cor, -cont][+cor, -cont]	*[-son, -cont][-son, -cont]	*[+cor][+cor]	MAX	*[-son][-son]	*[-cont][-cont]
[s, š, z, ž]	/st/	2	-st	*!			*		*	
		1	-s∅					*		
[n]	/nt/	2	-nt		*!		*			*
		1	-n∅					*		
[k, g, p, b]	/kt/	2	-kt			*!			*	*
		1	-k∅					*		
[l]	/lt/	2	-lt				*			
		1	-l∅					*		
[f, v]	/ft/	1	-ft						*	
		2	-f∅					*		
[m, ŋ]	/mt/	1	-mt							*
		2						*		

(51) **Output of EVAL for first three contexts from (50)**



The markedness constraints that apply in the last three contexts are all ranked lower than the cut-off. For these contexts neither retention nor deletion violates a constraint ranked higher than the cut-off. We will therefore see variation between deletion and retention in these contexts. For the fourth context, we have the ranking

||Markedness o MAX|| so that the deletion candidate violates the lower ranking constraint. In this context deletion is therefore more frequent than retention. For the last two contexts we have the ranking ||MAX o Markedness|| so that retention violates the lower ranking constraint. For these contexts retention is therefore the more frequent variant. The output of EVAL for these last three contexts is shown in (52).

(52) **Output of EVAL for last three contexts from (50)**

/lt/	/ft/	/mt/
L -l∅ MAX	L -ft *[-son][-son]	L -mt *[-cont][-cont]
|	|	|
L -lt *[+cor][+cor]	L -f∅ MAX	L -m∅ MAX

———————————————————————— Cut-off

The ranking between the markedness constraints are fixed (see (28) above). Of the constraints that rank below the cut-off, only MAX can therefore move. If there are *n* markedness constraints ranked below the cut-off, then there are (*n* + 1) positions for MAX to rank into below the cut-off. In (53) I list all the possible patterns with variation. I indicate for each line in the table the highest ranked markedness constraint that is ranked lower than the cut-off. For all those contexts in which higher ranking markedness constraints apply, only deletion will be observed (since the deletion candidate will violate MAX which is ranked lower than cut-off and the retention candidate will violate a markedness constraint ranked higher than the cut-off). Those contexts whose markedness constraints rank lower than the cut-off will show variation (since neither retention nor deletion will violate any constraints above the cut-off). If we have the ranking ||MAX o Markedness|| then the retention candidate will be the more frequent variant (since it violates a lower ranked constraint than deletion). If we have the ranking ||Markedness o

MAX|| then the deletion candidate will be the more frequent variant (since it violates a lower ranked constraint than retention). I therefore also indicate the highest ranked markedness constraint ranked lower than MAX. As before "D" indicates categorical deletion, "R" categorical retention, "D > R" variation with more deletion, and "R > D" variation with more retention. I also shade cells that represent contexts with more deletion than retention, i.e. both "D" and "D > R" cells. Comparison of the patterns in (53) with those in (33b) and (33c) will confirm that (33) does indeed include all and only the possible variation patterns.

(See next page for (53).)

(53) **All patterns with variation**

	Constraint that applies	*[+cor, -son] [+cor, -son]	*[+cor, -cont] [+cor, -cont]	*[-son, -cont] [-son, -cont]	*[+cor][+cor]	*[-son][-son]	*[-cont][-cont]
Cut-off above	**MAX ranked above**	**[s, š, z, ž]**	**[n]**	**[k, g, p, b]**	**[l]**	**[f, v]**	**[m, ŋ]**
*[-cont][-cont]	–	D	D	D	D	D	D>R
	*[-cont][-cont]	D	D	D	D	D	R>D
*[-son][-son]	–	D	D	D	D	D>R	D>R
	*[-cont][-cont]	D	D	D	D	D>R	R>D
	*[-son][-son]	D	D	D	D	R>D	R>D
*[+cor][+cor]	–	D	D	D	D>R	D>R	D>R
	*[-cont][-cont]	D	D	D	D>R	D>R	R>D
	*[-son][-son]	D	D	D	D>R	R>D	R>D
	*[+cor][+cor]	D	D	D	R>D	R>D	R>D
*[-son,-cont] [-son,-cont]	–	D	D	D>R	D>R	D>R	D>R
	*[-cont][-cont]	D	D	D>R	D>R	D>R	R>D
	*[-son][-son]	D	D	D>R	D>R	R>D	R>D
	*[+cor][+cor]	D	D	D>R	R>D	R>D	R>D
	*[-son,-cont][-son,-cont]	D	D	R>D	R>D	R>D	R>D
*[+cor,-cont] [+cor,-cont]	–	D	D>R	D>R	D>R	D>R	D>R
	*[-cont][-cont]	D	D>R	D>R	D>R	D>R	R>D
	*[-son][-son]	D	D>R	D>R	D>R	R>D	R>D
	*[+cor][+cor]	D	D>R	D>R	R>D	R>D	R>D
	*[-son,-cont][-son,-cont]	D	D>R	R>D	R>D	R>D	R>D
	*[+cor,-cont][+cor,-cont]	D	R>D	R>D	R>D	R>D	R>D
*[+cor,-son] [+cor,-son]	–	D>R	D>R	D>R	D>R	D>R	D>R
	*[-cont][-cont]	D>R	D>R	D>R	D>R	D>R	R>D
	*[-son][-son]	D>R	D>R	D>R	D>R	R>D	R>D
	*[+cor][+cor]	D>R	D>R	D>R	R>D	R>D	R>D
	*[-son,-cont][-son,-cont]	D>R	D>R	R>D	R>D	R>D	R>D
	*[+cor,-cont][+cor,-cont]	D>R	R>D	R>D	R>D	R>D	R>D
	*[+cor,-son][+cor,-son]	R>D	R>D	R>D	R>D	R>D	R>D