Tiberian Hebrew spirantization and related phenomena in stratal OT*

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Abstract

The present paper takes Idsardi's (1998) discussion of Tiberian Hebrew (TH) spirantization as a point of departure for an investigation of these phenomena within a stratal approach (Kiparsky 2000,2001) to optimality theory (Prince and Smolensky 1993). The paper begins by discussing the larger problem of phonological opacity (Kiparsky 1973) in optimality theory, since the TH facts have played a prominent role in this discussion. The analysis begins with an examination of the phenomena under study (spirantization, epenthesis, laryngeal deletion, vowel deletion and their interaction), followed by a look at the motivation for level-ordering in TH. Unique to the present analysis, in addition to the stratal OT approach in general, is the positing of a 'phrasal stratum' of OT phonology in TH, on the basis of Dresher's (1994) observation that several TH phonological processes take the phonological phrase as their domain of application, spirantization among them. The stratal optimality theoretic analysis, aside from accounting for the phenomena under study, raises several interesting theoretical questions for the stratal OT framework that merit further examination. Among these are: the status of what we dub the Constraint Promotion Hypothesis (an idea due to Kiparsky p.c.), whereby promotion of constraints between strata is promotion to undominated status; the status of vacuous Duke-of-York derivations; and the relative ranking of markedness constraints with respect to faithfulness constraints at different strata in the absence of positive evidence. As a preliminary extension of the analysis of the spirantization facts, the paper also includes discussion of epenthesis, umlaut, vowel lowering interaction, which according to Idsardi (2000) are problematic for a level-ordered approach to OT.

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1 Introduction

Phonological opacity (Kiparsky 1973), the phenomenon whereby it appears that a phonological generalization has 'overapplied' (cf. counterbleeding) or 'underapplied' (cf. counterfeeding), was a source of much debate in the rule-ordering literature of the 1970s (see e.g. Dinnsen 1979; Hooper 1976; Koutsoudas 1976). This phenomenon has once again become of central importance in phonological theory due to the advent of optimality theory (OT; **?**),[1] an output oriented theory of grammar that has been widely accepted in the field of phonology (and is becoming increasingly applied in syntax and semantics). Under OT as it was originally developed (cf. **?** and Kager (1999) for an overview), there are only two levels of representation–input and output, with violable constraint evaluation taking place at the output level, and with no intermediate levels of representation between these two levels. This strong output orientation poses severe problems for the analysis of phonological opacity, since in many cases a level of representation intermediate to the input and output is required to properly characterize the phenomenon.[2] Because of this, there have been many efforts, even since OT's early days, to deal with phonological opacity. Among the various different types of proposals that have been made are two-level constraints (McCarthy 1997), Turbidity (Smolensky and Goldrick 1999; Goldrick 2000), local conjunction (Smolensky 1995; Łubowicz 1998), output-to-output constraints (Benua 1995, 1997), and sympathy (McCarthy 1999a, 1999b), the proposal which has perhaps received the greatest deal of attention.[3] What all of these proposals have in common is their effort to PRESERVE THE PARALLEL REPRESENTATION of OT as originally proposed by **?**. Recently, however there have been arguments in favor of abandoning OT's parallel representation (e.g. Rubach 2000; Kiparsky 2000, 2001 among others). Kiparsky, in particular, has argued in favor of a stratal OT, with the different strata corresponding to different levels of word formation, similar to the view presented in the lexical phonology literature (e.g. Mohanan 1985). Under a level-ordered OT such as the one proposed by Kiparsky, opacity is a derivative of the interaction of the various strata, whose existence receives INDEPENDENT MOTIVATION by way of analysis of the behavior of phonology/morphology interactions in the language. The fact that opacity is derived from the interaction of strata that are INDEPENDENTLY MOTIVATED ELSEWHERE, places a very strict upper limit on the amount of opacity that can be generated by the phonology, and in a sense reduces opacity to an epiphenomenon (see Kiparsky (2000, 2001) for further elaboration of these points).

In the present study I investigate the well-known Tiberian Hebrew (TH) spirantization facts within a stratal OT approach to phonology and phonology/morphology interactions. The TH spirantization facts are worth revisiting (yet again) for two reasons. First Idsardi (1998), in a very detailed exposition of the TH spirantization facts, has argued (following comments made by Chomsky (1995)) that these complex facts cannot only not be accounted for by parallel OT, but rather can likely not be well-accounted for by any variety of OT. To date, there has been no response to Idsardi's claims that takes into account the full range of

[1]Indeed, there have been two recent collections of papers addressing issues related to this phenomenon in an OT context. See Roca (1997) and Hermans and Oostendorp (1999)

[2]Indeed, some have even argued that the phenomenon of phonological opacity poses prima facie evidence against an OT-style phonology (Chomsky 1995; Idsardi 1998; Idsardi 2000; Halle and Idsardi 2000).

[3]See e.g. Davis 1997; de Lacy 1998; Itô and Mester 1997; Itô and Mester 1999; Karvonen and Sherman 1998; McGarrity 1999; Walker 1998

data he carefully lays out. Indeed, there has been no comprehensive account of the spirantization facts in the OT literature, outside of Idsardi's discussion. Although there have been accounts of particular subsets of the spirantization data (e.g. Benua (1995,1997) on underapplication with epenthetic vowels, and McCarthy (1999a) on epenthesis/laryngeal deletion interaction), there has been no OT analysis of a significantly large subset of the facts taken as a whole, making the evaluation of OT vis-à-vis the spirantization facts a difficult task. At the same time, since Idsardi (1998), there have been a number of developments in the OT literature which bear on these issues (stratal OT, in particular). By looking at the larger set of TH spirantization facts discussed by Idsardi (1998) it is seen not only that an OT account can be maintained (contra Idsardi), but also that a particular approach (that is, the stratal approach) offers a unified analysis of the facts. Indeed, it is seen that the only mechanism that needs to be added to 'standard' OT in order to account for the range of spirantization facts is strata—stem, word, phrase, and postlexical levels, that are themselves seen to be independently motivated on the basis of phonology/morphology/prosody interactions in the language. Furthermore, the account requires no appeal to any constraints other than the standard sets of constraints of the well-motivated and uncontroversial markedness and IO faithfulness families.

The structure of the paper is as follows. In section 2, I lay out the basic and not-so-basic TH spirantization facts to be accounted for. In section 3 I discuss the ordering relations between the various 'processes' interacting with spirantization in TH. Section 4 is a discussion of the motivation for different strata in TH. Here I present evidence motivating stem, word, phrase, and postlexical strata. In section 5, I develop a stratal OT analysis of the TH facts in light of the motivation for level-ordering presented in the previous section. In section 6 I offer some thoughts on the present approach vs. parallel approaches, and how the present approach might be extended to account for additional opaque phenomena in TH also claimed by Idsardi (2000) to pose problems for OT, and for varieties of OT such as stratal OT in particular. Section 7 gives some concluding remarks.

2 The TH spirantization facts

The basic TH spirantization facts are well documented in the phonological literature: stops and spirants are in complementary distribution with one another, with (non-emphatic) stops alternating with their spirantized counterparts following vowels (and semivowels), as shown by the alternations in (1) and (2) (Idsardi 1998:39, (2)).[4]

(1) a. ka:θáv 'write 3MS PERF'
    b. yixtó:v 'write 3MS IMPF'

(2) a. ga:đlú: 'be great 3P PERF'
    b. yiɣdá:lu: 'be great 3MP IMPF'

Several additional phonological processes, such as vowel deletion, epenthesis, and laryngeal deletion among others, interact with spirantization in non-trivial ways. The interaction of

[4]Data in this section and throughout the paper are taken primarily from Idsardi (1998); Dresher (1994, n.d.; Lambdin (1971); Rappaport (1984). I assume the underlying representations of Idsardi (1998), where these are given by him. See McCarthy (1999b) for an alternative.

these processes with spirantization can be seen perhaps most clearly in the different TH verbal paradigms, where morphological affixation interacts in non-trivial ways with many of these phonological processes. The perfective, imperfective, and Piʕel perfective paradigms are given in (3) for the root /ktb/ 'to write' for reference throughout the paper.

(3) Three TH verbal paradigms

	Perfective	Imperfective	Piʕel perfective
1s	ka:θáv-ti:	ʔe-xtó:v	kittáv-ti
2ms	ka:θáv-ta:	ti-xtó:v	kittáv-ta:
2fs	ka:θáv-t	ti-xtəv-í:	kittáv-ta:
3ms	ka:θáv	yi-xtó:v	kittév
3fs	kaθv-á:	ti-xtó:v	kittəv-á:
1p	ka:θáv-nu:	ni-xtó:v	kittáv-nu:
2mp	kəθav-tém	ti-xtəv-ú:	kittav-tém
2fp	kəθav-tén	ti-xtó:v-na:	kittav-tén
3mp	ka:θv-ú:	yi-xtəv-ú:	kittəv-ú:
3fp	ka:θv-ú:	ti-xtó:v-na:	kittəv-ú:

The processes of vowel deletion, epenthesis, laryngeal deletion and their interaction with spirantization, are briefly discussed and exemplified below.

2.1 Vowel reduction and deletion

TH has a productive process of vowel deletion, whose domain of application is captured by the descriptive generalization in (4).

(4) A vowel in a light open syllable is deleted when it is preceded by an open syllable. Vowels in syllables with laryngeal onsets generally do not delete.[5]

This generalization is illustrated by the data in (5) (focusing on vocalic phenomena; spirantization of the stops is not shown).

(5) a. /yala:di:m/ → [yəla:di:m] 'children'
   b. /yalade:hem/ → [yalde:hem] 'their masc. children' (cf. (4b))
   c. /yiktobu:/ → [yiktəbu:] 'they masc. will write'
   d. /ko:tebi:m/ → [ko:tbi:m][6] 'they are writing'
   e. /kotobeka/ → [kətobka] 'your masc. sing. writing' (cf. (5))
   f. cf. [leʔelóah] 'upon God' (Malone 1993:88)

As the data in (5) illustrate, a vowel in a light open syllable is deleted when preceded by an open syllable. This is seen in particular in e.g. (5b), where the underlyingly antepenultimate vowel is deleted under these conditions. The same is true for the penultimate in (5d) and for the penultimate in (5e). (5f) illustrates the fact that vowel deletion is typically blocked when it would result in a syllable with a laryngeal coda (the discussion in fn. 5 notwithstanding).

[5] Further exploration of this issue is needed, as SOME post-laryngeal vowels do in fact undergo deletion, viz, /ya+ʔakal/→[yo:xál] 'eat 3MS IMPF'.

[6] It is apparently a matter of debate whether or not vowels are deleted when preceded by CV: syllables.

Vowel deletion interacts with spirantization in both transparent and opaque fashions. While some stops transparently fail to spirantize following vowels that are deleted at the surface, as in (6), other stops do in fact spirantize following such surface deleted vowels, as the data in (7) illustrate. In the processual rule interaction terminology of Kiparsky (1973), it can be said that under certain circumstances vowel deletion BLEEDS spirantization while in other cases it COUNTERBLEEDS spirantization.

(6) Vowel deletion bleeds spirantization
  a. /ya+katob/→[yixtó:v] 'write 3MS IMPF'
  b. /na+katab/→[nixtáv] 'write 3MS PERF Nifʕal'
  c. /li+katob/→[lixto:v] 'to write INF CONSTRUCT'

(7) Vowel deletion counterbleeds spirantization
  a. /katab+u/→[ka:θvú:] 'write 3P PERF'
  b. /bi+katob/→[bixθó:v] 'when writing INF CONSTRUCT'

Spirantization is said to be OPAQUE in examples such as (7), since the vowel that triggers spirantization is not present on the surface. I.e. spirantization appears to overapply, or is not-surface-apparent.

2.2 Epenthesis

Under most circumstances, TH does not tolerate complex codas containing more than one consonant. When such sequences are presented to the phonology, the general repair strategy is epenthesis, as illustrated in (8) (from Malone (1993:93)).

(8) a. /qern/→[qéren] 'horn'
  b. /baʕl/→[báʕal] 'husband'

Just as there are apparently two classes of deleted vowels with respect to the triggering of spirantization, there are also two classes of epenthetic vowels—those that trigger spirantization, e.g. (9), and those that do not, e.g. (10).

(9) Epenthetic vowels trigger spirantization
  /malk/→[mélex]

(10) Epenthetic vowels fail to trigger spirantization
  /ʃamaʕ+t/→[ʃamaʕát] 'hear 2FS PERF'

As is the case with vowel deletion, epenthesis/spirantization interaction is also OPAQUE in certain cases, in particular in cases such as (10) where epenthesis counterfeeds spirantization. That is, epenthesis could feed spirantization, but does not in this particular case. In cases such as (9), epenthesis feeds spirantization, i.e. the epenthetic vowel is precisely what triggers spirantization of the following consonant.

Given this disjoint behavior of epenthesis with respect to spirantization, it appears that we may be dealing with two somewhat distinct types of epenthesis. This conclusion is supported by the fact that the environment for epenthesis in (10) was created by the affixation of the 2FS PERF suffix to a verb. Furthermore, while the 2FS PERF suffix often creates favorable conditions for epenthesis, it appears that epenthesis in these cases only occurs to break up $C_{laryngeal}C_{\sigma}$] sequences—i.e. epenthesis fails to occur following 2FS PERF affixation in $C_{non-laryngeal}C_{\sigma}$] contexts, such as in (11).

(11) Epenthesis fails to occur in other CC_{σ}] contexts created by 2FS PERF suffixation

a. /katab+t/→[ka:θav t] 'you wrote 2FS PERF'
b. /'amad+t/→['a:mađt] 'unknown 2FS PERF' (Lambdin 1971: 43)

Epenthesis with 2FS PERF suffixes, then, appears to be a special, more restricted type of epenthesis than that found in (12) above. This will be important in the OT analysis of these facts, developed below.[7]

2.3 Laryngeal deletion

As discussed by Idsardi (1998), McCarthy (1994:210-211) and many others, in TH *ʔ* deletes at the end of a syllable. This phenomenon is illustrated in (12).

(12) /qaraʔ/→[qa:ra:] 'he called'

As noted by Idsardi (1998:40, (4e)), stops spirantize following these deleted laryngeals (e.g. (13)), but not following exceptionally non-deleted laryngeals (e.g. (14)). Stated another way, laryngeal deletion feeds spirantization.

(13) Stops spirantize following deleted laryngeals

a. /ya+ʔakal/→[yo:xál] 'eat 3MS IMPF'
b. [ʔim-ʔemṣá:(ʔ) visdó:m] 'if find 1S IMPF in Sodom' Gen. 18:26

(14) Stops do not spirantize across exceptionally undeleted laryngeals
[wənaʔtó:r] 'and pray INF Nifʕal'

Thus, it can be said that laryngeal deletion and spirantization interact in a TRANSPARENT fashion—laryngeal deletion feeds spirantization in processual terms.

Interestingly, however, laryngeal deletion interacts opaquely with epenthesis. Although this has little direct bearing on spirantization, it gives a crucial ordering argument for two processes that are themselves directly related to the process in question. At the same time it offers indirect support in favor of the independently motivated strata introduced and discussed below. As illustrated in (15), then, deleted laryngeals trigger epenthesis in a counterbleeding fashion (i.e. laryngeal deletion could bleed epenthesis, but it does not).

(15) Deleted laryngeals trigger epenthesis

a. /palʔ/→[pele] 'wonder' (McCarthy 1994:211)

[7]It is not clear to me whether the only epenthetic segments that fail to induce spirantization are those resulting from 2FS PERF affixation. If this is the case, I would consider it at least partially an accident. As will be shown below, the epenthesis with 2FS PERF affixes is taken to occur postlexically, while the affixation of the 2FS PERF suffix is done at the word level, where there is no epenthesis. The prediction, then, would be that if there are any other single consonantal verbal suffixes that are demonstrably affixed at the word-level, they should show similar behavior with respect to epenthesis/spirantization interaction. This should become more clear in the discussion that follows.

b. /deʃʔ/→[deʃe] 'tender grass'

It is worth noting that the opaque interaction illustrated in (15) is apparently unrelated to any interaction with morphology. I.e., there is no morphological affixation that can be seen to be responsible for the opaque interaction.[8]

3 Crucial ordering relations

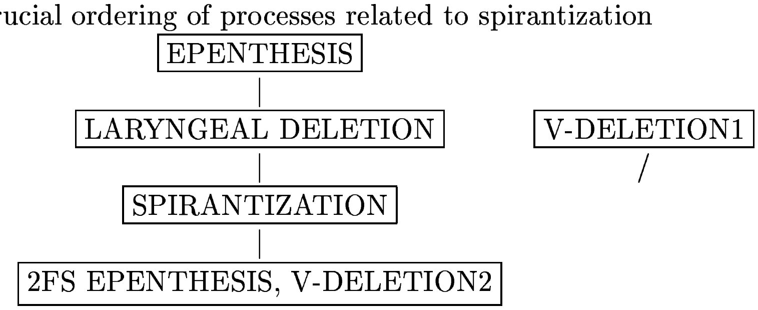
In light of the discussion above several ordering arguments can be made if we think about TH spirantization in processual terms (a viewpoint that will be abandoned below).

First, it was seen that VOWEL DELETION must both precede and follow SPIRANTIZATION, since some deleted vowels induce spirantization (e.g. *ka:θvu:*), while others do not (e.g. *yixto:v*). In processual terms, this entails having two instances of deletion (or both cyclic and non-cyclic application of V-DELETION as is the case in Idsardi (1998:51)), one instance, which we'll call here V- DELETION1, preceding spirantization, and the other, called V-DELETION2 following spirantization.

Likewise, it was observed that EPENTHESIS must both precede and follow SPIRANTIZATION, since there exist in TH epenthetic vowels that induce spirantization (e.g. *melex*) and epenthetic vowels that fail to induce spirantization (e.g. *ʃamaʕát*). As argued above, the variety of epenthesis that fails to induce spirantization appears to be a special case of the type that does induce spirantization, being limited to the breaking up of $C_{gutteral}C_{\sigma}$] clusters. For the purposes of discussion, then, we will dub the more general type of epenthesis EPENTHESIS and the more special case of epenthesis 2FS EPENTHESIS, since it appears to be caused under certain special circumstances most often, if not always, by 2FS PERF verbal affixation. Recall also that it was shown that EPENTHESIS must precede LARYNGEAL DELETION, since deleted *ʔ*s cause epenthesis in examples such as *pelʔ→pele*. No crucial ordering arguments can just yet be made between LARYNGEAL DELETION and SPIRANTIZATION, although below it will be suggested that while the former is a WORD-LEVEL PROCESS, the latter is a PHRASE-LEVEL PROCESS, thereby intrinsically motivating an ordering whereby LARYNGEAL DELETION precedes SPIRANTIZATION, when considered in processual terms.

This gives the ordering relations between the various processes in question as shown in (16), and the rule-interactions between them laid out in (17).[9]

(16) Crucial ordering of processes related to spirantization



[8]It is for these types of opaque derivations that McCarthy (1999a) has developed sympathy theory.

[9]See also Idsardi (1998:70) on this latter point. A couple of the interactions discussed by Idsardi are not directly taken up here, because they add nothing significant to the account.

(17)
a. EPENTHESIS counterbleeds LARYNGEAL DELETION, (15)
b. EPENTHESIS feeds SPIRANTIZATION, (9)
c. LARYNGEAL DELETION feeds SPIRANTIZATION, (13)
d. V-DELETION1 bleeds SPIRANTIZATION, (6)
e. 2FS EPENTHESIS counterfeeds SPIRANTIZATION, (10)
f. V-DELETION2 counterbleeds SPIRANTIZATION, (7)

4 Motivation for strata in TH

Certain TH processes behave in distinct manners from one another in ways that suggest that they may be sensitive to different morphological domains. Evidence in favor of the activity and restriction of certain processes to certain morphologically specific domains comes by way of (a) the activity and non-activity of certain processes across certain domains, and (b) the distinct behavior of certain affixes with respect to certain processes. That is, in order to state the empirically accurate generalization for these processes, one must appeal to a certain domain (e.g. level 1 vs. level 2 in English). Likewise, in order to make a formal distinction between the behavior of certain affixes with respect to certain processes, and other affixes with respect to these processes, one can appeal to the fact that they are affixed to different types of morphological constituents. In what follows, then, I discuss evidence for level ordering in TH. This evidence is, in turn, taken as support for different OT strata of the types discussed for various languages by Kiparsky (2000, 2001). I.e., the evidence adduced in support of distinctions in TH between stem, word, and phrasal processes is taken to justify the positing of corresponding strata in a stratal OT phonology.

4.1 Stem vs. word level

The existence of a stem level vs. a word level in TH phonology and morphology is supported by the differential behavior of certain affixes with respect to others vis-a-vis the triggering or failure to trigger the activity of certain phonological processes.[10] Two such processes which make a distinction between what we will call 'stem-level' and 'word-level' affixes are A-TO-I RAISING and SPIRANTIZATION. The latter of these is discussed at length in the following sections. For now, we turn to A-TO-I RAISING for evidence in favor of the stem/word distinction, outside the realm of spirantization.

According to Dresher (n.d.:16), following Prince (1975), TH has a rule that changes *a* to *i* in word-initial closed syllables. This is formulated by Prince (1975) along the lines in (18) (Dresher n.d.:16).

(18) A-TO-I
a→i/#C_CC

[10]Dresher (n.d.:14), following analysis in Dresher (1983) has argued that there is "...little evidence for stem-level phonology, apart from some minor rules that apply to particular morphemes", while at the same time demonstrating that there is a crucial distinction in TH phonology and morphology between 'regular' prefixes and 'word-level' prefixes. Regardless of what one wants to call these, I take Dresher's arguments as evidence in favor of some sort of level-ordering distinction, as I discuss further below.

This rule behaves differently with different prefixes, even when the prefixes in question are of the same prosodic shape, as illustrated with the examples in (19) (Dresher n.d.:16, (24)).

(19) a. No prefix
/gaddel/→[giddé:l] 'he brought up'
b. Stem-level prefix
/ya+gaddel/→[yəgaddé:l] 'he will bring up'
c. Word-level prefix
/wə+gaddel/→[wəgiddé:l] 'and he brought up'

As described by Prince and Dresher, A-TO-I applies to *a* in a word-initial closed syllable, giving as output *i* in its place, as illustrated in (19a). The data in (19b,c), show, however, that the the notion of 'word-initial' must be relativized to a certain level, since A-TO-I has applied in the surface-level second syllable in (19c), but failed to apply to the same syllable in (19b), despite the fact that the two pieces of data have the same prosodic form. The crucial observation, then, is that A-TO-I must apply at a level subsequent to the affixation of /ya-/, while it must apply prior to affixation of /wə-/. Affixes classified by Dresher (n.d.:16) as behaving uniformly with respect to A-TO-I are listed in (20).

(20) Word-level prefixes (Dresher n.d.:16)
a. Prepositions
bə-'in', lə-'to', kə-'like', mi-'from'
b. Conjunctive
wə-'and'
c. Definite article
ha-'the'

As would be predicted, these affixes also behave uniformly with respect to spirantization, as the data in (21) show, where (21a) crucially is an affix of the type in (20), while the affix in (21b) is a verbal inflection, and 'closer' to the verb, in a sense.

(21) a. /bi+katob/→[bixθó:v] 'when writing'
b. /ya+katob/→[yixtó:v] 'write 3MS IMPF'

Although behavior of prefixes in TH with respect to certain phonological phenomena is unpredictable solely on the basis of their status as prefixes (although relatively predictable on the basis of the morphological status of the affix in question), this is not the case with verbal suffixes. Indeed, verbal suffixes behave uniformly with respect to spirantization—they manifest the overapplication pattern, as can be seen in the data in the TH verbal paradigms in (3), and illustrated in (22).

(22) a. /katab+u/→[ka:θvú:] 'write 3P PERF'
b. /katab+á:/→[kaθvá:] 'write 3FS PERF'

Some of these verbal suffixes (all of which behave uniformly) are listed in (23).

(23) Verbal suffixes behave uniformly
-ti: 1S PERF; -ta: 2MS PERF; -t 2FS PERF; -a: 3FS PERF, etc. All verbal suffixes fall

in this category. See (3) above, and Lambdin (1971) among others for more.

Finally, the verbal prefixes also behave as a group with respect to spirantization (and with respect to A-TO-I, as discussed above), with vowel deletion induced by affixation bleeding spirantization of a following stop, as shown by the data in (24).

(24) a. /ya+katob/→[yixtó:v] 'write 3MS IMPF'
b. /na+katab/→[nixtáv] 'write 3MS PERF Nifʕal'
c. /la+katob/→[lixto:v] 'write INF CONSTRUCT'

This same pattern is manifested by all imperfective verbal prefixes (and by all verbal prefixes, according to Idsardi (1998)). Some of the verbal prefixes that behave in the same manner as those in (24), are listed in (25).

(25) Verbal prefixes
ʔe- 1S IMPERF; ti- 2,3F IMPERF; yi- 3MS IMPERF; la- INFINITIVE CONSTRUCT, etc. See (3) and Lambdin (1971) among others for more.

The generalization, then, is that while /ya-/ attaches to a stem, /wə-/ attaches to a word.[11] There are two possibilities for how to deal with this depending upon the morphological analysis of verbal prefixes (see e.g. the prefixes of the imperfective paradigm in (3) above) one assumes. The first possibility is that verbal prefixes are attached to a 'root' as part of the template of the verbal paradigm. If one adopts this view, then A-TO-I could be a stem-level process, since the prefixation of these prefixes prior to any phonology would block the application of A-TO-I, even if it takes place at the stem-level. For prefixes (i.e. clitics) attaching at the word level, however, this would not be the case, since they would attach to forms that have by themselves undergone the stem-level phonology PRIOR TO prefixation. An alternative view would be that the verbal prefixes are ones that attach to a stem to make a stem, allowing form to which they attach to cycle through the stem-level phonology prior to affixation. Under this view, A-TO-I crucially could not be a stem-level process, since it would overapply in forms such as *yəgaddé:l*, where *ya-* would attach to *gaddel* subsequent to *gaddel* cycling through the stem-level phonology. This would mean, then, that A-TO-I would be a word-level process, and that prefixes such as *wə-* would be affixes that attach to words to make words. I.e. the forms to which they attach would crucially have to cycle through the word-level phonology PRIOR TO affixation in order for A-TO-I to apply correctly. These two possible analyses are summarized in (26).

(26) a. A-TO-I is stem-level, and prefixes are attached prior to any phonology.
b. A-TO-I is word-level, and prefixes attach in stem level (so, e.g. *gaddel* cycles through stem-level phonology prior to affixation), and prepositions, conjunctives, definite articles, etc. are affixes of the type that attach to words to make words.

[11] I assume that this process is not a phrasal one simply because of the way it is formulated by Prince. The fact that the generalization that it applies to a 'word-initial' closed syllable is opaque in a sense (since in e.g. (19)[c], the syllable to which it applies is not the surface word-initial syllable) shows that the process cannot be phrasal or postlexical, assuming the generalization has been properly captured by the type of formulation in (19).

I am unaware of evidence definitively favoring either (26a) or (26b). Idsardi (1998) tacitly adopts a version of (26a), a view which relegates a significant amount of the phonology/morphology interaction to a level prior to the phonology. In the analysis that follows, I adopt (26b), since under stratal OT, a theory of phonology/morphology interaction, it makes sense to account for as much of the phonology/morphology interaction as part of the level-ordered phonology. The type of analysis, then, with respect to the stem/word distinction that is adopted in the account that follows, is outlined in (27).[12]

(27) a. Verbal prefixes attach at the stem-level (i.e. are affixes that attach to stems to make stems).
b. Verbal suffixes attach at the word level (presumably they attach to stems to make words).
c. Clitics attach at the word-level (assumption is that attach to words to make words, although no evidence for distinct behavior from verbal suffixes).

It is worth noting that although I am at present unaware of evidence that would distinguish between the stem-to-word affixes (27b) and the word-to-word affixes (27c), there are significant theoretical predictions made by this distinction. Namely, stem-to-word affixes affix to the output of the stem-level phonology PRIOR TO cycling through word-level phonology, while word-to-word affixes allow the output of the stem level phonology to cycle through the word-level phonology, affixing only SUBSEQUENT TO word-level phonology, then cycling through it once again, subsequent to affixation. If it turns out that evidence cannot be adduced in favor of this distinction, it could be that there simply is no distinction of this type in TH, and that the affixes of type (27b) and (27c) are simply of the same type. Such a finding would not damage the account developed below.[13]

Additional processes sensitive to the stem/word distinction, as it is being called here, are VOWEL DELETION, LARYNGEAL DELETION, and EPENTHESIS. This will become more clear in the discussion that follows.

[12] This type of distinction is somewhat similar to Idsardi's analysis, whereby verbal prefixes are lexically marked as [+cyclic] and all other verbal affixes are [-cyclic]. What is similar in the present analysis is the lexical distinction between the types of affixes—in both Idsardi's and the present account there are crucial lexical distinctions made between the types of affixes. Also similar is the fact that both Idsardi and the present account make essentially the same distinction between prefixes and suffixes, with a few prefixes (namely the clitics) patterning with the verbal suffixes. Nonetheless, there are some non-trivial distinctions between the two accounts. One of these is the assumption here that prefixation takes place in the phonology, whereas it takes place PRIOR TO the phonology under Idsardi's account. It is this distinction that leads to Idsardi's claiming that A-TO-I is a cyclic process, whereas the claim here is that it is a WORD-LEVEL process. Also worth noting is the fact that the introduction of the stem-level phonology obviates the need for null-morphemes of the type posited by Idsardi (1998:51). Since all stems at some level cycle through the stem-level phonology, no null [+cyclic] morphemes are needed to force this.

[13] In fact, this seems to be precisely what Dresher (1983:72) is claiming when he says that "[n]o evidence of an internal cycle on the verb prior to cliticization has been brought to light." If Dresher is correct, then it would seem that there is, in fact, no stem-to-word/word-to-word distinction, and clitics and verbal suffixes are of the same morphological type.

4.2 Phrasal level

In his discussion of the TH accent system, Dresher (1994) identifies a diacritic in the TH orthographical system that marks what has been called in the TH philological literature the CONJUNCTIVE PHRASE. According to Dresher (1994:10) "[a] word marked with a conjunctive accent is part of the same conjunctive phrase as the word which follows it; a word with a disjunctive accent ends such a phrase." Of particular interest to us here is Dresher's (1994) convincing argument that the conjunctive phrase corresponds to the PHONOLOGICAL PHRASE of the present day prosodic hierarchy.

Dresher (1994:10-11) offers evidence in support of this assertion by showing that there are certain regular TH phonological processes that take the phonological phrase (conjunctive phrase) as their domain of application. The first of these is the rhythm rule, whose purpose is to resolve phrase-level stress clash. There is also a process of external gemination that takes the phonological phrase as its domain of application, geminating a word-initial consonant following a vowel final word.[14]

Finally, and of particular interest in the present context, Dresher shows that spirantization takes the phonological phrase as its domain of application. The generalization regarding spirantization is stated by Dresher as in (28).

(28) **Dresher's generalization regarding spirantization**
A nonemphatic nongeminate consonant is spirantized following a vowel, within words as well as across words that are in the same conjunctive phrase. (Dresher 1994:10)

This is illustrated quite nicely by an extract of the bible given by Dresher (1994:4, (1)), and reproduced below in (29).

(29) Spirantization across phonological phrase boundaries[15]

<table>
<tr><td>C</td><td>D1</td><td>|</td><td>C</td><td>D0</td><td>|</td></tr>
<tr><td>ʃimʕu:</td><td>đəv ar-yhwh</td><td>|</td><td>qəṣi:ne:</td><td>səđo:m</td><td>|</td></tr>
<tr><td>hear</td><td>word-(of)Yhwh</td><td>|</td><td>chieftains</td><td>(of)Sodom</td><td>|</td></tr>
</table>

<table>
<tr><td>D2</td><td>|</td><td>C</td><td>D1</td><td>|</td><td>C</td><td>DO</td><td>|</td></tr>
<tr><td>haʔazi:nu:</td><td>|</td><td>to:raθ</td><td>ʔelo:he:nu:</td><td>|</td><td>ʕam</td><td>ʕamo:ra:</td><td>|</td></tr>
<tr><td>give.ear.to</td><td>|</td><td>instruction</td><td>(of)our.God</td><td>|</td><td>folk</td><td>(of)Gomorrah</td><td>|</td></tr>
</table>

'Hear the word of the lord, you chieftains of Sodom; give ear to our god's instruction, you folk of Gomorrah.' (Isa. 1.10)

The words labeled with a D (see note 15) are marked with a disjunctive accent in the biblical text, thereby signaling the end of a conjunctive phrase. This explains, then, why

[14] According to Dresher (1994:10) there are several conditions on the application of this rule. They are unimportant here—what is important is the fact that the process takes the phonological phrase as its domain of application.

[15] In the text that follows, | marks the end of a phonological phrase and the beginning of a new one. This is marked in the TH orthography by the presence of a disjunctive accent, which is also illustrated in the text below with Dx, where x corresponds to the hierarchical level of the disjunctive accent in question within the discourse. This is unimportant for our purposes. See Dresher (1994:3-5) for discussion of this point.

we find spirantization across the C/D1 word boundary in (29), but not across the D2/C word boundary. In the first case, the two words are part of the same phonological phrase, whereas in the latter case the two words are in separate phonological phrases (signaled by the disjunctive accent), and spirantization therefore fails to apply across the word boundary. As expected spirantization also applies word-internally in these examples, as in e.g. D1 and D0.

Thus, we take the evidence in favor of phrase-level phonological processes in TH to be quite convincing. Of particular importance in the context of the present study is the fact that spirantization is a phrase-level phonological process, as shown convincingly by Dresher (1994). As noted, however, there are additional processes that take this as their domain, such as the rhythm rule and external gemination, which is further evidence in favor of an independent phrasal stratum in TH. It is also worth noting, as I have been reminded by Paul Kiparsky (p.c.), that phrase-level phonological processes do not appear to be all that uncommon. Kiparsky cites the French liaison process as an additional phonological process taking the phonological phrase as its domain. Dresher (1994:10) points to this process as well as to raddopiamento sintattico in Italian and the rhythm rule in English, as further evidence for phrase-level phonology. The existence of such phenomena becomes perhaps more important in the present context than in the past, as independent motivation is sought for each of the strata of the stratal OT phonology. That such phenomena are not restricted only to TH seems like evidence in favor, perhaps, of a somewhat more universal phrasal stratum of phonology, although I do not take this issue up here.

4.3 Postlexical level

In addition to the various strata above, I take as given the existence of a postlexical stratum of phonology, i.e. a stratum subsequent to all of the other strata discussed above. Direct evidence in favor of this stratum is somewhat complicated in TH by the existence of the phrasal stratum, since often much of the evidence in favor of the postlexical stratum is adduced from word-boundary interaction. One piece of direct evidence in favor of the processes claimed to be postlexical is their productivity and from the very nature of the postlexical stratum itself—given the fact that this is the final stratum of the phonology, all of the processes occurring at this level must be completely transparent, since there is no level subsequent to this one that can obscure these postlexical processes. This appears to be the case with 2FS EPENTHESIS.

It is somewhat difficult to make this argument with vowel deletion, since it is claimed to be active at more than one stratum. One place in which we might be able to adduce some independent evidence in favor of the activity of this process at the postlexical level could come from the interaction of this (postlexical) process with other postlexical processes. What sort of processes these might be and what sort of interaction might be seen remains work for future research.

Additional support for the claim that vowel deletion and 2fs epenthesis are postlexical comes from the fact that postlexical processes occurring in the final stratum of the grammar, can cause other processes that apply at earlier strata to be opaque. The facts of TH are consistent with this, since both 2fs epenthesis and vowel deletion cause spirantization to be opaque on the surface. Since these processes cause opacity with spirantization, and spirantization is demonstrably a phrase-level process, if 2fs epenthesis and vowel deletion necessarily applied at a different stratum, this would cause problems for the present account, since the types of opacity at issue are impossible to derive in parallel without appeal to constraints of the OO-Faith and sympathy types. Thus, while there may not be a lot of direct evidence in favor of certain processes being postlexical, the facts of the language and the stratal OT theory are at least consistent with them being postlexical. least consistent with t

4.4 Summary of TH level ordering

The overall picture of the different strata and the 'processes' active at these strata is illustrated graphically in (30).

(30) Processes related to spirantization, and stratum at which they apply

STEM LEVEL
V-DELETION
EPENTHESIS
|
WORD LEVEL
LARYNGEAL DELETION
|
PHRASE LEVEL
SPIRANTIZATION
|
POSTLEXICAL
V-DELETION
2FS EPENTHESIS

(31) a. V-DELETION at stem-level, since stem-level prefixation causes deletion which bleeds spirantization, (6), while postlexical v-deletion counterbleeds spirantization, (7).
b. EPENTHESIS at stem level, since it is counterbled by LARYNGEAL DELETION, (15).
c. LARYNGEAL DELETION at word level, since feeds spirantization, (13), but does not appear to be a phrase-level phenomenon, and since it counterbleeds epenthesis, (15).
d. SPIRANTIZATION is phrase level, see arguments from Dresher.
e. 2FS EPENTHESIS is postlexical, since not opaque to any processes, and since counterfeeds spirantization, (10), which is phrase-level.

5 OT analysis

5.1 Theoretical preliminaries

It is assumed, as discussed above, that each of the strata may differ from the others in the relative ranking of the markedness constraints and the faithfulness constraints. In particular, I follow Kiparsky in assuming that they differ through the promotion of one or more constraints to UNDOMINATED STATUS from one stratum to the other. Although nothing here rests on this assumption, it is potentially an important generalization (with implications for e.g. language acquisition, typology, etc.), if found to be true, and therefore worth being aware of as we proceed. It is by way of differential constraint ranking at the various strata, then, that the framework deals not only with cyclic effects, but with opacity as well. A further theoretical assumption is that in the absence of any evidence to the contrary (i.e. the somewhat idealized evidence of the type used by phonologists, whereby opaque interaction can count as evidence for (non)activity), 'processes' are 'active' (i.e. markedness dominates faithfulness) at all levels. This should be an uncontroversial assumption given standard assumptions about the nature of child language acquisition, and about the learning of OT grammars (e.g. Tesar and Smolensky (2000)). These two assumptions are made explicit in (32) and (33).

(32) **Working definition of the constraint promotion hypothesis**[16]
If stratum ϕ has ordering α of the constraint set and stratum ϕ+1 has ordering β of the constraint set, then β differs from α only in having a small number of constraints promoted (from α to β) to undominated status in the constraint hierarchy.

(33) **Negative evidence hypothesis**
In the absence of evidence to the contrary, markedness constraints outrank faithfulness constraints.

I should also be explicit in what is considered 'evidence' for the negative evidence hypothesis. In addition to the standard types of evidenced considered by typical OT learning algorithms (Tesar and Smolensky 2000; Boersma and Hayes 2001), I also assume that maintaining consistency with the constraint promotion hypothesis can count as 'evidence' to override the default MARKEDNESS>>FAITHFULNESS ranking provided for by the negative evidence hypothesis. This assumption would ideally form part of a more general theory of acquisition in stratal OT. Further elaboration of it, however, goes beyond the scope of this paper.

Throughout the discussion, these two ideas, in addition to the correspondence theory of faithfulness (McCarthy and Prince 1995) are assumed unless otherwise noted. Formulation of the faithfulness constraints is either taken from or closely follows Kager (1999).

[16]The hypothesis is due to Kiparsky (p.c.); I am responsible for this interpretation and formulation of it. The definition is offered only in the interest of making it more clear what I am assuming; it leaves out the definition of non-trivial notions, which would, nevertheless be defined in a more complete formulation (which probably merits a paper of its own). These notions include e.g. 'stratum,' 'constraint set,' 'promote,' and 'undominated.' One also would be justified in questioning what precisely is meant by 'a small number of constraints.' These issues are left unaddressed here.

5.2 Constraints and rankings

In section 3, I laid out the TH spirantization data and discussed the processes interacting with spirantization. In the present section, I discuss the constraints and rankings of these constraints at each of the four strata independently motivated in the prior section.

5.2.1 Spirantization

The constraints responsible for the spirantization of stops following vowels in TH are taken from Benua (1997:133). Markedness constraints bearing on spirantization are given in (34), while the corresponding antagonistic faithfulness constraints are given in (35).

(34) Markedness constraints governing spirantization
  a. *SPIR
     Non-strident fricatives are prohibited.
  b. *STOP
     [−cont, −son] segments are prohibited.
  c. *V-STOP
     Post-vocalic stops are prohibited.

(35) Faithfulness constraints governing spirantization
  a. IDENT[CONT]
     Input-output correspondents are identical in the value of the feature [cont]
  b. MAX-C
     An input consonant has a correspondent in the output.
  c. MAX-V
     An input vowel has a correspondent in the output.

In addition to Benua's constraints in (34) and (35), the markedness constraint in (36), militating against complex codas, is also relevant, since a possible response to a VStop sequence might be simply to remove the vowel from the context of the stop (by way of deletion, metathesis, etc.).

(36) Markedness constraint on coda well-formedness
     $CC_\sigma]$ (Kager 1999:97)
     Syllable codas are 'simple', i.e. codas are composed of no more than one consonant.

*V-STOP is a context-sensitive version of *STOP, and is therefore presumed to be universally ranked above *STOP. Following Benua, I will also assume that spirants are universally marked with respect to stops, and that *SPIR therefore universally outranks *STOP. Benua (1997:133,fn.74) notes that this assumption is problematic for certain situations and certain languages. It is not a crucial assumption in the present context. This gives the universal rankings in (37).[17]

[17] Depending upon one's approach to markedness, the non-existence of a *STOP constraint might be assumed, as Kiparsky (p.c.) has pointed out to me. This approach would have the advantage of reducing the number of constraints, and thereby decreasing the size of the factorial typology. Nevertheless, as Benua has discussed, the universal ranking of *SPIR>>*STOP appears to be an idealization, so *STOP apparently does surface in some languages ranked above *SPIR, thereby necessitating its existence. I'll continue to

(37) Ranking of markedness constraints bearing on spirantization

a. *V-STOP>>*STOP

b. *SPIR>>*STOP

The ranking of these constraints relative to one another that generates spirantization is given in (38) (with the hypothetical input /melek/ for illustratory purposes—the actual input, /melk/, illustrates both spirantization and epenthesis, whose interaction is discussed below). The generation of spirantization with this constraint hierarchy is illustrated in the tableau in (39).

(38) Ranking of constraints generating spirantization
MAX-V,*CC$_\sigma$],MAX-C,*VSTOP>>*SPIR>>IDENT[CONT]>>*STOP

(39) Spirantization illustrated[18]

	/melek/	*CC$_\sigma$]	MAX-C	*VSTOP	*SPIR	IDENT[CONT]	*STOP
a.	melek			*!			*
b.⇒	melex				*	*	
c.	mele		*!				
d.	meelk	*!					*
e.	melk	*!					*

As the tableaux in (39) illustrates, there are several possible ways of repairing a disfavored VStop sequence. One possibility for repair is represented by candidate c, deletion of the postvocalic consonant. This is ruled out by the high-ranking MAX-C constraint. Another possibility is metathesis (candidate d), which is ruled out by the high-ranking constraint against complex codas, *CC$_\sigma$].[19] Deletion of the pre-consonantal vowel (candidate e) would be another possibility. This also violates *CC$_\sigma$], and is therefore sub-optimal.[20] Finally, another option would be to simply do nothing, which violates the very constraint against the VStop sequences, *VSTOP, leaving the spirantized candidate, candidate b, as optimal.

As will be recalled from the discussion above, spirantization is a phenomenon that takes the phonological phrase as its domain of application. I.e. it applies not only within words,

assume, for the purposes of this paper, however, that *SPIR>>*STOP, if for no other reason than that the facts of TH necessitate such a ranking.

[18]Throughout the paper, I use the absence of a — rather than a slashed vertical - - to represent in the tableaux that two constraints are unranked with respect to one another. The rightward arrow, ⇒, denotes the optimal candidate.

[19] This candidate would probably also violate some sort of LINEARITY constraint. Because the *CC$_\sigma$] constraint is shown on independent grounds below to be 'active' in TH, I consider this constraint here, while noting the possibility that LINEARITY could also be relevant.

[20]This candidate would also violate MAX-V, a constraint that is considered below in reference to the vowel deletion phenomena. There seems to be no direct way, however, of determining its ranking with respect to the constraints bearing on spirantization, since any vowel that deletes in order to prevent spirantization would create a complex coda, thereby also violating the high-ranking *CC$_\sigma$], which can somewhat independently be argued to be high-ranking (see e.g. candidate d), but also note 19.

but also across word boundaries. Crucially, however, it does not apply across all word boundaries—indeed, contrary to what is suggested in Idsardi's discussion, spirantization across word boundaries can be blocked by phrasal boundaries.[21] It must be noted, though, that there is no reason why spirantization must be necessarily restricted to the phrase-level, since there is no opaque interaction between any word-level process (i.e. laryngeal deletion) and between spirantization. Likewise, there are no known opaque interactions between stem-level processes (epenthesis and vowel deletion) and spirantization. We know that spirantization MUST BE a phrase-level process due to the behavior in phonological phrases discussed by Dresher (1994). Likewise, it cannot be postlexical, since postlexical epenthetic vowels do not cause spirantization of a following stop, and since postlexical vowel deletion fails to 'undo' spirantization. The question, then, is whether spirantization must also be a stem-level and a word-level process. There are certain consequences associated with this decision that will become clear as spirantization/vowel deletion phenomena are discussed. Kiparsky (p.c.) has suggested that all 'processes' are active unless there exists evidence suggesting otherwise. This operating assumption keeps to a minimum the amount of reranking done between the various strata, and is adopted in the analysis that follows. It is noted, however, that this is not necessarily the case, and it could be that spirantization is exclusively a phrase-level process. We simply assume that it is also stem-level and word-level because it theoretically CAN be. This assumption, as mentioned is not without consequences, which are discussed below. On the view, then, that spirantization is active at all strata except the postlexical, the ranking of the constraints at the four strata is as shown in (40).[22]

(40) Ranking of the constraints bearing on spirantization at the four different strata

STEM-LEVEL	$*CC_\sigma]$,MAX-C,*VSTOP>>*SPIR>>IDENT[CONT]>>*STOP
WORD-LEVEL	$*CC_\sigma]$,MAX-C,*VSTOP>>*SPIR>>IDENT[CONT]>>*STOP
PHRASE-LEVEL	$*CC_\sigma]$,MAX-C,*VSTOP>>*SPIR>>IDENT[CONT]>>*STOP
POSTLEXICAL	$*CC_\sigma]$,MAX-C,IDENT[CONT]>>*VSTOP>>*SPIR>>*STOP

5.2.2 Epenthesis

TH seems to be especially sensitive to the well-formedness of its codas. Although it also certainly has constraints on onset well-formedness as well, they do not appear to be relevant for the phenomena under consideration. The markedness constraints governing coda well-formedness in TH are outlined in (41).

(41) Markedness constraints bearing on coda well-formedness

[21] It is unclear whether or not this may be the reason why, according to Idsardi (1998:40-41) stops following semivowels typically (but apparently not always) block spirantization across word boundaries. That is, it could be that the boundary phenomena have not been properly considered here. This merits further investigation. For the purposes of the present discussion, I assume that the semivowels and the vowels behave uniformly with respect to spirantization. If a more in depth discussion were to find that this is not the case (and that Idsardi's generalizations are indeed correct), the solution would be for spirantization following semivowels to go forward at the word level, but to be blocked at the phrase level, while spirantization following vowels would go forward at both levels. This would be implemented formally by way of an additional context sensitive markedness constraint, banning semi-vowel/stop sequences.

[22] I am giving here rankings motivated only by the spirantization phenomena. These hierarchies will be slightly revised below, as further phenomena are considered.

a. $*ʕC_\sigma]$
Complex codas of the type $ʕC_\sigma]$ are prohibited.
b. $*CC_\sigma]$ (Kager 1999:97)
Syllable codas are 'simple', i.e. codas are composed of no more than one consonant.

(41a) is considered to be a context-sensitive instantiation of (41b). These two constraints, then, are assumed to be universally ranked in a SPECIFIC>>GENERAL fashion, as shown in (42).

(42) Universal ranking of constraints on coda well-formedness
$ʕC_\sigma]{>}{>}*CC_\sigma]$

The implication here is that a relatively high ranking of $*CC_\sigma]$ necessarily implies a higher ranking of $*ʕC_\sigma]$, while the reverse is not the case. I.e. $*ʕC_\sigma]$ can be ranked relatively high at the same time that $*CC_\sigma]$ is ranked relatively low. This will be important for the analysis of TH epenthesis/spirantization interaction, and will become more clear below.

The faithfulness constraints antagonistic to the markedness constraints in (41), are defined in (43).

(43) Faithfulness constraints interacting with markedness constraints on syllable well-formedness
a. MAX-C
An input consonant must have an output correspondent.
b. DEP-V
An output vowel must have an input correspondent.

The relative ranking of the markedness constraints and faithfulness constraints that leads to across-the-board epenthesis, is given in (44). As discussed above, this is the type of epenthesis found in TH at the stem-level. I.e., all stem-level $CC_\sigma]$ clusters are broken up by epenthetic vowels in TH that in turn trigger spirantization.[23] This result is demonstrated in the tableau in (45).

(44) Constraint rankings responsible for stem-level epenthesis
$*ʕC_\sigma]{>}{>}*CC_\sigma]$,MAX-C>>DEP-V

[23] As shown in the tableau, with the assumption that spirantization goes forward at all strata except the postlexical, then stem-level epenthesis feeds spirantization at the stem-level. An alternative is that epenthesis occurs at the stem-level, feeding spirantization at the phrase-level.

(45) Epenthesis feeds spirantization[24]

	/melk/	*ʕC$_\sigma$]	MAX-C	*CC$_\sigma$]	*VSTOP	DEP-V	*SPIR	IDENT[CONT]	*STOP
a.	melk			*!					*
b.	melek				*!	*			*
c.	mel		*!						*
d.⇒	melex					*	*	*	
e.	mele		*!			*			

Recall from the layout of the TH facts presented above, that in addition to spirantization inducing epenthesis, TH also has certain epenthetic vowels that crucially DO NOT INDUCE EPENTHESIS, as in e.g. (46).

(46) Stops following certain epenthetic vowels fail to spirantize
/ʃamaʕ-t/→[ʃamaʕát] 'hear 2FS PERF'

These are cases where epenthesis is caused by the introduction of the second feminine singular suffix *-t*.[25] It is important to recall, though, that for many CC$_\sigma$] clusters resulting from 2FS PERF affixation, there is no epenthesis breaking up these clusters, as in e.g. (47).

(47) No epenthesis with all CC$_\sigma$] clusters resulting from 2FS PERF affixation
/katab+t/→[ka:θáv-t] 'write 2FS PERF'

This shows, then, that the epenthesis resulting from 2FS PERF affixation is a special instance of the more general stem-level epenthesis. In particular, this special type of epenthesis appears only to break up ʕC$_\sigma$] clusters. Under these circumstances, it becomes 'more important' not to delete or insert segments in most CC$_\sigma$] sequences, the exception being the ʕC$_\sigma$] sequences, due to the domination of MAX-C and DEP-V by C$_\sigma$]. The relevant constraint rankings for this situation are given in (48).

(48) Constraint rankings responsible for postlexical 2fs epenthesis
*ʕC$_\sigma$],MAX-C>>DEP-V>>*CC$_\sigma$]

The fact that 2FS PERF affixation does not induce spirantization of a following consonant falls out from the fact that SPIRANTIZATION DOES NOT APPLY AT THE POSTLEXICAL STRATUM. Since 2fs epenthesis is a postlexical process and spirantization crucially is not a postlexical process, there is a counterfeeding effect, whereby it appears on the surface as

[24] Although vowel-quality is a very interesting and important issue in TH, it is beyond the scope of the present study. Throughout the tableau, I show changes in vowel quality from input to output without generally addressing their significance or how they are accounted for.

[25] According to Benua (1997), and Idsardi (1998) following her, 2fs perfective affixation is really truncation of *i* from the 1s perfective. Whether the 2FS PERF affix *-t* results from affixation of *-t* or truncation of *-i* is irrelevant here, provided that whatever occurs, occurs at the word-level. I.e., as long as either affixation or truncation occurs at the word-level, then the present account properly deals with these forms. In the interest of maintaining a uniform terminology, I refer to this process throughout the paper as 2FS PERF affixation.

though spirantization has underapplied. Likewise, there can be no epenthesis at the word level (where 2FS PERF affixation occurs). If this were the case, then these epenthetic vowels would induce spirantization with the 2FS PERF suffix. The rankings of the constraints governing epenthesis at the four different strata, then, are given in (49).

(49) Rankings of the constraints governing epenthesis at the four strata[26]

STEM-LEVEL	*ʕC$_{\sigma}$]>>*CC$_{\sigma}$],MAX-C>>DEP-V
WORD-LEVEL	DEP-V>>MAX-C>>*ʕC$_{\sigma}$]>>*CC$_{\sigma}$]
PHRASE-LEVEL	DEP-V>>MAX-C>>*ʕC$_{\sigma}$]>>*CC$_{\sigma}$]
POSTLEXICAL	*ʕC$_{\sigma}$], MAX-C>>DEP-V>>*CC$_{\sigma}$]

The tableaux in (50) and (51) give full derivations for *melex* 'king', where epenthesis FEEDS spirantization, and for *ʃamaʕát* 'hear 2FS PERF', where epenthesis COUNTERFEEDS spirantization.

(50) Epenthesis feeds spirantization

STEM

	/malk/	*ʕC$_{\sigma}$]	*CC$_{\sigma}$]	MAX-C	DEP-V	*VSTOP	*SPIR	ID[CONT]	*STOP
a.	melk		*!						*
b.	mel			*!					
c.	melek				*	*!			*
d.⇒	melex				*		*	*	

WORD

	/melek/	DEP-V	MAX-C	*ʕC$_{\sigma}$]	*CC$_{\sigma}$]	*VSTOP	*SPIR	ID[CONT]	*STOP
a.	melek					*!			*
b. ⇒	melex						*	*	

PHRASE

	/melek/	DEP-V	MAX-C	*ʕC$_{\sigma}$]	*CC$_{\sigma}$]	*VSTOP	*SPIR	ID[CONT]	*STOP
a.	mele		*!						
b.	melk				*!				*
c.	melek					*!			*
d. ⇒	melex						*	*	

POSTLEXICAL

[26]The reranking of MAX-V with respect to DEP-V is due to the levels where laryngeal deletion and epenthesis do and do not apply. This is discussed and illustrated below.

/melex/	*ʕC$_\sigma$]	Max-C	Dep-V	*CC$_\sigma$]	Id[cont]	*VStop	*Spir	*Stop
a. melek					*!	*		*
b. ⇒ melex							*	

(51) Spirantization counterfeeds postlexical 2fs epenthesis

STEM

/malk/	*ʕC$_\sigma$]	*CC$_\sigma$]	Max-C	Dep-V	*VStop	*Spir	Id[cont]	*Stop
a. ⇒ ʃamaʕ								
b. ʃamaʕe				*!				

WORD

/ʃamaʕ+t/	Dep-V	Max-C	*ʕC$_\sigma$]	*CC$_\sigma$]	*VStop	*Spir	Id[cont]	*Stop
a. ⇒ ʃamaʕt			*	*				
b. ʃamaʕat	*!			*				
c. ʃamaʕ		*!						
d. ʃamaʕaθ						*	*	

PHRASE

/ʃamaʕt/	Dep-V	Max-C	*ʕC$_\sigma$]	*CC$_\sigma$]	*VStop	*Spir	Id[cont]	*Stop
a. ⇒ ʃamaʕt			*	*				*
b. ʃamaʕθ			*!	*		*	*	
c. ʃamaʕaθ	*!					*	*	*
d. ʃamaʕ		*!						

POSTLEXICAL

/ʃamaʕt/	*ʕC$_\sigma$]	Max-C	Dep-V	*CC$_\sigma$]	Id[cont]	*VStop	*Spir	*Stop
a. ʃamaʕt	*!			*				*
b. ʃamaʕ		*!						
c.⇒ ʃamaʕat			*			*		*
d. ʃamaʕaθ			*		*!		*	

These tableaux demonstrate several important properties of the analysis. In particular, they show how the constraint rankings differ from one stratum to the next. As argued by Kiparsky (2001), the constraint rankings differ in minor ways from one stratum to another, by way of promotion of a small number of constraints over other competing constraints.

In (51) and (50), we observe that from the stem-level to the word-level, the mini-hierarchy MAX-C>>DEP-V is promoted over the mini-hierarchy of antagonistic constraints on coda well-formedness *ʕC$_\sigma$]>>*CC$_\sigma$]. From the phrase-level to the postlexical level, *ʕC$_\sigma$] is promoted above the faithfulness constraints MAX-C<<DEP-V to give 2fs epenthesis at this stratum. Also promoted from the phrase-level to the postlexical level is ID[CONT] above *VSTOP<<*SPIR to prevent spirantization from going forward at the postlexical level. These two final promotions of separate constraints are responsible for the counterfeeding effect in certain 2FS PERF verbal forms such as *ʃamaʕat* 'hear 2FS PERF'. It is also worth highlighting the fact that in all cases of promotion, promotion is to UNDOMINATED status in the hierarchy. This fact is discussed below in more detail when we consider the rankings and the re-rankings of all of the constraints discussed here.

5.2.3 Vowel deletion

As has likely become clear already, the TH phonological system is very tightly woven, such that there is very close interaction between the many different phonological processes of the language. Of the many processes that interact directly with spirantization, VOWEL DELETION is one that is particularly complex, largely due to the claim that it itself interacts with the process of VOWEL REDUCTION, a process which has figured prominently in several dissertation-length treatises on metrical structure (e.g. Prince (1975); McCarthy (1979); Rappaport (1984)).

Past rule-based accounts of vowel reduction and deletion in TH have relied on multiplanar representations, crucially making reference to the notion of a REDUCTION FOOT (McCarthy (1979); although cf. Churchyard (1999:37ff.)), a level of metrical structure presumed to exist independently of the metrical structure responsible for the assignment of stress. In his discussion of similar phenomena, Kager (1997) argues that reduction can be thought of in OT as a type of economy of structure constraint, minimizing the number of moras a word has,[27] while deletion can be conceived of as a way of minimizing the amount of metrical structure in a word, i.e. as a way of minimizing the number of PARSE-σ violations. Although Kager's approach seems like the obvious starting point for an OT account of reduction and deletion in TH, there are some non-trivial issues beyond the scope of the present paper (e.g. the relation (or non-relation, cf. the multiplanar accounts) of the process to stress assignment, and by relation to pre-tonic lengthening, syllable structure, etc.) that have to be considered for the full development of an analysis of these phenomena. For the purposes of the present paper, then, I will not consider the reduction facts, since they don't bear directly on spirantization (i.e. they are only linked to the extent that deletion is dependent upon reduction). The primary motivation of the present paper is, rather than to provide a full-scale OT analysis of TH metrical structure (which certainly would be a worthwhile endeavor), to show how the vowel deletion/spirantization interaction can be accommodated within a stratal OT. Because of this, I gloss over the constraints responsible for the deletion phenomena, referring to the set of constraints responsible for deletion as in (52).

[27] Kager argues that schwa is moraless.

(52) DELETION
A vowel in a light open syllable is deleted when it is preceded by an open syllable.

As is made evident by the non-consideration of the reduction phenomena in the present context, for the purposes of the present discussion, I assume that reduction and deletion are somewhat independent of one another (to the extent that this is possible under an OT account).[28]

Although deletion is a very robust phenomenon in TH, there is at least one context in which it is generally blocked—when the vowel that would be deleted is preceded by a guttural. I.e., deletion appears to be blocked whenever deletion would cause the creation of a guttural coda (which are prohibited in TH—cf. section 2.3 on laryngeal deletion/spirantization interaction). This, in addition to the well known laryngeal deletion facts considered below, suggest the presence of a constraint such as that in (53) (cf. McCarthy's (1999b:336) anti-[ʔ] CODACOND constraint).[29]

[28]This represents a departure from the view of reduction and deletion presented in the rule-based literature (since Prince (1975), although cf. Malone (1993)), where reduction feeds deletion. It is not clear, however, that this need be the case under OT. It does seem to be the case that one may view the set of vowels that delete as a subset of those that reduce, but as far as I have been able to tell, it is not the case that one needs to make reference to reduction in order to account for deletion. I.e. the generalizations governing deletion seem to be statable, as has been done in (52), independently of the generalizations governing reduction. Obviously under OT, where a phonology is viewed as an ordering of universal constraints, there will by definition be interaction between these two 'processes' (as well as between all other 'processes' in the language).

I do not think that the separation of reduction and deletion is absolutely crucial in the present context. In the event that it is found that reduction must 'feed' deletion, even in the OT context, it would not be fatal to the account presented here, although it would present some complications related to the output quality of vowels. In particular, there would seemingly be an overgeneration of schwa in the output. Obviously, these phenomena are in need of reexamination in light of both the advent of OT and in light of Kager (1997).

[29] This constraint could perhaps be considered shorthand for the local conjunction of two more general markedness constraints governing first, the general cross-linguistic markedness of laryngeals, and secondly the markedness of codas.

There will, in fact, have to be two constraints of this type for different types of laryngeals. The motivation for this is as follows. While it appears v-deletion is blocked when it would create a laryngeal coda of any sort, the laryngeals do not behave homogeneously with respect to the phenomenon of laryngeal deletion (see section 2.3). In particular, appears as though the laryngeals farthest back in the vocal tract do not delete when in coda position. This is illustrated by the data in (i) (cf. Idsardi (1998:68-69)), where ʔ is [-back] and ʕ is [+back] (following the classification of the TH laryngeals in Malone (1993:194)).

(i) a. /ʃamaʕ+t/→[ʃamaʕat] 'hear 2FS PERF'
b. /śaneʔ+t/→[śane:θ] 'hate 2FS PERF'

If this generalization is correct (which remains to be fully investigated—note that past analyses, e.g. McCarthy (1999b) have not considered this issue), there will have to be two separate constraints against laryngeal codas, as in (ii).

(ii) a. $*ʔ_\sigma]$
[−back] laryngeals are prohibited in coda position.
b. $*ʕ_\sigma]$
[+back] laryngeals are prohibited in coda position.

These two constraints will BOTH be ranked above DELETION, since vowel deletion is blocked by all laryngeals. Only $*ʔ_\sigma]$ will be ranked above MAX-C at the stem level, however, thereby accounting for the fact that only the back-most laryngeals delete when in coda position. The relevant portion of the stem-level constraint hierarchy, under this analysis, would be as in (iii).

(53) *ʔ$_\sigma$]
ʔ is prohibited in coda position.

The fact that vowels do not delete when preceded by a laryngeal, then, motivates the ranking in (54).

(54) Deletion fails when it would create a laryngeal coda
ʔ$_\sigma$]>>DELETION

Whatever the markedness constraints are that are represented by DELETION, they obviously are in competition with faithfulness constraints militating against the deletion of vocalic segments. The relevant faithfulness constraint is given in (55).

(55) Faithfulness constraint militating against vowel deletion
  a. MAX-V
  An input vowel must have an output correspondent.

For deletion to take place, DELETION will have to outrank MAX-V. When deletion is blocked, however, MAX-V outranks DELETION.

Interaction of vowel deletion and spirantization As noted by Idsardi and discussed above, a particularly important aspect of TH spirantization/deletion interaction is that stops spirantize following some deleted vowels (e.g. (56)), while they do not spirantize following others (e.g. (57)).

(56) Stops fail to spirantize following deleted vowels where deletion occurs as result of stem-level affixation
  a. /ya+katob/→[yixtó:v] 'write 3MS IMPF'
  b. /na+katab/→[nixtáv] 'write 3MS PERF Nifʕal'
  c. /li+katob/→[lixto:v] 'to write INF CONSTRUCT'

(57) Stops do spirantize following deleted vowels where deletion occurs as postlexical process
  a. /katab+u/→[ka:θvú:] 'write 3P PERF'
  b. /bi+katob/→[bixθó:v] 'when writing INF CONSTRUCT'

The generalization is that stops following vowels whose deletion is conditioned by STEM-LEVEL AFFIXATION, DO NOT SPIRANTIZE, while stops following vowels whose deletion is condition by WORD-LEVEL AFFIXATION, DO SPIRANTIZE. This is illustrated in the tableaux in (58) for *lixtó:v* and in (59) for *bixθó:v*.

(58) Non-spirantization following vowels deleted at stem-level
STEM

(iii) *ʔ$_\sigma$]>>MAX-C>>*ʕ$_\sigma$]>>DELETION

In the analyses that follow, I gloss over this complication.

	/katob/	Max-C	*CC$_\sigma$]	Del	Max-V	*VStop	*Spir	Id[cont]	*Stop
a.	katob					*!*			***
b.	ktob				*!	*			***
c.	ktov				*!		*		**
d. ⇒	kaθov						**	**	*

STEM

	/la+kaθov/	Max-C	*CC$_\sigma$]	Del	Max-V	*VStop	*Spir	Id[cont]	*Stop
a.	likatob			*!		***		**	***
b.	liktob				*!	**		**	***
c. ⇒	lixtov				*		**	**	*
d.	lixaθov			*!				***	

WORD[30]

	/lixtov/	Max-C	*CC$_\sigma$]	Max-V	Del	*VStop	*Spir	Id[cont]	*Stop
a. ⇒	lixtov						**	**	
b.	liktob					*!*		**	***

PHRASE

	/lixtov/	Max-C	*CC$_\sigma$]	Max-V	Del	*VStop	*Spir	Id[cont]	*Stop
a. ⇒	lixtov						**		*
b.	liktob					*!*		**	***
c.	lixtb		*!	*			*	**	
d.	lixto	*!				*	*		

POSTLEXICAL

	/lixtov/	Max-C	*CC$_\sigma$]	Del	Max-V	Id[cont]	*VStop	*Spir	*Stop
a. ⇒	lixtov							**	
b.	liktob					*!*	**		***

(59) Spirantization following vowels deleted postlexically
STEM

[30] Although the tableau representation below implies that Max-V>>Id[cont], there is no evidence that this is the case.

/katob/	MAX-C	*CC$_\sigma$]	DEL	MAX-V	*VSTOP	*SPIR	ID[CONT]	*STOP
a. katob					*!*			***
b. ktob				*!	*			***
c. ktov				*!		*		**
d. ⇒ kaθov						**	**	*

WORD[31]

/bi+kaθov/	MAX-C	*CC$_\sigma$]	MAX-V	DEL	*VSTOP	*SPIR	ID[CONT]	*STOP
a. ⇒ bixaθov				*		***	*	
b. bixtov			*!			**	**	**
c. bixθov		*!			***	*	*	

PHRASE

/bixaθov/	MAX-C	*CC$_\sigma$]	MAX-V	DEL	*VSTOP	*SPIR	ID[CONT]	*STOP
a. ⇒ bixaθov				*		***		
b. bixtov			*!			**	*	*
c. bikatob				*	*!**		***	****
d. bixaθb		*!			**	**	*	

POSTLEXICAL

/bixaθov/	MAX-C	*CC$_\sigma$]	DEL	MAX-V	ID[CONT]	*VSTOP	*SPIR	*STOP
a. ⇒ bixθov				*			***	*
b. bixaθov			*!				***	*
c. bixtov				*	*!		**	**

5.2.4 Laryngeal deletion

As discussed above, TH has a process of laryngeal deletion that feeds spirantization. The OT constraints relevant for the discussion of laryngeal deletion are given in (60).

(60) Constraints governing laryngeal deletion (many of which are repeated from discussion above)

a. *ʔ$_\sigma$] (repeated from (53))
ʔ is prohibited in coda position.

[31] It is worth noting that there appears to be no evidence in TH for a distinction between stem-to-word affixes and word-to-word affixes.

b. MAX-C
An input consonant must have an output correspondent.

c. DEP-V
An output vowel must have an input correspondent.

The ranking of these constraints that generates laryngeal deletion is illustrated in (61). It is worth emphasizing that in order for laryngeals in coda position to be deleted, rather than e.g. placed in the onset through epenthesis, and thereby through violation of DEP-V, DEP-V must outrank MAX-C. This ranking is precisely the opposite ranking of these constraints needed at the stem-level to properly generate epenthesis. Thus, this is further evidence (albeit theory internal), that laryngeal deletion cannot be a stem-level process.

(61) Ranking responsible for laryngeal deletion[32]
$ʔ_\sigma$]>>DEP-V>>MAX-C

As discussed above, laryngeal deletion crucially must take place SUBSEQUENT to stem-level epenthesis in order to generate the types of counterbleeding i interaction discussed by e.g. McCarthy (1999). There is no evidence suggesting that laryngeal deletion cannot be active at the other strata in the phonology. We therefore assume that the rankings in (62) hold, with *$ʔ_\sigma$] crucially dominated by MAX-C at the stem-level, but dominating MAX-C at all other strata.[33]

(62) Rankings of constraints generating laryngeal deletion at each of the four strata[34]

STEM-LEVEL	MAX-C>>DEP-V>>*$ʔ_\sigma$]
WORD-LEVEL	*$ʔ_\sigma$],DEP-V>>MAX-C
PHRASE-LEVEL	*$ʔ_\sigma$],DEP-V>>MAX-C
POSTLEXICAL	*$ʔ_\sigma$],MAX-C>>DEP-V

The tableaux in (63) give a full derivation illustrating laryngeal deletion/spirantization interaction.

(63) Laryngeal deletion feeds spirantization
STEM

[32]Recall the caveat discussed in fn. 29. I gloss over this issue here in the interest of simplifying the discussion.

[33]The relative rankings of MAX-C and DEP-V are determined on the basis of the behavior of epenthesis at the strata in question. It is noteworthy that the MAX-C>>DEP-V ranking is forced by this account at the postlexical level—the prediction, then, in the absence of any evidence is that *$ʔ_\sigma$] sequences, if they were to make it to the postlexical stratum without being repaired, would be repaired by epenthesis, rather than be deletion. If this prediction turned out to be incorrect, the analysis could, of course, be adjusted to properly account for e.g. deletion, or even for no repair at all. This would entail, however, abandonment of the assumption that a constraint can only be promoted one time in the grammar.

[34]There is no evidence that I am aware of that would suggest that laryngeal deletion takes place anywhere other than the word-level. At the same time, though, I am aware of no evidence suggesting that there is a reranking of the constraints from the word-level to the phrase and postlexical levels to PREVENT FURTHER laryngeal deletion. In the absence of evidence in either direction, then, I assume stasis.

/he:vi:ʔ/	*CC$_\sigma$]	MAX-C	DEP-V	*ʔ$_\sigma$]	*VSTOP	*SPIR	ID[CONT]	*STOP
a. ⇒ he:vi:ʔ				*		*		
b. he:vi:		*!				*		

WORD

/he:vi:ʔ/	DEP-V	*ʔ$_\sigma$]	MAX-C	*CC$_\sigma$]	*VSTOP	*SPIR	ID[CONT]	*STOP
a. ⇒ he:vi:			*			*		
b. he:vi:ʔ		*!				*		
c. he:vi:ʔe	*!					*		

PHRASE

/he:vi: gam/	DEP-V	*ʔ$_\sigma$]	MAX-C	*CC$_\sigma$]	*VSTOP	*SPIR	ID[CONT]	*STOP
a. he:vi: gam					*!			*
b. he:vi: agm				*!				*
c. he:vi: am			*!					
d. he:vi: egam	*!				*			*
e. ⇒ he:vi: ɣam						*	*	

POSTLEXICAL

/he:vi: ɣam/	*ʔ$_\sigma$]	MAX-C	ID[CONT]	DEP-V	*CC$_\sigma$]	*VSTOP	*SPIR	*STOP
a. ⇒ he:vi: ɣam							*	
b. he:vi: gam			*!			*		*
c. he:vi: am		*!						

The tableaux in (64) give a full derivation for *deʃ*, illustrating the interaction between laryngeal deletion and epenthesis. It is worth noting that this is the type of pattern sympathy theory (McCarthy 1999a, 1999b) was developed to handle. Under the present analysis, it comes for free. I.e., there is no need for special constraints of any sort—the opaque interaction is derived from interaction of the independently motivated stem and word levels.

(64) Laryngeal deletion/epenthesis interaction[35]

STEM[36]

/deʃʔ/	*ʕC$_\sigma$]	*CC$_\sigma$]	MAX-C	DEP-V	*ʔ$_\sigma$]	MAX-V
a. ⇒ deʃeʔ				*	*	
b. deʃ			*!			
c. deʃʔ		*!			*	
d. deʃe			*!	*		

WORD

/deʃeʔ/	*ʔ$_\sigma$]	MAX-V	DEP-V	MAX-C	*ʕC$_\sigma$]	*CC$_\sigma$]
a. deʃeʔ	*!					
b. deʃ		*!		*		
c. deʃʔ	*!	*				*
d. ⇒ deʃe				*		
e. deʃeʔe			*!			

PHRASE

/deʃe/	*ʔ$_\sigma$]	MAX-V	DEP-V	MAX-C	*ʕC$_\sigma$]	*CC$_\sigma$]
a. deʃeʔ	*!					
b. deʃ		*!		*		
c. deʃʔ	*!	*				*
d. ⇒ deʃe						

POSTLEXICAL[37]

/deʃe/	*ʕC$_\sigma$]	*ʔ$_\sigma$]	MAX-V	MAX-C	DEP-V	*CC$_\sigma$]
a. deʃ			*!			
b. dee				*!		
c. deʃee					*!	
c. ⇒ deʃe						

[35] The ranking of MAX-V with respect to *ʔ$_\sigma$] cannot be determined at the stem-level on the basis of laryngeal deletion/spirantization interaction. Nevertheless, as seen in (65), *ʔ$_\sigma$] does outrank MAX-V at this level. The reasoning is as follows. *ʔ$_\sigma$] always outranks DELETION, since laryngeals block v-deletion, and since DELETION outranks MAX-V at the stem-level (due to the fact that v-deletion goes forward at this level), *ʔ$_\sigma$] therefore dominates MAX-V at the stem-level by transitivity.

[36] One interesting candidate left out of the tableaux below (which also is not found in McCarthy (1999a:336)) is *deʃʔe*. If nothing else rules out this candidate, its sub-optimality could be attributed to a LINEARITY constraint dominating MAX-C. LINEARITY, although it has not been explicitly considered here, appears to be undominated in the language at all strata, at least as far as the phenomena under consideration are concerned.

[37] *ʔ$_\sigma$] dominates MAX-V at the postlexical stratum by the argument in note 35.

5.3 Constraint rankings in the different strata

In the present section, I bring together the findings from above regarding the constraint rankings bearing on the particular processes at the particular stages to examine the constraint hierarchy as a whole. Of particular interest in the theoretical context of stratal OT is whether or not the proposed rerankings are consistent with the constraint promotion hypothesis (cf. (32)) suggested by Kiparsky (p.c.).

5.3.1 Stem-level constraint hierarchy

The final stem level constraint hierarchy is given in (65).

(65) Final stem-level constraint hierarchy

```
              MAX-C
                |
              *ʕCσ]
                |
              *CCσ]
      /                 \
   DEP-V               *VSTOP
     |                    |
    ʔσ]                 *SPIR
     |                    |
  DELETION             ID[CONT]
     |                    |
   MAX-V                STOP
```

As will be recalled from the discussion above, we are assuming (by the negative evidence hypothesis, (33)) that spirantization is active at all strata except for the postlexical stratum. This gives the ranking in (65) of *VSTOP, *SPIR, ID[CONT], and *STOP. Parallel to this subhierarchy is the subhierarchy dealing with vowel deletion, among other processes. Since vowel deletion goes forward at the stem-level, DELETION must outrank MAX-V. As discussed above, vowel deletion is blocked when a laryngeal coda would be created, giving the ranking *ʔ$_\sigma$]>>DELETION. There is no laryngeal deletion at the stem level (due to opaque interaction with epenthesis), which gives the ranking of DEP-V and MAX-C with respect to *ʔ$_\sigma$]. Epenthesis goes forward at the stem level, giving the ranking MAX-C>>DEP-V. Also motivated by stem-level epenthesis, is the ranking of the subhiearchy *ʕC$_\sigma$]>>*CC$_\sigma$] over DEP-V. This leaves us with one final ranking to justify—MAX-C must outrank DEP-V, since epenthesis is the favored stem-level method of complex coda repair. There appears to be no evidence, however, for a ranking of MAX-C with respect to the constraints against complex codas. Such a ranking, however, IS FORCED if we are to maintain the constraint promotion hypothesis, laid out in (32). This is where our assumption, made explicit above, that maintenance of consistency with the constraint promotion hypothesis can constitute evidence in favor of abandoning the default MARKEDNESS>>FAITHFULNESS ranking, becomes important. The precise reasoning behind the claim that MAX-C must dominate the complex coda constraints in order to maintain the constraint promotion hypothesis will become clear in the section that follows.

5.3.2 Word-level constraint hierarchy

The final word-level constraint hierarchy is given in (66) with an outline of the constraints promoted from the stem-level to the word-level given in (67).

(66) Final word-level constraint hierarchy

Max-V   *ʔ$_\sigma$]   Dep-V
| / \ |
Deletion   Max-C
|
*ʕC$_\sigma$]
|
*CC$_\sigma$]
|
*VStop
|
*Spir
|
Id[cont]
|
*Stop

(67) Constraints promoted from stem to word level

a. Max-V (due to non-deletion of vowels at word-level)
b. *ʔ$_\sigma$] (due to laryngeal deletion at word-level)
c. Dep-V (due to fact that ʔ$_\sigma$] sequences are repaired by way of deletion rather than by way of epenthesis)

As shown in (67), Max-V is promoted at the word-level, due to the fact that vowel deletion cannot go forward at this stratum (since the to-be-deleted vowels must not be deleted until the postlexical level, in order to preserve spirantization of following stops, e.g. *bixθov*). *ʔ$_\sigma$] is also promoted at this stratum, since laryngeal deletion occurs at the word level. The issue of laryngeal deletion brings us to the status of Max-C and Dep-V. Since ʔ$_\sigma$] sequences are repaired at the word-level by way of deletion, Dep-V must be promoted from the stem-level to the word-level, crucially above Max-C. This brings us back to the matter of complex codas, which go unrepaired when encountered at the word level (which accounts for lack of epenthesis with certain verbal suffixes, and lack of epenthesis with 2fs epenthesis, see discussion above). This being the case, not only Dep-V must dominate these constraints (by virtue of the constraint promotion hypothesis), but Max-C must also crucially dominate these constraints (otherwise the complex codas could be repaired at this level by deletion). This is where the assumption that Max-C>>*ʕC$_\sigma$] at the stem-level is important. If this is the case, then nothing happens with Max-C at the word-level; it simply becomes dominated by Dep-V by virtue of Dep-V's promotion. If, however, Max-C is unranked with respect to the complex coda constraints at the stem-level, then it must somehow come to dominate these constraints at the word-level, while at the same time becoming dominated itself by DEP-V (in order that $ʔ_\sigma]$ sequences be repaired by deletion rather than by epenthesis). Such a reranking from one stratum to the next would obviously be inconsistent with the constraint promotion hypothesis. If we are to maintain it, then MAX-C must dominate the complex coda constraints at the stem-level, as proposed above. It is for reasons like this that consistency with the constraint promotion hypothesis must be able to be motivation for abandonment of the default MARKEDNESS>>FAITHFULNESS ranking otherwise mandated by the negative evidence hypothesis.

5.3.3 Phrase-level constraint hierarchy

The final phrase-level constraint hierarchy is given in (68). On the view that spirantization is not only a phrase-level, but also a word-level and stem-level process (by virtue of the negative evidence hypothesis in (33)), then there are no changes in the relative ranking of constraints from the word-level to the phrase-level. As mentioned above, however, this is not necessarily the case, and the rankings generating spirantization could be different at the stem and word levels. Simply put, while spirantization can, but need not necessarily be a stem and word-level process, it MUST be a phrase-level process, as Dresher (1994) has shown.

(68) Final phrase-level constraint hierarchy

```
MAX-V      *ʔσ]     DEP-V
  |         / \       |
DELETION            MAX-C
                      |
                    *ʕCσ]
                      |
                    *CCσ]
                      |
                    *VSTOP
                      |
                    *SPIR
                      |
                   ID[CONT]
                      |
                    *STOP
```

5.3.4 Postlexical constraint hierarchy

The final complete constraint hierarchy at the postlexical stratum is given in (69), with the constraints promoted from the phrase-level to the postlexical level outlined in (70).

(69) Final postlexical constraint hierarchy

```
                    *ʔσ]   *ʕCσ],MAX-C   ID[CONT]
                    / \          |
   DELETION                    DEP-V
      |                          |
   MAX-V                       *CCσ]
                                 |              /
                              *VSTOP
                                 |
                               *SPIR
                                 |
                               *STOP
```

(70) Constraints promoted from phrase-level to postlexical level

a. Max-C (due to postvocalic epenthesis)
b. *ʕC$_\sigma$] (due to postvocalic epenthesis (only with ʕC$_\sigma$] sequences))
c. *ʔ$_\sigma$]>>Deletion subhierarchy (due to postvocalic deletion)
d. Id[cont] (due to lack of postlexical spirantization)

There is nothing too surprising about the postlexical rerankings in light of the discussions above; they are generally consistent with the constraint promotion hypothesis.[38] This discussion of the constraint rankings at the various strata has hopefully shown how the whole system fits together, while at the same time serving as a preliminary empirical test of the constraint promotion hypothesis.

5.4 Outstanding issues in the stratal OT account

Although the account developed above has attempted to accommodate more interactions between spirantization and relevant phenomena than any other OT account of the TH spirantization facts than I am aware of, there are still some serious outstanding issues that could not be considered in the context of the present discussion, but which bear on the analysis and merit consideration. Among the relevant outstanding issues are those in (71).

(71) Important outstanding issues

a. Interaction or not of vowel reduction and vowel deletion
b. Formalization of vowel deletion
c. Stress (especially the stress/epenthesis interaction in the segholates, e.g. /malk/→[mélex])

[38]The one apparent exception to this is the relationship of *ʔ$_\sigma$] and Deletion. We have been assuming that *ʔ$_\sigma$] outranks Deletion due to the fact that generally vowel deletion is blocked when the vowel targeted for deletion is preceded by a laryngeal (not only laryngeals, but presumably pharyngeals as well, which I haven't considered here). As Idsardi (1998:45) notes, however, this generalization is not without exceptions (e.g. /ya+ʔakal/→[yo:xál] 'eat 3ms impf'). Furthermore, I have not even touched the surface of an OT analysis of vowel deletion in the present paper. Thus, two investigations are needed prior to really taking *ʔ$_\sigma$]>>Deletion at the postlexical level as counterevidence to the constraint promotion hypothesis: (i) a more thorough understanding of the (apparent?) exceptions to non-deletion in the environment of laryngeals, and (ii) a thorough OT analysis of TH vowel deletion and reduction.

d. Are there as many 'depths' of opacity in TH phonology as predicted by the current account?
e. Vacuous DY derivations at stem-level
(e.g. /katob/→kaθov→li+kaθov→[lixtov])

On the descriptive side, the formalization of vowel deletion in OT and the relationship of vowel deletion and vowel reduction within an OT context is perhaps the most urgent, as vowel deletion interacts directly with spirantization. The nature of TH stress within OT, and by implication TH metrical structure, is also in need of examination, since it is potentially related to the reduction and deletion phenomena. What is really needed, then, on the descriptive side, is a comprehensive metrical analysis of TH within stratal OT.

On the more theoretical side, (71e) is of particular interest. This issue is illustrated by the tableaux in (58), where our assumption that spirantization is active everywhere except at the postlexical level (since it can be), forces what McCarthy (1999b:2) calls a vacuous Duke-of-York derivation,[39] since a stop is spirantized on the first cycle of the stem-level phonology, only to be despirantized after vowel deletion (which is caused by prefixation of the imperfective prefix). The OT constraint hierarchy gives this result since, due to the context-sensitive markedness constraint *VSTOP and its ranking above *SPIR, spirantization is motivated ONLY FOLLOWING VOWELS. At levels where *VSTOP and *SPIR dominate ID[CONT], spirantization cannot only go forward, but can also be undone if the vowel originally motivating spirantization is deleted (due to e.g. prefixation). If we take the DY derivation to be a negative result, there are a couple of possible solutions. The first solution would be a reanalysis of the morphology of TH prefixes, assuming, perhaps an analysis whereby prefixation is templatic, taking place prior to the operation of any phonology. Such a view, as discussed above, would apparently leave us with less motivation for stem-level phonology in TH, other than the claim that such a level is universal. A second possible solution would be to abandon our assumption that all processes are 'active' unless there exists positive negative evidence to the contrary. On this view, we might simply assume that spirantization IS NOT a stem level process, as we had assumed. This issue is in need of further study, and would perhaps be best considered in the context of a larger examination of the theoretical assumptions and motivations of stratal OT.

6 Discussion

6.1 Thoughts on parallelism vs. strata

Ideally the stratal OT analysis of TH spirantization would be compared to a comparable parallel OT account. Unfortunately, however, all of the analyses of TH spirantization in the parallel OT literature to date have focused only on subsets of the larger analysis developed above. So, for example, McCarthy (1999a) examined epenthesis/laryngeal deletion interaction as due to sympathy (although not considering these processes within the context of TH spirantization—this was not the focus of the article).

Benua (1997:chapter 4) has suggested that the opaque interaction of spirantization and vowel deletion in forms such as *bixθo:v* 'when writing' (in our analysis due to spirantization

[39] See also Pullum (1976), on whose work McCarthy (1999b) draws.

at levels prior to postlexical deletion) should also be analyzed as due to sympathy, since in Benua's (1997:139) words "...opacity is not driven by paradigmatic identity. Opaque spirantization cannot be understood as an effort to maintain identity between morphologically-related words because opacity effects are not consistent across any kind of morphological paradigm." McCarthy (1999b:8), however, has argued that overapplication of spirantization in forms such as these SHOULD be analyzed as "...faithfulness to the free-standing word *kəθo:v* 'writing' through the output-ouput constraint IDENT[CONT]," and by way of distinct OO-faithfulness constraints, such as are needed for e.g. a level 1 vs. level 2 distinction in English. Neither McCarthy (1999b) nor Benua (1997), however, develops a formal analysis to support their claims, so it is difficult to compare the two possible analyses. The analysis of such phenomena in stratal OT has been made explicit above. Further work in the parallel literature should be carried out, with a focus on comparison (i) between the two possible analyses suggested by McCarthy and Benua, and (ii) between whatever parallel account can be developed and the stratal OT account.

Underapplication of spirantization with postvocalic epenthesis is argued by Benua (1995, 1997) to be due to output-to-output faithfulness. Idsardi (1998:66-69) offers a relatively detailed criticism of this proposal. I simply note here that regardless of the merits/detractions of this proposal, it is a proposal to account only for a subset of the data. I.e., as Benua herself notes, paradigm uniformity is not the source of opaque spirantization in TH.

Finally, it is unclear how parallel OT would deal with the phrasal nature of spirantization. Phrasal phenomena are naturally accommodated in the stratal approach by way of the introduction of a phrasal stratum. In the parallel context, however, the situation is not so straight-forward. It is noteworthy that the motivation for this stratum, in the stratal OT account, is fundamentally non-morphological (in contrast to the type of evidence typically taken in favor of level-ordering). This fact, that the operation of TH spirantization cannot be reduced entirely to morphological interaction combined with the fact that its domain of application is NEITHER SOLELY THE WORD NOR PERVASIVE ACROSS WORD BOUNDARIES, would seem to suggest that there is at present no mechanism in parallel OT to deal with this sort of phenomenon. Of course, these phenomena could also be dealt with in 'parallel' OT by way of a separate phrasal phonology. Such a move, however, would seem to amount to an abandonment of the parallel architecture anyway. Once such a move is made, it would seem to make sense, in the interest of providing a unified analysis, to account for opacity effects by way of independently motivated strata as well (since the introduction of a phrasal phonology in the context of parallel OT amounts, at a certain level, to the introduction of strata anyway, as Kiparsky (p.c.) has noted).

6.2 A few thoughts on stratal OT and 'opacity capacity'

In a recent discussion of opacity in OT, Idsardi (2000:346) makes a brief comment on the inability of opacity to be accounted for within a level-ordered OT, since "...the levels must be empirically motivated, and not all opacity can be reduced to well-motivated level-ordering." Idsardi cites as evidence for his claim epenthesis, umlaut, lowering interaction in TH (e.g. /zarʕ/→[zéraʕ] 'seed'), which he claims are all postlexical, and for which "[a]ny postulation of level-ordering...would be entirely ad-hoc." Although a full formal analysis of epenthesis, umlaut, lowering interaction is obviously well beyond the scope of the present paper, there are two issues that seem worth touching on, especially in light of Idsardi's claims, since if he is correct, whether or not stratal OT can handle TH spirantization is irrelevant, since (on his view), it cannot handle epenthesis, umlaut, lowering interaction.

6.2.1 On the term 'postlexical'

I believe Idsardi's conclusion that epenthesis, umlaut, lowering interaction cannot be accounted for by a level-ordered OT since these processes are, following Dresher (1983) 'postlexical' may stem from some terminological confusion. In particular, I think that it very important to point out that 'postlexical' in the present context is perhaps quite different from 'postlexical' in the traditional lexical phonology context within which Dresher (1983) was making his arguments.

Without going into a full-scale exegesis of Dresher's (1983) findings (which is also beyond the scope of the present paper), it appears as though at least one source of confusion might be the conflation of phrasal phonology (or perhaps even a level above this, e.g. utterance phonology, another issue I won't go into here) with postlexical phonology, a move that does not seem supported by Dresher's later work (e.g. Dresher 1994). Dresher's (1983) conclusion that much of TH phonology is postlexical is based upon the observation (not original to Dresher) that words behave differently according to their position in the hierarchical prosodic structure. In particular, 'pausal' forms often have certain vowels lengthened, thereby causing vowel deletion to be bled. This does not happen with 'contextual' forms, forms I understand not to be marked by a disjunctive accent (see discussion above). This leads Dresher (1983) to conclude that a word's position within the phrase must be available to the phonology quite 'early' in the derivation. What I believe the analysis offered above would suggest, however, is that the vowel lengthening process that bleeds vowel deletion in pausal forms may be a phrasal process (or perhaps a process taking place at an additional stratum motivated by the prosodic organization of TH). Phrase-level lengthening then (assuming it to be phrase-level rather than e.g. possibly utterance-level, for the sake of discussion), which crucially must make reference to prosodic position, will bleed postlexical deletion (which has been discussed above). The contextual forms, however, also by virtue of their position in the prosodic hierarchy will fail to undergo phrasal lengthening, and postlexical vowel deletion will therefore go through as normal.

Obviously much remains to be worked out, and it is not entirely clear if the phrasal stratum is the proper one at which to calculate the 'pausal' phenomena. The point I hope to have made, however, is that 'postlexical' as it is understood in the present context crucially cannot include the phrasal phenomena discussed by Dresher (1994) or likely the 'pausal' phenomena outlined by Dresher (1983), since these make reference to specific positions within the prosodic hierarchy. 'Postlexical' in the present context is reserved for phenomena THAT ARE NOT SENSITIVE TO HIERARCHICAL PROSODIC POSITION.

6.2.2 A brief note on epenthesis, umlaut, lowering interaction

The epenthesis, umlaut, lowering interaction in TH, briefly, is as follows. Epenthesis occurs to break up complex codas (as seen above). This epenthesis, in turn, feeds an umlaut rule, formulated by Idsardi (2000:339, (3)) as in (72).

(72) TH umlaut
a→e/_ Ce within a foot

The opaque interaction is between umlaut and lowering, a rule that lowers epenthetic vowels preceding coda laryngeals. These interactions are illustrated by the derivation in (73) (Idsardi 2000:340, (5)), with stress left unconsidered.

(73) Epenthesis, umlaut, lowering interaction

UR	/zarʕ/
epenthesis	zarʕ
umlaut	zereʕ
lowering	zeraʕ
SR	[zeraʕ]

In the present context, I believe that the misunderstanding stems from the failure to observe two separate types of epenthesis, which were discussed above—epenthesis at the stem level and epenthesis at the postlexical level. The type of epenthesis in (73), under the present analysis, can't be anything but epenthesis of the stem-level variety. Indeed, it would be impossible, under the analysis presented above, to claim that epenthesis was blocked at the stem-level for the form in (73), since all forms at one time or another must cycle through ALL OF THE STRATA.[40] Given this state of affairs, under the stem-level constraint ranking proposed above, the stem-level input /zarʕ/ cannot in any way avoid epenthesis at this stratum, due to the high-ranking of $^*CC_\sigma]$. Lowering, for its part, will have to be postlexical, since there is also a variety of postlexical epenthesis (2fs epenthesis above), and since lowering also occurs with these types of epenthetic vowels (a general fact about epenthetic vowels following laryngeals, cf. /ʃamaʕ-t/→[ʃamaʕát] 'hear 2FS PERF'). This leaves us with the status of umlaut, which interacts opaquely with lowering (a counterbleeding relationship). The architecture of the theory, coupled with the analysis outlined above (and the few comments offered in the present section) predicts that umlaut is either a stem, word, or phrasal process. It crucially cannot be, however, postlexical, since it interacts opaquely with lowering. If this is the case, then the stratal OT account generates such interaction without any problems.

The source of the confusion over the interaction of these processes may have to do with the failure to understand that under stratal OT, 'processes' may take place at more than one stratum by the very logic of the architecture. While on the surface this may seem akin to positing two or more rules with different orderings in a rule-based approach, it is actually quite different, since 'processes' are derived in stratal OT from constraint interaction, and since all of the constraints must be present at all of the strata (on the assumption that all constraints are universal). This leads to a situation whereby a process either goes forward,

[40] So, an interesting prediction we can derive from this is that if there were a monomorphemic stem (say, of the segholate noun class) such as the hypothetical /meʕt/, with the final two consonants identical to those in /ʃamaʕ+t/, the final 't' in the hypothetical form would, under this analysis, HAVE TO SURFACE SPIRANTIZED, since the entire stem goes through the stem-level phonology, and would undergo epenthesis at this level, and therefore spirantization also at this level. This contrasts with the spirantization epenthesis interaction with the polymorphemic 2FS PERF verbs, in the context where affixation creates illicit $ʕC_\sigma]$ sequences, e.g. /ʃamaʕ+t/→[ʃamaʕát] 'hear 2FS PERF.' In such forms, the 2FS PERF affix -t is crucially affixed at the word level, subsequent to stem-level epenthesis, as discussed above.

or is blocked at each stratum. This logic is somewhat different from the logic of rules, where it is not necessarily the case that rules are either active or inactive prior to each other rule posited in the language (which would be the analogous statement). Idsardi's assumption seems to be that epenthesis, being postlexical, must be only postlexical (an invalid conclusion under stratal OT). Since it is postlexical, and necessarily precedes the other two processes, they too must be postlexical. As has been argued above, however, this is not necessarily the case, since epenthesis is both stem-level and postlexical in TH.

7 Concluding remarks

In sum, I have taken a significant portion of Idsardi's (1998) discussion of TH spirantization as a point of departure for an account of these facts within a stratal organization of optimality theory. Although the account is somewhat preliminary (viz., e.g. the formulation of vowel deletion), I hope to have shown that by appealing to strata that are independently motivated on the basis of phonology/morphology interactions and on the basis of phonological sensitivity to prosodic organization that the opacity effects related to spirantization can be naturally accommodated in an OT phonology. The examination has highlighted several interesting areas in need of future research, both in optimality theory in general (e.g. TH metrical structure) and in stratal OT in particular (e.g. the status of vacuous Duke-of-York derivations, the constraint promotion hypothesis, the negative evidence hypothesis, and the relationship between the two in a theory of acquisition in stratal OT). In addition to the pursuit of these issues, it is hoped that further research will be carried out on TH spirantization in the parallel literature in order to facilitate better theoretical comparison.

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