# Contrast and Redundancy in OT

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## 1. Introduction

In pre-OT generative phonology, issues of contrast, redundancy, and underspecification represented active research areas for many years. For example, Stanley (1967) argues that it is arbitrary which feature is left blank in lexical entries in cases in which there is a mutual implication between two features [+f] and [+g] in some environment. He suggests that fully specified lexical entries avoid this arbitrariness. Stanley also argues that underspecified representations are problematic, and that redundant features should be included in underlying forms. However, following Kiparsky (1981, 1985), underspecification and omission of redundant features again became the norm in phonological representations. With the advent of Optimality Theory, redundancy and underspecification have, once again, largely faded from view. Little, if any, attention is paid to the issue of redundant features in current discussions in OT. The purpose of this paper is to show that, as a consequence of the OT tenets of Richness of the Base and Lexicon Optimization, apparently redundant features will be specified in optimal lexical representations. We illustrate this by considering the treatment of voicing and aspiration in both Swedish and Turkish. In each case, features which, in pre-OT accounts, were excluded from underlying representations are shown to be required in underlying forms in OT.

## 2. Swedish laryngeal features

In many Germanic languages, there are aspirated stops and voiced stops. For example, in German there is a two-way stop contrast. In word-initial position, stops are voiceless aspirated or voiceless unaspirated (except when a preceding word ends in a voiced sound). In intervocalic

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position, however, stops are usually either voiced or aspirated. In syllable-final position, only voiceless stops are found (see Jessen 1998 and sources cited therein). Such a system is strikingly different from those found in the Romance and Slavic languages, where there is no aspiration, and where word-initial stops are consistently prevoiced. Many have argued that the contrasting feature in German is [spread glottis] ([spread]) or [tense], whereas the feature of contrast in Romance languages and Slavic languages is [voice] (Kloeke 1982, Anderson and Ewen 1987, Iverson and Salmons 1995, Jessen 1998, Jessen and Ringen 2002).

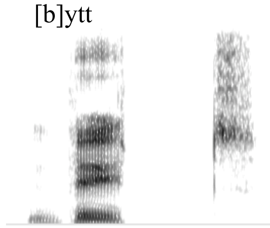
Although much of the available literature leaves the impression that Swedish stops are essentially like German stops, with the feature of contrast being [spread], Swedish is actually strikingly different from German. Initial stops are consistently prevoiced or voiceless aspirated;[1] fully voiced stops also occur intervocalically, in word-internal clusters, and word-finally (Ringen and Helgason 2002, to appear). Data illustrating the word-initial contrast in stops are shown in (1); initial voiced stops are pictured in (2).

(1)

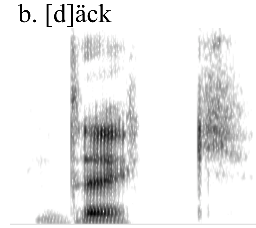
| | | | | | |
|---|---|---|---|---|---|
| [$p^h$]uck | 'puck' | [$t^h$]ak | 'roof' | [$k^h$]ub | 'cube' |
| [$p^h$]acka | 'pack' | [$t^h$]ub | 'tube' | [$k^h$]apa | 'capture' |
| [b]ytt | 'changed (p.p.)' | [d]äck | 'deck' | [g]ap | 'mouth' |
| [b]ad | 'bath' | [d]agg | 'dew' | [g]ubbe | 'old man' |

(2) Prevoicing of word-initial voiced stops

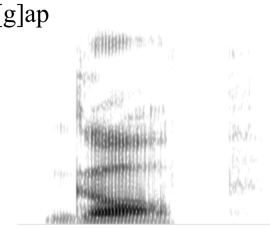
a. [b]ytt



b. [d]äck



c. [g]ap



Note that the prevoicing here is consistent across all three major places of articulation.

[1] These findings differ from those of Keating, Linker and Huffman (1983), who found no closure voicing on initial /b,d,g/.

Two examples of voiced stops in final position are shown in (3).

(3) Word-final voiced stops

a. ku[b] b. la[g]

Now consider an OT account of the Swedish word-initial facts.[2] We assume throughout this discussion that the feature [spread] is privative. However, since the status of [voice] as privative or binary is controversial, we consider both possibilities in turn. First assume that [voice] is a binary feature, as recently argued by Wetzels and Mascaró (2001) and Rubach (1996). If voiced stops are specified on the surface as [+voice] and aspirated stops as [spread], it might appear that a faithfulness constraint IDENT[Laryngeal], ranked above the markedness constraints prohibiting voiced obstruents (*voi) and spread glottis segments (*sg), would be sufficient. The relevant constraints are listed in (4).

(4) **IDENT[Lar]** An input segment and its output correspondent must have identical specifications for laryngeal features.

***sg** Segments specified as [spread] are prohibited.

***voi** [–son] segments specified as [(+)voice] are prohibited.

(We also assume an undominated constraint *voi/sg which prohibits segments specified for both [voice] and [spread]. We omit this constraint from the tableaux.) However, this set of constraints, when applied to Swedish, leads to an unattested three-way contrast in surface forms, as shown in the tableaux in (5).

(5)

| /t/ak | IDENT | *sg | *voi |
|---|---|---|---|
| ☞ tak | | | |
| dak | *! | | * |
| t$^{[sg]}$ak | *! | * | |

| /d/äck | IDENT | *sg | *voi |
|---|---|---|---|
| täck | *! | | |
| t$^{[sg]}$äck | **! | * | |
| d$^{[sg]}$äck | *! | * | * |
| ☞ däck | | | * |

[2] For an OT analysis of the behavior of stops in clusters, see Ringen and Helgason (to appear).

(5) *continued*

| /$t^{sg}$/ak | IDENT | *sg | *voi |
|---|---|---|---|
| tak | *! | | |
| dak | **! | | * |
| ☞ $t^{[sg]}$ak | | * | |

In order to derive the actual two-way contrast here, some constraint requiring that voiceless stops be [spread] must be present in the grammar, crucially dominating IDENT[Lar].

(6) **[-voi] is [spread]** A voiceless stop must be [spread].

As we see below in (7), this grammar designates the voiced stop output as optimal for [-voice], nonspread inputs, while voiceless [spread] inputs map to aspirated stop outputs.

(7) Input voiceless non-spread stops → Output voiced stops

| /t/äck | [-voi] is [sg] | ID | *sg | *voi | /$t^{sg}$/ak | [-voi] is [sg] | ID | *sg | *voi |
|---|---|---|---|---|---|---|---|---|---|
| täck | *! | | | | tak | *! | * | | |
| ☞ däck | | * | | * | dak | | *!* | | * |
| $t^{[sg]}$äck | | * | *! | | ☞$t^{[sg]}$ak | | | * | |

These constraints are sufficient to generate the correct surface distribution of [voice] and [spread]. (Note that the analysis of an input stop specified as [+voice], as in (5) above, is unaltered by the addition of the new constraint in (6).) Which of the three distinct inputs under consideration here are actually adopted in underlying representations? Since, at least in word-initial position, the surface specification of [spread] is predictable from the surface specification for [voice], it might seem that it is not necessary to ever have [spread] in the input—as in Lombardi (1999) and, apparently Wetzels and Mascaró (2001), where aspiration is disregarded completely.

However, simply omitting [spread] from consideration on inputs is not consistent with one of the basic hypotheses of Optimality Theory, Richness of the Base (ROTB; Prince and Smolensky 1993/2002). ROTB asserts that there are no language-specific limitations on the structure of input representations. Any input that meets universal well-formedness criteria (i.e., is admitted by Gen) is a possible input to the grammar of a language; it is the task of the language's grammar, by means of constraint ranking, to map any input onto a well-formed output. Thus, our grammar of Swedish, as in (7), must contend with an input stop which is [-voice], with no [spread] specification, as well as one which is specified with both [-voice] and [spread]—and it does so, mapping both onto actual surface forms.

Possible inputs and actual underlying representations are not one and the same, however. While the grammar is responsible for ensuring that all possible inputs map onto actually attested surface forms, this does not entail that speakers will posit the full range of possible inputs in their lexical entries. When faced with multiple inputs that map onto a single well-formed output, and when there is no evidence from overt alternations, Lexicon Optimization (Prince and Smolensky 1993/2002; c.f. Stampe 1973) provides a strategy that the language learner may use to resolve this indeterminacy. Lexicon Optimization favors the underlying representation that provides the most harmonic mapping from input to optimal output form.

Here, Lexicon Optimization chooses the input with [+voice] specified as the optimal lexical representation for a voiced stop output form, because this input yields the most faithful mapping to the actual output form. This is shown in the tableau des tableaux (Itô, Mester and Padgett 1995) in (8).

(8) Tableau des tableaux (Itô, Mester and Padgett 1995)

| Input | Output | [-voi] is [sg] | ID | *sg | *voi |
|---|---|---|---|---|---|
| /tak/ | $t^{[sg]}$ak | | *! | * | |
| ☞ /$t^{sg}$ak/ | $t^{[sg]}$ak | | | * | |

In the case of voiceless aspirated stops, only one input, namely a [-voice, spread] input, will correctly map to the desired output form. Hence, under this grammar, features that have been thought of as redundant will, by Lexicon Optimization, necessarily be present in the lexical representation. As we can see, if we are to take Lexicon Optimization seriously, redundant features cannot be ignored in either surface or underlying representations.

It might be argued that the specifications of [voice] or [spread] are the result of *phonetic* processes, and that the underlying forms are specified as only [+voice] and [-voice], or as only [spread] and no laryngeal feature. Consider first the possibility that only [voice] is specified in lexical representations: Since the feature [spread] is clearly a phonological feature that is active in some two-way laryngeal systems (German, Icelandic), if it is not present in output of the Swedish phonology, it must be excluded by high-ranking *sg, as shown in the tableaux in (9):

(9)

| /t/ak | *sg | ID | *voi |
|---|---|---|---|
| ☞ tak | | | |
| dak | | *! | * |
| $t^{[sg]}$ak | *! | * | |

| /d/äck | *sg | ID | *voi |
|---|---|---|---|
| täck | | *! | |
| $t^{[sg]}$äck | | **! | |
| $d^{[sg]}$äck | *! | * | * |
| ☞ däck | | | * |

(9) *continued*

| /$t^{sg}$/ak | *sg | Id | *voi |
|---|---|---|---|
| ☞tak | | * | |
| dak | | **! | * |
| $t^{[sg]}$ak | *! | | |

(We consider the possibility of an input with a [spread] stop because ROTB demands that all possible inputs map onto legitimate outputs. Given Lexicon Optimization and this grammar, the [spread] input will never be selected as the lexical representation for an output voiceless unaspirated stop.)

Since there are no initial voiceless unaspirated stops, the phonetic process in question must require that [-voice] stops be [spread]. This means that the constraint "[-voi] is [spread]" is, on such an account, phonetic. This leads to the question of whether such a constraint is reasonably treated as phonetic.

Our conception of the difference between phonology and phonetics is that phonology accounts for the categorical aspects of sound structure and that phonetics accounts for the gradient and variable aspects of the actual implementation of the sound structure (Cohn 1993; Keating 1988, 1990). Examples of aspects of the sound system that are appropriately attributable to phonetics are the gradient nasalization of a vowel that occurs as a consequence of an adjacent nasal consonant in English (Cohn 1993) or the variable voicing that occurs with German non-spread glottis stops between sonorants (Jessen and Ringen 2002). Hence we conclude that this analysis avoids the specification of both [voice] and [spread] in underlying forms at the price of forcing a phonological constraint into the phonetics. The response to this might be that the realization of [spread] as aspiration is variable: stressed [spread] stops are more heavily aspirated than unstressed [spread] stops. However, this is the *phonetic* realization of the feature [spread], which is variable and appropriately in the phonetics, *not the specification of which stops are [spread]*.

Consider, then, the alternative that [spread], but not [voice], is present in the underlying representation, with [voice] resulting from a phonetic process. Since the feature [voice] is clearly a phonological feature that is active in some two-way laryngeal systems (Russian, French), if it is not present in the output of the Swedish phonology, the markedness constraint *voi must be high-ranked in the grammar. Consider the tableaux in (10).[3]

[3] Just as in (9) above, ROTB demands that we consider all three possible input specifications. Here, an input [+voice] stop will always map onto a voiceless unaspirated output; in such a case, Lexicon Optimization favors an underlying form

(10)

| /tak/ | *voi | Id | *sg | /t$^{sg}$ak/ | *voi | Id | *sg |
|---|---|---|---|---|---|---|---|
| ☞ tak | | | | tak | | *! | |
| dak | *! | * | | dak | | *!* | * |
| t$^{[sg]}$ak | | *! | * | ☞ t$^{[sg]}$ak | | | * |

Again, this results in phonetically inaccurate output forms (voiceless unaspirated stops), but we might hypothesize that there is a phonetic process requiring that non-spread glottis stops be voiced. Assuming that in the phonetics, both values of all features are available, we would need a constraint stating that [-spread] segments are [+voice]. However, while passive voicing (as in German, where non-spread glottis stops are voiced in voiced environments) has all the hallmarks of a phonetic constraint, the context-free voicing of [-spread] segments is a different matter entirely and has no *phonetic* motivation. Passive voice occurs without any *active* voicing gestures when non-[spread] stops occur between voiced sounds (Westbury 1983, Westbury and Keating 1986). As shown in Jessen and Ringen (2002), passive voicing in German varies according to speaker gender and stop place of articulation. Even more variability of passive voicing is found in Austrian German (Moosmüller and Ringen 2003).

Summarizing at this point, we have argued that if [voice] is binary, the Swedish facts are best accounted for by assuming that both [voice] and [spread] are present in underlying (and surface) forms.

Consider now the alternative that [voice] is privative.[4] If we assume that both privative [spread] and privative [voice] are present in Swedish, then, as with the account with binary voice, an unattested three-way contrast is predicted, because a possible input is one with no laryngeal specification at all, as shown in (11).

(11)

| /t/ak | Id | *voi | *sg | /d/äck | Id | *voi | *sg |
|---|---|---|---|---|---|---|---|
| ☞ tak | | | | täck | *! | | |
| dak | *! | * | | t$^{[sg]}$äck | *!* | | * |
| t$^{[sg]}$ak | *! | | * | d$^{[sg]}$äck | *! | * | * |
| | | | | ☞ däck | | * | |

with no laryngeal features (/t/ak). For brevity's sake, the tableaux illustrating this point, and the parallel points in (15) and (16) below, are omitted.

[4] Wetzels and Mascaró (2001) use Swedish voice assimilation as one argument against Lombardi's (1999) privative voice OT account of voice assimilation, suggesting that, in Swedish, [-voice] spreads. However, Wetzels and Mascaró (as well as Lombardi) ignore the possibility that the apparent bidirectional spreading of voicelessness in Swedish results from the spreading of the feature [spread].

(11) *continued*

| /t^sg/ak | Id | *voi | *sg |
|---|---|---|---|
| tak | *! | | |
| dak | *!* | * | |
| ☞t^[sg]ak | | | * |

In order to derive the actual two-way contrast here, a high-ranking constraint requiring that a stop be specified for some laryngeal feature is necessary. This is Specify Laryngeal, given in (12). The effects of adding Specify to the grammar are illustrated in (13).[5]

(12) **Specify[Lar]:** Stops must be specified for a laryngeal feature.

(13)

| /t/äck | Spec | Id | *sg | *voi | /d/äck | Spec | Id | *sg | *voi |
|---|---|---|---|---|---|---|---|---|---|
| [t]äck | *! | | | | [t]äck | *! | * | | |
| ☞[d]äck | | * | | * | ☞ [d]äck | | | | * |
| [t^sg] äck | | * | *! | | [t^sg]äck | | *!* | * | |

Depending on whether *sg or *voi is higher ranking, an input stop with no laryngeal specification will be either voiced or specified as [spread] in the output. We assume, arbitrarily, that *sg is ranked higher than *voi, so the optimal output for a form with no input laryngeal specification will contain a voiced obstruent.

Lexicon Optimization chooses /d/äck, with [voice] specified, as the optimal lexical representation for [däck] because this yields the most faithful mapping. This is shown in (14).

(14)

| Input | Output | Specify | Id | *sg | *voi |
|---|---|---|---|---|---|
| /t/äck | [d]äck | | *! | | * |
| ☞ /d/äck | [d]äck | | | | * |

Again, it might be argued that the specifications of [voice] or [spread] are the result of *phonetic* processes—that is, that the contrast in the Swedish stop system is underlyingly represented as [voice] vs. zero, or as [spread]

[5] The addition of Specify to the grammar predicts the existence of languages in which a single stop series is either voiced or voiceless aspirated, rather than voiceless unaspirated. As the phonetic facts of such single-series languages are not typically well-documented, this remains an important empirical issue for further research. One alternative to Specify would be to assume only input [spread] and some sort of phonetic enhancement constraint that has the effect of maximizing the laryngeal contrast; see Avery and Idsardi (2001).

vs. zero. Consider first the possibility that only [voice] is specified in the underlying form: As before, since the feature [spread] is clearly a phonological feature that is active in some two-way laryngeal systems, if it is not present in the output of the Swedish phonology, it must be excluded by high-ranking *sg. That is, the ranking in (15) must obtain.

(15)

| /t/ak | *sg | Id | *voi | /d/äck | *sg | Id | *voi |
|---|---|---|---|---|---|---|---|
| ☞ tak | | | | täck | | *! | |
| dak | | *! | * | $t^{[sg]}$äck | *! | ** | |
| $t^{[sg]}$ak | *! | * | | $d^{[sg]}$äck | *! | * | * |
| | | | | ☞ däck | | | * |

Since there are no initial voiceless unaspirated stops in Swedish, the phonetic process in question must require that the laryngeally unspecified stops be specified as [spread]. If we assume that both values of the privative features are available in the phonetics, then the necessary constraint will be "[-voi] is [spread]." As we suggested above, this constraint is not easily seen as *phonetic*. And since we are assuming that, in the phonology, [voice] is privative, this is not a possible phonological constraint**,** as it refers to [-voi].

Consider next the possibility that only [spread] is specified in the underlying form. Again, since the feature [voice] is clearly a phonological feature that is active in some two-way laryngeal systems, if it is not active in the phonology of Swedish, the constraint *voi must be high-ranking, as in (16).

(16)

| /t/ak | *voi | Id | *sg | /$t^{sg}$/ak | *voi | Id | *sg |
|---|---|---|---|---|---|---|---|
| ☞ tak | | | | tak | | *! | |
| dak | *! | * | | dak | *! | ** | |
| $t^{[sg]}$ak | | *! | * | ☞ $t^{[sg]}$ak | | | * |

Once again, this results in phonetically inaccurate output forms (voiceless unaspirated stops), but we might hypothesize that there is a phonetic process requiring that non-spread glottis stops be voiced. Assuming that, in the phonetics, both values of all features are available, we would need a constraint stating that [-spread] segments are [+voice]. Again, this constraint does not appear to be a phonetic constraint. Since we assume that [voice] and [spread] are privative, it is not possible that this is a phonological constraint.

To summarize, we have seen that whether we assume privative voice or binary voice in Swedish, unless we are willing to abandon any coherent notion of phonetic constraint, we will have to have both [voice] and [spread] in input forms in Swedish. To exclude voiceless unaspirated stops, we must assume a constraint requiring that [-voi] be [spread] if it is assumed that voice is binary, or a constraint requiring that laryngeal features be specified if we assume that voice is privative.

### 3. Turkish laryngeal features

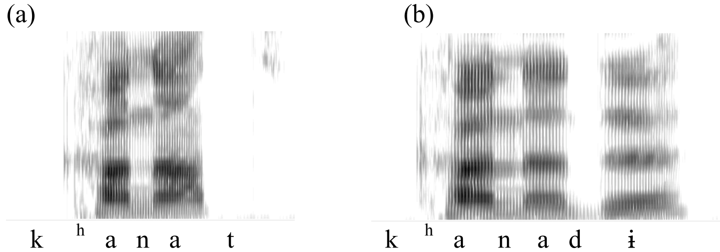
Turkish is another language which has surface aspirated stops and voiced stops, and which, we suggest, like Swedish has both [voice] and [spread] in input forms. At first glance, Turkish appears to be like German, which can be analyzed with an underlying [spread] contrast, with voicing the result of a *phonetic* passive voice constraint. However, in word-final position in Turkish, there are voiced stops that cannot be the result of phonetic passive voicing. In fact, root-final stops in Turkish exhibit a three-way difference in behavior that is neutralized to a two-way distinction in word-final position. This is illustrated in (17), and in the spectrograms in (18) through (20); data are drawn from Kallestinova (2004).[6]

(17) Turkish Word Final Stops

| | | | | |
|---|---|---|---|---|
| a. | $k^{h}$ap | 'container' | $k^{h}$abɨ | 'container-3SG. POSS.' |
| | $k^{h}$anat | 'wing' | $k^{h}$anadɨ | 'wing-ACCUS.' |
| b. | sap | 'stem' | $sap^{h}$ɨ | 'stem-ACCUS.' |
| | at | 'horse' | $at^{h}$ɨ | 'horse-3SG. POSS.' |
| c. | ad | 'name' | adɨ | 'name-3SG. POSS.' |
| | öd | 'gall' | ödü | 'gall-ACCUS.' |

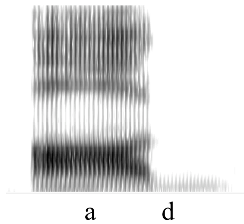
(18) Final alternating stops: (a) [$k^{h}$anat] vs. (b) [$k^{h}$anadɨ]

(a) (b)



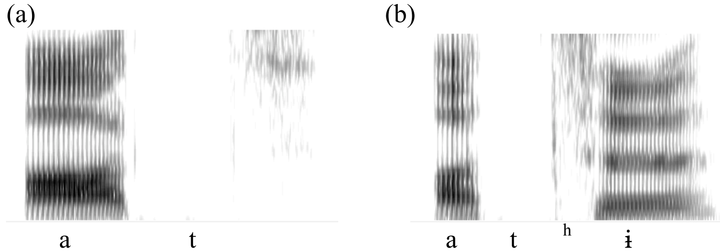

[6] Kallestinova (2004) analyzed 168 words produced by an adult male speaker from Istanbul. Our preliminary analysis of an additional six adults (3 males; 3 females; 1 male and 1 female from each of Ankara, Istanbul and Izmir) is consistent with her findings.

(19) Final nonalternating voiced stop: [ad]




(20) Final non-alternating voiceless stop: (a) [at] vs. (b) [at$^{h}$ɨ]

(a) (b)




Crucially, root-final voiceless stops in Turkish exhibit two different patterns of behavior. One group, as shown in (17a) and (18), undergoes voicing in intervocalic position; the second group is uniformly voiceless ((17c) and (20)).

Now consider the OT analysis of the Turkish facts. For the sake of illustration, we assume that [voice] is privative; however nothing in this analysis depends crucially on this point. We can straightforwardly account for the Turkish facts if we assume, following Kallestinova (2004), that the intervocalic (passive) voicing of laryngeally unspecified stops results in the voicing of underlyingly non-[spread] stops as in (17a) and (18) above. Stops that are underlyingly [spread] are always voiceless (and aspirated intervocalically), as in (17b). Stops that are always voiced, as in (17c), are straightforwardly analyzed as underlyingly specified for [voice]. Hence, Turkish, like Swedish, seems to necessitate the use of both [spread] and [voice] in underlying representations.[7] This is illustrated in (21), (22) and (23). The ranking of IDENT[Lar] above the markedness constraints results an optimal output that is identical to the input in each case. In (21), a stop underlyingly specified as [spread] retains its [spread] specification, both in word-final and word-medial positions. (We assume that a [spread] specification on a stop is realized as aspiration only before a sonorant.)

[7] See Kallestinova (2004) for a full analysis, as well as discussion of how to prevent a three-way contrast in word-initial position.

(21)

| /at$^{sg}$/+i | ID | *sg | *voi | /at$^{sg}$/ | ID | *sg | *voi |
|---|---|---|---|---|---|---|---|
| ☞ at$^{[sg]}$ɨ | | * | | ☞ at$^{[sg]}$ | | * | |
| adɨ | *!* | | * | ad | *!* | | * |
| atɨ | *! | | | at | *! | | |

A parallel result obtains in (22), where the input stop is specified as [voice]—voicing is retained in the output in both final and medial positions.

(22)

| /ad/+i | ID | *sg | *voi | /ad/ | ID | *sg | *voi |
|---|---|---|---|---|---|---|---|
| at$^{[sg]}$ɨ | *!* | * | | at$^{[sg]}$ | *!* | * | |
| ☞ adɨ | | | * | ☞ ad | | | * |
| atɨ | *! | | | at | *! | | |

In (23), the input stop is unspecified for [voice] and [spread], and remains so in the output of the phonology. The presence of voicing on the stop in intervocalic position is the result of Passive Voicing.

(23)

| ka/p/+i | ID | *sg | *voi | ka/p/ | ID | *sg | *voi |
|---|---|---|---|---|---|---|---|
| kap$^{[sg]}$ɨ | *! | * | | kap$^{[sg]}$ | *! | * | |
| kabɨ | *! | | * | kab | * | | * |
| ☞ kapɨ | | | | ☞ kap | | | |

→ *In the phonetics, PASSIVEVOICE yields [kabɨ]*

As noted above, we take passive voicing to be phonetic. However, the same result is obtained if PASSIVEVOICE is incorporated into the phonology, as assumed in Kallestinova (2004).

Inkelas (1995) (c.f. Inkelas and Orgun 1994, 1995) disregards the surface aspiration in Turkish and argues that the facts in (17) necessitate both the reformulation of Lexicon Optimization, and what amounts to ternary-valued [voice]. She suggests that the (root) final stop in (17a) is unspecified for [voice], while in (b) it is [-voice] and in (c) it is [+voice].[8] Actually, however, the principles of OT require that the aspirated stops be [spread] and the non-alternating voiced stops be [voice]. This means that a possible input with no laryngeal specification can be voiced intervocalically (by phonetic passive voicing), and voiceless elsewhere. Underlyingly

[8] Note that Inkelas's (1995) account is inconsistent with the assumption that [voice] is privative.

[spread] stops stay [spread] throughout, and those specified as [voice] remain voiced.

The Turkish example is particularly interesting because if we take seriously the OT tenets of Richness of the Base and Lexicon Optimization, we will be forced to assume both [voice] and [spread] in input representations. Once we do this, the resolution of the problem discussed in Inkelas (1995) with the apparent three-way contrast in stops receives a straightforward solution, with no revision of Lexicon Optimization and no ternary-valued [voice].

## 4. Conclusion

We have considered the implications of ROTB and LO for underlying representations in Turkish and Swedish, showing that certain features traditionally considered to be "redundant" must be included in optimal lexical representations. Once we accept the inclusion of both [spread] and [voice] in underlying representations, a novel understanding of the recalcitrant Turkish data is at hand. McCarthy (2003), who also considers the consequences of Lexicon Optimization and ROTB for the structure of underlying representations, makes a different, but related, point. He argues that ROTB and Lexicon Optimization will solve a long-standing indeterminacy in the underlying specification of final vowel length in Arabic. These studies highlight the importance of reexamining both the phonetic facts and our hidden assumptions about the nature of underlying representations.

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