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Taiwanese Tone Sandhi as Allomorph Selection

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1. Introduction

Recently there has been interest in what might be termed *Lexicalized Phrasal Phonology* (LPP), phonology that appears to apply at a phrasal level but which otherwise has lexical characteristics (Kaisse 1985, 1990, Hayes 1990, Odden 1990, Kenstowicz 1994). A debate in the literature concerns whether LPP should be considered postlexical phonology (e.g. Kaisse 1990), lexical phonology that is able to refer to phrasal information (e.g. Odden 1990), or else a sort of lexical phonology Hayes (1990) calls *precompiled*, in which the generation of allomorphs (i.e. forms of a word where a rule applies and forms where it does not) occurs lexically, whereas selection between these allomorphs for insertion into a syntactic frame occurs postlexically. In this paper we show how the analysis of Taiwanese Tone Sandhi requires separation of LPP into the two mechanisms of allomorph generation and allomorph selection, thus supporting precompilation theory over other models of LPP.

This paper is organized as follows. First, we review the characteristics of LPP and the approaches towards it that have appeared in the literature. Second, we provide evidence to show that Taiwanese Tone Sandhi is indeed a case of LPP. Finally, we argue that Taiwanese Tone Sandhi favors the dual mechanism approach offered by precompilation theory because it involves only the mechanism of allomorph selection, and not that of allomorph generation.

2. Lexicalized Phrasal Phonology

Lexicalized Phrasal Phonology is phonology that occurs within domains larger than the word (always syntactic rather than prosodic constituents) and yet displays all the hallmarks of being lexicalized, with lexical exceptions, structure-preserving alternations, and often apparent ordering before rules that are sensitive to morphology or restricted to within the word. In this section, we first explain how LPP is a problem for standard models of Lexical Phonology, and then summarize three approaches towards it that have been taken in the literature.

2.1. The Problem of Lexicalized Phrasal Phonology

The theory of Lexical Phonology distinguishes two kinds of phonological regularities: lexical rules and postlexical rules. A variety of diagnostics have been observed to distinguish these rule types in most cases. In (1) below, we list only those that are most relevant to our discussion.

(1) Lexical rules vs. Postlexical rules (e.g. Hargus and Kaisse 1993)

	LEXICAL	POSTLEXICAL
a.	word-bounded	not word-bounded
b.	may refer to morphology	cannot refer to morphology
c.	may have exceptions	automatic
d.	semi-productive	fully productive
e.	categorical	may be gradient

One outstanding problem is the existence of phonological patterns that seem to have the properties of lexical rules but at the same time apply at the phrasal or sentence level, i.e. postlexically (Kaisse 1985, 1990, Hayes 1990, Odden 1990, Kenstowicz 1994). The division of properties is not arbitrary, as indicated in the figure below; the patterns of Lexicalized Phrasal Phonology show primarily lexical characteristics, the only putatively postlexical characteristic being that they are sensitive to information beyond the word boundary. This information, however, is always of a very restricted kind, specifically syntactic structure.

(2) Characteristics of LPP

	LEXICAL	POSTLEXICAL
a.		not word-bounded: refer to syntactic structure
b.	may refer to morphology	
c.	may have exceptions	
d.	semi-productive	
e.	categorical	

For example, in Hausa (Hayes 1990) final long vowels of verbs are shortened when preceding a full NP direct object. This rule can be formalized as in (3a) with some illustrative data given in (3b).

(3) Hausa Shortening (Hayes 1990; data from Kraft and Kirk-Greene 1973)

a. $V: \rightarrow V / [\_ NP ...]_{VP}$, NP non-pronominal

b.

ná: ká:mà:		"I have caught (it)"
ná: ká:mà: ʃí		"I have caught it"
ná: ká:mà̀ kí:fí:		"I have caught a fish"

Hayes (1990:98) shows that Shortening precedes the rule of Low Tone Raising, which raises a low tone on a word-final long vowel to a high tone when it follows a low tone, as illustrated by the derivations in (4). Low Tone Raising is arguably a lexical rule because it has a number of lexical exceptions and "native speakers seem clearly aware of its effects" (this latter point being indirect evidence for semi-productivity and categoricality). Therefore, in spite of its reference to word-external (i.e. syntactic) information, Shortening must in fact be lexical.

(4) Shortening precedes Low Tone Raising:

$$L \rightarrow H / L \_ \#$$
$$\begin{array}{c} /\backslash \\ V\ V \end{array}$$

	"read"	"read X"	(X = full NP)
	ká̀rà̀ntà̀:	ká̀rà̀ntà̀: X	
Shortening	---	ká̀rà̀ntà̀ X	
Raising	ká̀rà̀ntá:	---	

2.2. Three approaches to LPP

There are three approaches to LPP that have appeared in the literature. First, some researchers treat LPP as postlexical phonology that happens to have primarily lexical characteristics (e.g. Kaisse 1985, 1990). The second approach is to treat LPP as lexical phonology, but relaxes the restriction that lexical rules can only refer to word-internal information (e.g. Odden 1990). The third approach is the precompilation theory of Hayes (1990), which posits two separate mechanisms for lexical phonology; in LPP these operate independently in an unusual but constrained fashion.

All three approaches appear overly powerful. As Hayes (1990) points out, viewing LPP as a form of postlexical phonology fails to explain why all of its characteristics are those of lexical rules, except for the fact that syntactic information may be referred to. However, viewing LPP as lexical phonology that can refer to syntactic information ignores the considerable linguistic and psycholinguistic evidence suggesting that phonological forms of words are not built simultaneously with the syntactic form of sentences (e.g. Levelt 1989). Finally, although precompilation theory does not face the problems of these other two models, it does have the apparent disadvantage of positing two separate mechanisms for lexical rules where they posit only one. Because we will be arguing in favor of this third approach, we first need to examine it a bit more closely.

The solution that Hayes (1990) proposes for dealing with the problem of LPP requires that the application of a lexical rule involves two distinct mechanisms, which for clarity we term *allomorph generation* and *allomorph selection*. Allomorph generation refers to the generation by a lexical rule of an output form. In standard lexical phonology, there will be precisely one possible output for any given input. In LPP, however, an input will have two allomorphs at the output of the lexical phonology. Allomorph selection then occurs as a part of the general mechanisms of lexical insertion, selecting the proper allomorph for a particular environment. As in standard models of lexical insertion going back to Chomsky (1965), only syntactic information is relevant at this point, which means that allomorph selection can only choose between allomorphs on the basis of syntactic criteria. Precompilation theory therefore explains both why LPP patterns show primarily lexical characteristics (allomorph generation involves true lexical rules) and why the only word-external information they may refer to is syntactic structure (allomorph selection is part of syntactically-sensitive lexical insertion).[1]

As an example, the way precompilation theory would model Hausa Shortening is illustrated in (5) and (6).
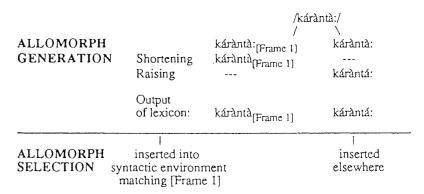
(5) Lexical representations and rules for LPP in Hausa:

LEXICON	RULES
Frame 1:	Shortening: $V: \rightarrow V / [\ldots \_]_{[Frame\ 1]}$
[_ NP ...]VP,	Tone Raising: $L \rightarrow H / L \_ \#$
NP non-pronominal	/\
	V V
/káràntà:/, ...	

(6) Two mechanisms for LPP in Hausa:

```
                                              /káràntà:/
                                            /           \
ALLOMORPH                    káràntà:[Frame 1]       káràntà:
GENERATION      Shortening   káràntà[Frame 1]          ---
                Raising          ---                  káràntá:

                Output
                of lexicon:  káràntà[Frame 1]        káràntá:
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ALLOMORPH SELECTION	inserted into syntactic environment matching [Frame 1]	inserted elsewhere

As noted above, precompilation theory seems overly complex, as it posits allomorph generation and allomorph selection as independent mechanisms. The natural rebuttal to this criticism would be the demonstration that both mechanisms are necessary and independent. The form of the demonstration would be that of a double dissociation, where all of the four logical possibilities listed in (7) would have to be found. As can be seen in this figure, the first three of these have in fact been attested. Standard postlexical phonology takes place entirely after lexical insertion, so neither lexical allomorph generation nor allomorph selection is relevant. In standard lexical phonology, allomorph generation takes place, but since only one allomorph is produced per input, nothing of relevance occurs during allomorph selection. Finally, as we've just seen, standard cases of LPP like that in Hausa involves both allomorph generation and allomorph selection.

(7) The logic of double dissociation:

Allomorph Generation	Allomorph Selection	Example
no	no	Standard postlexical phonology
yes	no	Standard lexical phonology
yes	yes	Standard LPP (e.g. Hausa)
no	yes	*Taiwanese Tone Sandhi*

The demonstration of double dissociation would therefore be complete if we had a case where allomorph selection takes place, but without the allomorphs first being generated. That is, lexical insertion would choose between allomorphs that are essentially listed in the lexicon. Limited cases of this sort abound, of course; Hayes (1990) uses English *a/an* allomorphy in his argument, and Tranel (1994) includes a discussion of suppletive forms in an analysis of French liaison. We argue that Taiwanese Tone Sandhi provides a far more dramatic example. Like standard cases of LPP, Taiwanese Tone Sandhi affects every morpheme in the lexicon. Nevertheless, we give evidence that it does not involve allomorph generation in the usual sense. Instead, the surface tone of a morpheme is simply looked up in a table based solely on the morpheme's abstract tone-class diacritic. This is the claim we argue for in the following sections.

3. Taiwanese Tone Sandhi

Morphemes in Taiwanese are overwhelmingly monosyllabic.[2] Taiwanese Tone Sandhi (henceforth TTS) refers to a tonal phenomenon where every morpheme has two alternating tones, one showing up in *juncture* position (including in citation), the other showing up in *context* position (e.g. in first position in a bisyllabic compound). The definition for the juncture/context distinction involves, as we discuss later, only syntactic factors.

Examples of the tonal alternations are given below, where the juncture forms are given in the left-hand column and the right-hand column shows the same words in context (lack of a juncture is indicated with "-"). H, M, and L stand for high, mid, and low tone levels, respectively.
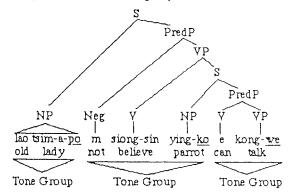
(8) Examples of TTS

Juncture Position		Context Position	
si[H]	"poetry"	si[M]-bun[LH]	"poetry and prose"
si[LH]	"time"	si[M]-kan[H]	"time span; time"
si[M]	"temple"	si[L]-tsiŋ[H]	"temple monk"
si[L]	"four"	si[HL]-tiam[HL]	"four o'clock"
si[HL]	"die"	si[H]-laŋ[LH]	"dead people"

In the remainder of this section, we address evidence showing that TTS is an example of LPP. That is, TTS refers to information beyond the word, but only syntactic information (Section 3.1), while all of its other properties are lexical (Section 3.2).
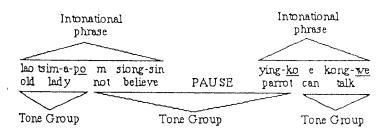
3.1. The phrasal nature of TTS

The constituent referred to by the juncture/context distinction is often called the *Tone Group*, which may be larger than a word. Chen (1987) has convincingly shown that the Tone Group is syntactically defined, rather than prosodically defined. Following up on this work, Lin (1994) shows that the boundaries of the Tone Group are defined by matching the right boundary with that of every XP (maximal projection) in an utterance, unless the XP is lexically governed (Chen 1987 had incorrectly reserved this caveat only for adjuncts). These generalizations are exemplified in (9); the underlined morphemes appear with the appropriate juncture tones, while the rest appear with context tones.

(9) Syntax and TTS Tone groups (Chen 1987:114):

Not only is TTS sensitive to syntax, but it is sensitive *only* to syntax. As illustrated in (10), TTS ignores prosodic information, such as the intonational phrases whose boundaries can be emphasized by pauses (Chen 1987:143). Thus TTS shows the first characteristic of LPP listed above in (2a).

(10)   TTS refers to syntax, not to prosody (Chen 1987)

3.2. Lexical properties of TTS

Aside from this reference to syntactic structure, all the other properties of TTS are characteristic of lexical phonology. Because of the lack of the relevant morphology in Taiwanese, there is no evidence one way or the other regarding point (2b), but there is evidence for the remaining three lexical properties listed in (2). First, TTS does not apply automatically for all forms, as there are lexical idiosyncrasies. Second, TTS is only semi-productive, which is typical of a lexical pattern. Third, TTS is categorical, as has been demonstrated using acoustic phonetic methods. We will discuss each of these points in turn.

3.2.1. Lexical idiosyncrasies

Some morphemes are lexically marked to undergo sandhi in a way that is not expected given the regular pattern. For example, the verb meaning "give" normally conforms to the standard TTS pattern, as shown in (11a). However, as shown in (11b), it may appear with an unexpected context tone when preceding certain pronouns; whether this unusual tone appears optionally or obligatorily

depends on the specific pronoun. Other verbs do not behave this way. Note that the pronouns themselves also show unexpected sandhi patterns.

(11) Lexical idiosyncrasies in TTS

a. Normal TTS

Juncture	Context	
hɔ[M] "give"	hɔ[L] kao[HL]	"give to the dog"

b. Idiosyncratic TTS

free variation
$$\begin{cases} \text{hɔ[L] gua[HL]} \\ \text{hɔ[M] gua[M]} \end{cases}$$
"give to me"

free variation
$$\begin{cases} \text{hɔ[L] li[HL]} \\ \text{hɔ[M] li[M]} \end{cases}$$
"give to you"

$$\begin{array}{l} \text{*hɔ[L] i[HL]} \\ \text{hɔ[M] i[M]} \end{array}$$
"give to him"

3.2.2. TTS is only semi-productive

Psycholinguistic and diachronic studies have shown a difference between the full productivity of postlexical phonology and the partial productivity of lexical phonology (e.g. Kiparsky 1975, 1982, 1988, Shattuck-Hufnagel 1986). It appears that TTS behaves more like lexical phonology in this regard, because the TTS alternations are at best semi-productive.

Evidence for this comes from experiments that find that native speakers do not apply TTS consistently (Hsieh 1970, 1975, 1976, Wang 1995). For example, Hsieh (1975) reports that when native speakers performed a task where they had to produce the context form of morphemes based on the given juncture form, or vice versa, they did not apply TTS correctly in all cases.

(12) Results of Hsieh (1975)

Juncture → context.		Context → juncture.	
Real morphemes	Artificial morphemes	Real morphemes	Artificial morphemes
85.0% correct	66.2% correct	96.3% correct	88.7% correct

This failure of TTS when challenged with novel forms and environments is typical of lexical phonology; English speakers correctly apply Velar Softening in *electricity*, for instance, but may not apply it consistently in a novel form such as *cubicity*. By contrast, postlexical phonology will either always apply in appropriate environments (e.g. flapping in English), or will apply at a consistent rate of probability whether or not the words are novel. Thus, in spite of the fact that the choice between juncture or context tone clearly must be made during the on-line generation of syntactic structure, the semi-productivity of TTS marks it as lexical rather than postlexical phonology.

3.2.3. TTS is categorical

Although it has been shown that lexical phonology is not always structure-preserving (see Borowsky 1993 for the most extensive summary of evidence), a weaker claim does seem to hold: lexical phonology must always be categorical. That is, phonology that has other characteristics marking it as lexical never produces phonetic output that vary gradiently along a continuum.

This phonetic claim allows us to test the assumption hidden in figures such as (8). Such figures imply that TTS is structure-preserving, since the set of context tones is a subset of the set of juncture tones, but this is only true if a phonological category like [M] is indeed realized phonetically the same way wherever it appears.

Recent acoustic phonetic studies by one of the authors has verified this assumption (Tsay and Charles-Luce, in prep). First, it was shown that the context [M] tone that is paired with the juncture [LH] is phonetically identical with the context [M] that is paired with juncture [H]. Second, juncture and context tones represented by the same categories are in fact phonetically identical, so that, for example, juncture [H] is realized the same way as context [H] (see also Lin 1988 and Peng 1993; the latter observes lowering of pitch in phrase-final and utterance-final position that appears to be due to intonation effects independent of TTS itself).

4. TTS as Allomorph Selection

So far, we have shown that TTS is LPP — it is sensitive to syntactic structure, but every other property marks it as lexical. In this section we argue that TTS involves only allomorph selection but not allomorph generation. This will demonstrate the separation of lexical phonology into these two mechanisms, and thus argue in favor of the precompilation theory of Hayes (1990) as a model of LPP. We thus provide arguments for this claim in Section 4.1, and then in Section 4.2 we show how TTS should be analyzed within precompilation theory.

4.1. Allomorphy in TTS is not generated

Unlike standard cases of LPP as exemplified by Hausa, we argue that the TTS alternations are suppletive, as would be expected if TTS does not involve allomorph generation. We provide three arguments for this claim. First, the direction of TTS alternations is indeterminate. Second, the explanatory power of TTS rules proposed in the literature is extremely limited. Finally, productivity experiments suggest that allomorph selection occurs without allomorph generation. We discuss these points in turn.

4.1.1. The direction of TTS alternations is indeterminate.

The literature on TTS contains some controversy concerning whether the juncture or context tones should be set up as underlying. While the neutralization of juncture [H] and [LH] as context [M] has lead most researchers to conclude that the direction of tone alternation in TTS is *Juncture → Context* (e.g. Cheng 1968, 1973, Yip 1980), the direction *Context → Juncture* has also been plausibly argued (e.g. Tsay 1994; see also Hashimoto 1982, Ting 1982, Ho 1984), because [H] and [LH] appear in nearly complementary onset voicing environments.

Further evidence for the direction *Context → Juncture* comes from neutralization in juncture position. This happens in TTS in so-called short tones with /ʔ/ as coda. The standard short tone TTS pattern, illustrated in (13a), is usually thought to derive from the long tone pattern (e.g. Yip 1980, Tsay 1994)

However, some speakers seem to neutralize short tones in juncture position, as shown in (13b) (Kuo, in prep).

(13) Short tones in TTS

a. Juncture		Context	
pe?[M]	"white"	pe:[L]-sá[H]	"white clothes"
pe?[L]	"eight"	pe:[HL]-tiŏ[H]	"eight pieces"

b. Juncture		Context	
pe?[M]	"white"	pe:[L]-sá[H]	"white clothes"
pe?[M]	"eight"	pe:[HL]-tiŏ[H]	"eight pieces"

Since neutralization occurs in both context and juncture positions, the direction of TTS alternations is indeterminate, so that there is no compelling reason for choosing one of the alternating tones as underlying and the other as derived.

4.1.2. The limited explanatory power of proposed TTS rules

The five (long tone) alternations of TTS are so dissimilar that it is impossible to describe them with fewer than three rules. Even such minor reduction has costs. Tsay (1994) describes the five alternations with four rules by assuming a rule that derives [LH] from underlying [H] in syllables with voiced onsets, even if the voicing is rather abstract and does not show up on the surface in all cases. Yip (1980) requires only three rules, but the analysis makes multiple violations of structure-preservation. For example, the juncture and context [M] tones are not represented the same way, leaving it a puzzle as to why they are realized identically in the phonetics, as discussed above.

(14) Violations of structure preservation in Yip (1980):

Juncture	Context
H	M
[+upper]	[-upper]
[+raised][+raised]	[+raised][+raised]
M	L
[+upper]	[-upper]
[-raised][-raised]	[+raised][-raised]

Difficulties like these have led some researchers (e.g. Hsieh 1975) simply to assume five separate rules, each applying disjunctively (disjunctive application, incidentally, is another property characteristic of lexical phonology, as noted by Kiparsky 1982). Rule formalism therefore does nothing to simplify the description of TTS.

4.1.3. Experimental evidence for allomorph selection

Recall from the results of Hsieh (1975) cited above in (12) that subjects are more accurate in applying TTS when actual morphemes are used in novel contexts than when novel (artificial) morphemes are used. The relative accuracy in the former situation implies that subjects are able to select between juncture and context

allomorphs on-line when they know what the allomorphs are. When they must derive the allomorphs themselves, as in the case of the artificial morphemes, their accuracy falls off. This suggests that in normal language processing, the mechanism of allomorph selection is actively used, while that of allomorph generation is not.

4.2. TTS within precompilation theory

Summarizing the arguments in the previous subsections, TTS demonstrates that LPP may involve allomorph selection without allomorph generation. If so, then we must adopt precompilation theory as the proper model for LPP. In this section we explain how precompilation theory would model TTS.

As illustrated in the following figures, TTS involves the syntax-sensitive allomorph selection of a sort familiar from Hausa, but there is no lexical rule that derives the allomorphs. Instead, morphemes are stored in the lexicon with an abstract diacritic indicating tone category. This diacritic is then used to determine the proper phonological values for the juncture and context tones by simply looking them up in a table.

(15) The lexicon in TTS

LEXICON	RULES
Frame 1:	NONE
[... _]XP,
XP not lexically governed

si[Tone 1], si[Tone 2], si[Tone 3], ...

ALLOTONE TABLE

| Tone 1 | Tone 2 | Tone 3 | Tone 4 | Tone 5
--- | --- | --- | --- | --- | ---
[Frame 1] | LH | H | HL | L | M
Elsewhere | M | M | H | HL | L

(16) Allomorph selection in TTS

		si[Tone1]
	si[Tone1]$_{[Frame 1]}$	si[Tone1]
Output	
of lexicon:	si[LH]	si[M]
ALLOMORPH	inserted into	inserted
SELECTION	syntactic environment	elsewhere
matching [Frame 1]

5. Conclusions

We have argued that Taiwanese Tone Sandhi is an example of Lexicalized Phrasal Phonology. Because TTS involves the mechanism of allomorph selection without the mechanism of allomorph generation, TTS must be analyzed with the dual mechanism approach of precompilation theory. Parsimony considerations thus lead to the conclusion that the proper analysis of LPP, or indeed of lexical phonology in general, requires the dual mechanism approach.

NOTES

1. Although our discussion is couched entirely in rule formalism, there is no reason to believe that the insights could not be given instead in terms of the constraint-based formalism of Optimality Theory (e.g. Prince and Smolensky 1993); see, for example, the OT analysis of the LPP phenomena of French liaison and elision by Tranel (1994). However, we feel that Lexical Phonology provides a much more clearly articulated theory of the lexicon than any yet provided within OT. In particular, OT researchers appear to have lost interest in the important discovery that lexical and postlexical processes differ in specific and systematic ways, a discovery whose fundamental correctness is only reconfirmed by a deeper examination of apparent paradoxes like LPP.

2. Taiwanese is a language in the South Min branch of the Chinese family. For the most part, our discussion refers only to the dialect of this paper's first author (Tsay), an Inland dialect spoken in the southern area of Taiwan including Chia-Yi, Tainan, and Kaohsiung counties.

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