On the importance of perceptual salience for tonology

Cathryn Donohue
Department of Linguistics, Stanford University

This paper addresses issues in motivating natural classes for tonology and in Fuzhou tone sandhi in particular. I also present new quantified data which suggests a more complex system may exist in at least this one variety of Fuzhou. Previous researchers in autosegmental frameworks have accounted for the sandhi with seemingly theory-internally motivated rules. In this paper I discuss some of the literature on perceptual salience of linguistic tone and show how the same ideas can be extended to correctly motivate the natural classes required to account for the Fuzhou tone sandhi.

0. Introduction

Fuzhou tone sandhi has been studied and analysed by a number of researchers, though none are without problems. Previous analyses of Fuzhou tone sandhi have captured the relevant natural classes with phonological features that are often very abstract and certainly phonetically opaque.I have found that there is often reference to other people's (differing) data for feature assignment justification and there is little in the way of theory external motivation for these natural classes.

In this paper I will present new data for Fuzhou tone sandhi, appropriately controlled for between-speaker differences which shows greater complexity than previously reported. I will also motivate the natural classes and actual elegance of Fuzhou tone sandhi by considering perceptual salience. I will first give an introduction to the Fuzhou citation tones, then briefly overview two leading analyses of Fuzhou tone sandhi, namely the analyses by Chan (1988) and Yip (1990). The third section presents my work: data and analysis.

1. Overview of the tonal system

Fuzhou is a Min dialect, spoken in and around Fuzhou city, NE Fujian province, China.[1] There are seven citation tones, which may be described as follows:[2]

[1] Dialects of Fuzhou spoken outside of China (in Sarawak, Malaysia for example), while recognisably Fuzhou, are significantly phonetically different from those spoken within China which is why I do not mention them here.

[2] The following impressionistic descriptions are mine and are from my own data.

Tone 1	[pa]	[˥]	high level
Tone 2	[pa̰]	[˧]	mid, slight drop, optional creaky voice
Tone 3	[pa̰]	[˨]	low, slight drop, creaky voice
Tone 4	[paʔ]	[˩˧]	low rise, "checked" syllable, creaky
Tone 5	[pa]	[˥˩]	high fall
Tone 6	[ta̰]	[˩˧˩]	low rise-fall, creaky
Tone 7	[paʔ]	[˥]	high, very short, "stopped" syllable

A reasonable amount of descriptive work has been done on Fuzhou, however the variation in what has been reported for the citation tones is enormous. A sample of the differences is shown below in table 1.[3]

Author:		Tone 1	Tone 2	Tone 3	Tone 4	Tone 5	Tone 6	Tone 7
Chan	1985	44	32	213	13	51	131	5
Chen	1967	44	22	312	24	52	242	55
Corbato	1945	44	21	25	24	52	232	5
Ergerod	1956	55	33	13	13	52	242	55
Lan	1953	55	33	11	13	61	242	56
Nakajima	1979	55	33	31	23	52	242	55
Norman	1988	55	22	13	24	41	342	55
Yip	1980	44	22	12	13	52	242	4
Yuan	1980	44	31	213/13	23	52	353	4

Table 1. Differing auditory descriptions for Fuzhou citation tones.

There is obviously not general agreement on the appropriate representations of the tones, even with respect to the other tones within the given system. This could be due to any number of reasons including sub-dialectal or between-speaker differences but also questions the reliability and consistency of linguists' pitch transcriptions. One way to factor out these differences and get to some objective data is to measure aspects of the acoustic

[3] Standard conventions: underscoring indicates a tone on a checked syllable, and, following Chao's 'tone letters', the numbers indicate a pitch scale where five is the highest level and one is the lowest. (Lan's use of 6 was to emphasize a perceived exceptionally high level).

phase, so for pitch then, one would measure fundamental frequency.[4] I will return to this later in sesction 3 when I present quantified data for the citation tones.

In the next section I will introduce the reader to the tone sandhi phenomena and some ways that have been proposed to account for them.

2. Tone Sandhi

Like the values for the citation tones, there have been similarly differing reports of the tone sandhi phenomena. However, to put my work in context I will give a very brief overview of two well-received and influential works which have provided theoretical analyses of Fuzhou tone sandhi. The brevity of these overviews does not do justice to the original works, but the point is not to focus on the previous analyses, but rather to introduce the reader to the kind of work that currently exists for Fuzhou.

2.1. M. Chan (1985/1988)

Chan uses data she collected herself from a single-speaker (and pitch-traces when useful for clearing up impressionistic uncertainties), and interestingly, these data are closest to the data I obtained. In her analysis, Chan uses one feature [highpitch] to describe the tones and to account for the sandhi changes. The citation tonal values and feature assignments are as follows:

Tone 1	Tone 2	Tone 3	Tone 4	Tone 5	Tone 6	Tone 7
44	32	213	13	51	131	5
H	L@	LH	L@ LH	HL	LHL	HL

Table 2. Chan's tonal feature assignments

The @[5] refers to a "floating high tone" which "docks" under certain sandhi conditions. Notice that there are two representations for Tone 4. This is because Tone 4 has two sets of sandhi changes (though some diachronic motivation is given to Tone 2's final @). Chan describes the reason for the split is attributable to two different sources for the final glottal stop in Fuzhou: either an earlier proto-Min *k (for those with the floating high tone) or *ʔ.[6]

[4] Donohue 1992*a* shows that amplitude is not relevant for the citation tones in Fuzhou.

[5] Traditionally, and in Chan's work, this is typographically an encircled H.

[6] Others have claimed that its possibly being one group is the result of a diachronic merger of all non-glottal stops (*p, *t, *k) whereas the other is (similarly) derived from *ʔ.

There are a couple of tones, such as tone 2 and tone 3 whose phonetics is somewhat obscured. Tone 7 is represented as a HL, though this is accounted for by a rule which delinks the final L prepausally in the presence of a checked syllable.

The sandhi tones are shown below in table 3. As Fuzhou has right dominant tone sandhi, it is the second or last syllable in a disyllabic expression that remains *unchanged* and the first syllable which will change according to the tone of the syllable following it.[7] I have included the features that Chan assigns to the sandhi tones. The possibly baffling assignment of H and L to [33] is explained as the broader-grained height distinction being relatively determined.

<table>
<tr><th>Syllable 2 →</th><th>Tone 1
[44]</th><th>Tone 5, 7
[51,5]</th><th>Tone 2
[32]</th><th>Tone3,4,6
[213,13,131]</th></tr>
<tr><td>Syllable 1:</td><td>Syllable</td><td>1 sandhi</td><td>tones</td><td>below</td></tr>
<tr><td>Tone 1 H
Tone 3 LH
Tone 6 LHL
Tone4 (<h) LH</td><td rowspan="2">44
H</td><td rowspan="2">33
H</td><td>53
HL</td><td>51
HL</td></tr>
<tr><td>Tone 5 HL
Tone 7 HL</td><td>33
L</td><td>22
L</td></tr>
<tr><td>Tone 2 L@
Tone4 (<k)[L@</td><td colspan="2">22
L</td><td>13
LH</td><td>44
H</td></tr>
</table>

Table 3. Disyllabic Tone Sandhi after Chan

Chan proposes the following rules to account for the tone sandhi patterns, which must be applied strictly in the order presented below:[8]

First: Dock the final @ to stressed Tone 4<k syllables.
Also: Glottal stop raises the final L tone to a H.
Then:

1. Final L deletion Rule: LHL → LH
2. Initial L deletion Rule: LH → H
3. /HL/ deletion Rule: HL → Ø
4. L-spreading Rule: H L → HL L

[7] One of Fuzhou's fames is its morphonemically conditioned vowel alternations. I will not mention these here as, while interesting, are easily explained in my full-blown analysis. See Donohue (forthcoming) for details.

[8] I am simplifying the rules that were originally represented geometrically with respect to the syllable/word. I similarly simplify Yip's original formulations to show the relevant tone features only.

5. Sandhi-H Docking Rule: L@ L → LH L
6. /LH/ dissimilation Rule: LH LH → H LH

Then the OCP applies. Then some pitch lowering rules:

a. H delinking and lowering Rule: H HL → M HL
b. H lowering: LH → LM
c. L-raising: HL → HM

These are all the rules that Chan used in her analysis. In fact Chan 1985 also gives an account of the tone sandhi of the tri- and quadri-syllabic expressions. However, I restrict the phenomena discussed in this paper to the disyllabic words. Next I will give an overview of Yip's 1980 proposal for the disyllabic tone sandhi.

2.2. M. Yip (1980/1990)

The data that Yip uses are gathered from other sources, and are noticably different from Chan's data. Yip uses two features to describe the tones and to account for the sandhi changes: Register ([±upper]) and Tone ([±raised]). In Yip's analysis, Register is described as dominating Tone, interacting to define 4 pitch levels (a typologically desirable maximum):

Register	Tone
+ upper (H)	+ high (h)
	- high (l)
- upper (L)	+ high (h)
	- high (l)

Table 4. Interaction of Register and Tone

Another typological consideration that was able to be explained by the use of register was the maximum of two of any given contour:[9]

[9] Though these generalisations are in fact disputable to some extent: the difficulty being where (if at all) one can draw the line between phonetics and phonology.

Register	Tone
+ upper	HL (Falling)
	LH (Rising)
- upper	HL (Falling)
	LH (Rising)

Table 5. The restrictions on numbers of tonal contours

The citation tonal values that Yip uses and her feature assignments are as follows:

Tone 1	Tone 2	Tone 3	Tone 4	Tone 5	Tone 6	Tone 7
44	22	12	13	52	242	4
H-h	H-ll	L-lh	L-ll	H-hl	L-lhl	H-hl

Table 6. Yip's tonal feature assignments

Yip also has a late rule of L-raising applying in stopped syllables only. This applies to both the stopped tones, Tone 4 and Tone 7.

Yip's account of the split in the Tone 4 sandhi patterns is accounted for again by final -ʔ or -k, though this time no appeal is made to their historical development.

The data that Yip uses for the sandhi output forms are as follows:

Syllable 2 →	Tone 1,5,7 [44, 52, 4]	Tone 2 [22]	Tone 3,4,6 [12, 13, 242]
Syllable 1:	*Syllable 1*	*sandhi tones*	*below*
Tone 1 H-h Tone 3 L-lh Tone 6 L-lhl (13)	44	52	52
Tone 5 H-hl Tone 7 H-hl	44	22	22
Tone 2 H-ll	22	35	35
Tone 4 L-ll	22	35	4

Table 7. Disyllabic tone sandhi after Yip.

The rules that Yip proposes to account for the tone sandhi forms also must apply in order and strictly only apply to the tones in sandhi position. Massively simplified, these are as follows:

1. Register Raising: Register → [+upper]
2. LHL Simplification: LHL → LH
3. T-Deletion: T → Ø / [-upper]
4. L-spreading: (H)H L → (H)HL L
5. HL Deletion: HL → Ø
6. L dissimilation: LLL → LHL
7. [-upper] deletion: [-upper] → Ø / [+closed glottis]
8. Glottal Stop deletion: ʔ → Ø / [+upper]

There is an elegance in the analysis, but there remains the problem of phonetic opacity and external motivation for the types of rules and their orders presented.

2.3. Summary

The two analyses capture the sandhi facts but occasionally must obscure the phonetic facts with their feature assignment, making the motivation for the natural classes and feature assignments rather theory internal and seemingly arbitrary.

In the next section I will present new data for Fuzhou and an account of the tonal phenomena that is phonetically transparent, appealing to perceptual facts for motivation.

3. My data: citation tones

Donohue (1992a) presents quantified data for the citation tones (appropriately controlled for possibly influential sociolinguistic and phonetic variables: 4 speakers - 2 men and 2 women were chosen. All speakers had been in Australia (where the recordings were made) about 2 years at the time, were from roughly the same socio-economic background, and had Fuzhou as their mother tongue and the language spoken at home while growing up. Tokens were phonetically controlled to all begin with a voiceless unaspirated consonant and included each of [i] [a] and [u] for each tone. About 20 repetitions per speaker per token were measured at significantly frequent percentage point intervals of absolute duration.). These were then normalised across speakers to factor out between-speaker differences, and, factoring out on- and offset perturbations we are left with:

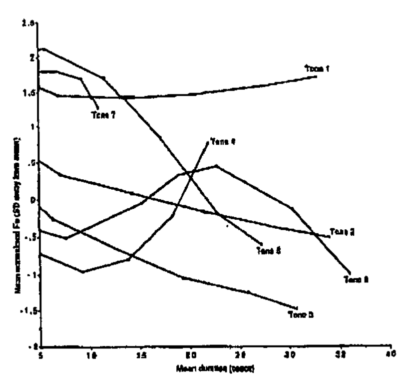

Figure 1a. Mean Normalised F0 for Fuzhou citation tones

This is objective data representative of Fuzhou (or at least the variety spoken by these four speakers) *as a whole.*

3.2 Tone sandhi: a description

Below is a summary of the disyllabic tone sandhi data that I obtained, 'translated' into the Chao tone letters.

Syllable 2	Tone 1 [44]	Tone 2 [32]	Tone 3 [21]	Tone 4 [13 ʔ]	Tone 5 [52]	Tone 6 [231]	Tone 7 [5 ʔ]
Syllable 1		*output*	*sandhi*	*forms*	*below*		
Tone 1 [44]	44 44	43 32	42 21	41 13	33 51	42 231	3 5
Tone 2 [32]	21 44	44 32	44 21	44 13	33 51	44 231	3 5
Tone 3 [21]	44 44	43 32	42 21	41 13	33 51	42 231	3 5

Tone 4 [13ʔ]	21 44	44 32 35 32	44 21 35 21	35 13 5 13	33 51	45 231 44 231	3 5
Tone 5 [52]	44 44	33 32	21 21	21 13	33 51	21 231	3 5
Tone 6 [231]	44 44	43 33	42 21	41 13	33 51	42 231	3 5
Tone 7 [5ʔ]	44 44	33 32	21 21	21 13	33 51	21 231	3 5

Table 8. Fuzhou tone sandhi forms

I will now describe the tone sandhi as it appears, first my illustrating the feature assignment and then motivating the natural classes.

3.3 Tonal feature assignment

I will use Register ([±upper]) and Tone ([±raised] or H/L) features to represent these tones. I will however remain completely agnostic about their (highly controversial) geometric relationship at this stage (as it does not make a difference to the results of this paper).

I define Register here according to the onset of the tones[10], with Tone 2 then defining the actual mid-range point. I have chosen to describe tone 2 as [−upper] H (though it could easily have been [+upper], L).

[10] See Donohue 1992b for other possible definitions.

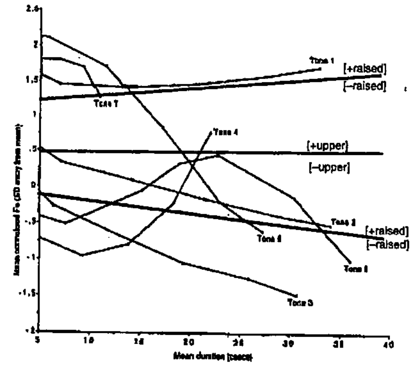

Figure 1b. The definition of Register in Fuzhou illustrated.

The [−upper] register tones also have a creaky/breathy phonation associated with them (curiously not before reported in the literature). Not surprisingly this is stronger with the L onset tones, but is optionally produced with the H onset tone, the mid level tone 2. The creaky voice is probably also part of the reason why the [−upper] register tones fall slightly.

Tone 1	Tone 2	Tone 3	Tone 4	Tone 5	Tone 6	Tone 7
44	32	21	13ʔ	52	231	5ʔ
[+upper] H	[−upper] H	[−upper] L	[−upper] LHL (→LH?)	[+upper] HL	[−upper] LHL	[+upper] HL (→H?)

Table 9. Tonal feature assignment

Note that Tone 5 and Tone 7 are in fact the same tone, as are Tone 4 and Tone 6. This is because they pattern together for sandhi and can nicely capture the fact that stopped syllables can only occur with contour tones, as the glottal stop seems to behave prosodically, displacing a Tone feature. Thus, if it were to occur on a level tone, it would eliminate all tonal information.

For the exact phonetic realisations of these tones, the following phonetic generalisations apply (which apply across the board–citation or sandhi position). These fall into two basic categories that can be described as 'perceptual enhancement of distinction' and 'ease of production':

- [+upper] level tones rise a little
- [−upper] level tones drop a little *Perceptual enhancment of distinction*

- High fall falls further (i.e. beyond it's own register, which is OK in Fuzhou as it's not encroaching on the phonemic space of another fall) *Ease of production*

The system is typologically sound: There are more level tones than contour tones. There is a convex tone, but there is also a simple fall, so the implicational universal that if there is a complex tone there will also be a simple one is not contradicted.

3.4. Tone sandhi: perceptual salience

I was able to shed light on the natural classes relevant for Fuzhou tone sandhi by exploring the literature on the perception of tone. Gandour (and others) in various of his papers finds the following to be perceptually salient aspects of linguistic tone in contour tone languages:

- *height*: average pitch
- *direction*: from A towards B (rise vs. fall)
- *contour*: basically [±level]
- *slope*: magnitude of slope.

Scholars have used various of these concepts, though without actually making the connection to the perceptual literature. Zhang (1997) makes use of the magnitude of the slope, and the use of *fall* could date back to much earlier works on tonal features (eg Wang 1967), but as far as I know no-one has made use of 'average pitch height'.

I will explore *direction* (specifically *fall*) and *height* with the new Fuzhou data and show that they are relevant for the natural classes involved in tone sandhi. Specifically, for *height* I will be looking at the mid range average pitch.

3.5. The Tone 4 alternations explained

For a long time the alternations of Tone 4's sandhi tones have had mostly diachronic explanations. In my data it is clear. The Tone 4 syllables produced, as is normal in sandhi, without a glottal stop, group with Tone 6 (and Tones 1 and 3), whereas there are others that are actually produced *with* a glottal stop. These group with Tone 2 for their sandhi patterns. I believe that the presence of the stop in sandhi position means that the tone is featurally different as input for sandhi (as the glottal stop would have displaced the L tone), and thus (at some level) would perceptually group better with Tone 2 as 'mid' tones, as they both end with a [−upper] H tone.

The other natural classes consist of the 'falls' and what I will call 'rest', though the latter are also captured by 'extreme'. I will return to this later.

Table 10 presents an impressionistic pattern of what is going on with Fuzhou tone sandhi.

Second σ → (First σ below)	T5,T7: "Fall"	T4,T6: "rise-fall"	T1: "high level"	T2: "mid level"	T3: "low level"
T5,T7: "Falls"	M	L	H	M	L
T2,T4: "Mid tones–av. pitch"	M	T2: H T4: H-rise	L	T2: H T4: H-rise	T2: H T4: H-rise
T1,T3,T4/6: extreme on/off	M	H-fall	H	H-fall	H-fall

Table 10. Impressionistic description of Fuzhou tone sandhi

In features, this translates to:

Second σ → (First σ below)	T5,T7: H-hl	T4,T6: L-lhl	T1: H-h	T2: L-h	T3: L-l
T5,T7: H-hx	M	L-l	H-h	L-h	L-l
T2,T4: L-(l)h	M	T2: H-h T4: H-lh	L-l	T2: H-h T4: H-lh	T2: H-h T4: H-lh
T1: H-h, T3: L-l, T4/6: L-lhl	M	H-hl	H-h	H-hl	H-hl

Table 11. Featural description of Fuzhou tone sandhi

Note that for ease of exposition I have referred to the features as follows:

[+upper]: H [−upper]: L
[+raised]: h [−raised]: l

So for example, the high level, which would be ([+upper], [+raised]), I will write as H-h. Note also that the x in H-hx refers to a filled tonal position, beit filled with a glottal stop of a L tone feature.

3.6. Findings

The sandhi natural classes are not dissimilar to those reported in the literature, though the actual sandhi forms are not the same. There is complete neutralisation of all tones before a fall. I suggest that the enforcement that any tone is realised as a mid-level (with no phonetic interpolation) is to enhance the falling contour. This is exceptionless, and thus will translate to an undominated constraint.

The falling tone (T5/T7): This fall loses all it's features and completely assimilates to the onset of the following tone - both in Tone and in Register. Why? I propose that this is a restriction that there be no falls in sandhi (i.e. in a non-prominent (ie. non-phase-final)) position. So therefore there must also be a constraint then on each syllable having to have tone.

The Mid tones (T2/T4a: those that show up with ʔ and render the tones compatible with this mid-range group). These seem to preserve their distinctiveness only before [−upper] tones. However, this is explainable via a general rule of dissimilation. They dissimilate in *either* Register *or* Tone, but not both (and ensuring a [−α upper] Register takes priority over the Tone specifications. But, when the register is already different, you take on the [-α raised] feature, hence both tone 2 and 4a become L-l before H-h.

This also explains the slight asymmetry between the tones (not before reported in the literature) that appear a subset of the time: when the Register is dissimilating, the Tone features remain the same, and tones 2 and 4 differ in their tone features (L-h vs. L-lh).

The "rest" - these form a natural class in terms of their extreme on-/off-sets, and become the 'extreme' tones by a constraint that requires that there be no complex contours in non-final position. Thus they simplify. Tones 1 and 3 are already 'level' tones, but the complex rise-fall must simplify. As the language is R-headed, and that is the relevant point of contact for sandhi, it is the left branch that deletes. This provides some insight into the nature of the Tone 6 contour, that its constituency be (lh)l. However, in sandhi position these tones do not retain their L-l specification, but rather become H-h and assimilate to the onset of the following tone. Why? I propose that this is because of tonal markedness: *L >> *H. If there is a grouping of 'extreme' tones, then L and H is the set defined by this grouping, so for sandhi position, the preferred H tone outranks the faithfulness to the underlying form.

3.7. Summary

A summary of my tone sandhi data is as follows:

1. *Fall enhancement*: any tone → mid level before fall
2. *Dissimilation*: mid tones → dissimilate in Register OR Tone
3. *Tonal markedness /H Preferred in non-prom:* Extreme tones become H.
4. Ban on falls in non-prom syllables (lose features and assimilate)

Assimilation:
Unless you're dissimilating, assimilate to the onset of following tone.

4. Conclusion

I believe that tone sandhi is driven by perceptual salience and that to best understand the principles involved in determining the phenomena, we should first understand the targets that the speakers perceive, and thus must try to produce.

In this paper I have used Fuzhou tone sandhi as a case to illustrate this point. Through a discussion of Fuzhou tone sandhi data, I have shown how facts about perceptual salience of linguistic tone has shed some light on understanding the natural classes relevant for understanding the tone sandhi alternations in Fuzhou.Several sandhi changes which were previously harder to explain may be seen as natural perceptual enhancments. Finally, these perceptually oriented natural classes and facts would lend themselves well to an Optimality Theoretic account of the tone sandhi phenomena.

References:

CHAN, MARJORIE K. M. 1985. *Fuzhou Phonology: a non-linear analysis of tone and stress.* University of Washington PhD dissertation. Published in 1988 by UMI Publishers.

CHEN, LEO and JERRY NORMAN. 1965. *An introduction to the Foochow dialect.* San Francisco: San Francisco State College.

DONOHUE, CATHRYN. 1992a. The phonetics of Register in the Fuzhou dialect of Chinese. In: J. Pittam (ed.) *The proceedings of the Fourth Australian International Conference on Speech Science and Technology.* Brisbane: University of Queensland Press.

DONOHUE, CATHRYN. 1992b. The Phonetics and Phonology of Fuzhou tones. Australian National University Honour's thesis.

DONOHUE, CATHRYN. An OT account of Fuzhou tone sandhi. ms, Stanford University.

Gandour, Jack. 1981. Perceptual dimensions of tone: evidence from Cantonese. In: *Journal of Chinese Linguistics* 9 (1): 20-37.

GANDOUR, JACK. 1983. Tone perception in Far Eastern languages. In: *Journal of Phonetics* 11: 149-175.

GANDOUR, JACK. 1984. Tone dissimilarity judgements by Chinese listeners. In: *Journal of Chinese Linguistics* 12 (2) 235-261.

WANG, WILLIAM S-Y. 1967. The phonological features of tone. *The International Journal of American Linguistics, 33 (2):* 93-105.

YIP, MOIRA. 1980. *The tonal phonology of Chinese.* Massachusetts Institute of Technology PhD dissertation. Published in 1990 by Garland Publishing Co.

YIP, MOIRA. 1996. Feet, tonal reduction and speech rate at the word and phrase level in Chinese. To appear in *The Proceedings of the OTS Workshop on Prosodic and Phrasal Phonology.* (ROA-159-1196)

ZHANG, JIE. 1997. Checked tones in Chinese dialects -- Evidence for phonetically-driven phonology. ms, UCLA.

Theoretical Implications of Huojia Rime Change*

Yen-Hwei Lin
Michigan State University

The Huojia dialect of Henan in China (He 1982ab, 1989) exhibits alternations in three morphological classes: *zi*-nouns, *er*-nouns, and D-words. This set of data is of theoretical interest because at first glance an optimality-theoretic approach (Prince and Smolensky 1993) seems to face several problems. In this paper, I demonstrate that a non-derivational constraint-based analysis provides a successful account and discuss the theoretical implications of the proposed analysis.

1. Introduction

In this paper I discuss some issues that arise when Optimality Theory (OT) is adopted to analyze alternations under Huojia affixation. The tenets of OT are summarized in (1).

(1) Optimality Theory
  a. UG provides a set of constraints that are universal and universally present in all grammars.
  b. Constraints are violable; but violation is minimal.
  c. The constraints are ranked on a language-particular basis. A grammar is a ranking of the constraint set.
  d. The constraint hierarchy evaluates a set of candidate analyses that are admitted by very general considerations of structural well-formedness.
  e. Best-satisfaction of the constraint hierarchy is computed over the whole hierarchy and the whole candidate set. There is no serial derivation.

The universal constraints that OT admits include (i) the faithfulness/correspondence constraints that require identity between input and output, between a reduplicant and its base, and among morphologically related words, (ii) the markedness/wellformedness constraints on the output, and (iii) the alignments constraints that match the edges of phonological and morphological categories. These constraints are minimally violable and ranked on a language-particular basis. The correct output is then selected through evaluation of a set of ranked universal constraints. The tableau in (2) illustrates how an output is selected through constraint evaluation. Given the constraint ranking A >> B >> C, and input k, k-$cand_3$ is the optimal output because it violates the lowest ranked constraint.

* I would like to thank the audience of IACL-7/NACCL-10 for their comments and suggestions.