



Issues in the Analysis of Chinese Tone

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Review

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1. Introduction

It is a well known fact that Chinese languages are tonal, in the sense that the pitch with which a syllable is uttered can cue meaning differences. Linguists who specialize in Chinese languages are occasionally disenchanted by the exclusive use of the *ma55/ma35/ma213/ma51* quadruplet made popular by introductory linguistics textbooks, as other examples just as capable of illustrating the tonal contrasts abound in Mandarin Chinese — *ʂow55/ʂow35/ʂow213/ʂow51*, *tʰaŋ55/tʰaŋ35/tʰaŋ213/tʰaŋ51*, *ci55/ci35/ci213/ci51*, to name just a few.¹

The influence of Chinese tone, however, goes far beyond an apt illustration of a salient piece in the colorful fabric of linguistic typology. Chinese tone has also played important roles at various stages in the development of phonological theory. Its significance to generative phonology was first noted in Wang (1967) and Woo (1969), who identified the independent nature of tones from their segmental carriers and the necessity of a separate tonal representation in phonological derivations with tone rules. Its popularity peaked around the 1980's and 1990's together with the advent of autosegmental phonology (Goldsmith 1976) and feature geometry (Clements 1985, Sagey 1990), and a large body of literature investigating the feature-geometric representations of tones and how tonal processes in Chinese dialects could be captured via the autosegmental framework was spawned by the interest to better understand these formalisms and to see how they could be applied to a set of data largely unfamiliar to the

1 theoretical phonology readership (Bao 1990, 1999, Chan 1985, 1991, Chen 1996,
2 Duanmu 1990, 1994, Yip 1980, 1989, 1995, among others). The field of phonology
3 continued to develop, most notably with Optimality Theory (OT; Prince and Smolensky
4 1993/2004) and its various renditions such as Stochastic OT (Boersma 1998, Boersma
5 and Hayes 2001, Harmonic Grammar (Smolensky and Legendre 2006), and Maximum
6 Entropy Grammar (Goldwater and Johnson 2003, Jäger 2007), but the study of Chinese
7 tone somehow stagnated. In this review article, I discuss a number of reasons for this
8 hopefully temporary stagnation and point to a few directions in which the analysis of
9 Chinese tone may fruitfully proceed.

11 2. *Chinese tone in generative phonology*

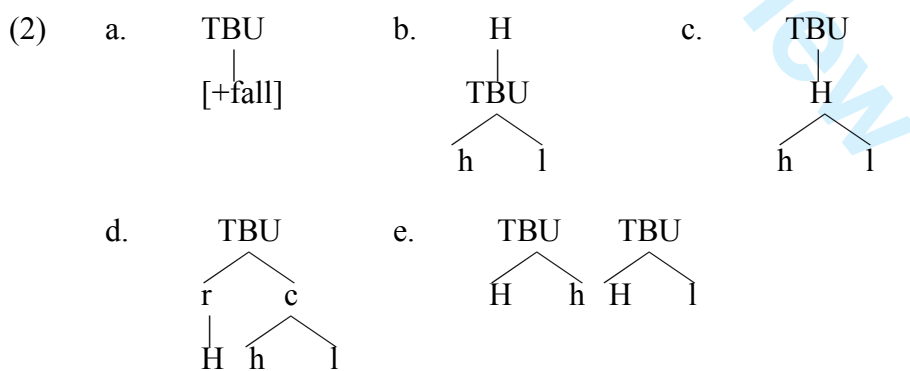
13 2.1 REPRESENTATION ISSUES

15 The main issue of contention that the study of Chinese tone focused on before the
16 turn of the century was the formal representation of tone. This issue revolved around the
17 following questions:

- 19 (1) a. What is the Tone Bearing Unit (TBU)? Is it the syllable, the rhyme, the
20 sonorous portion of the rhyme, or the mora?
- 21 b. What are the primitive features of tone? How many level-tone features are
22 needed, and are contour tones represented by unitary features or sequences
23 of level features?

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4 1 c. If there are different layers of tonal features such as Register and Contour,
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6 2 what is the geometric relation among the features — independence,
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8 3 dominance, or sisterhood?
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5 Based on answers to these questions, a high falling tone over a syllable can be
6 represented as one of the five representations in (2). The TBU in (2a)-(2d) can be the
7 syllable, the rhyme, or the sonorous portion of the rhyme, while the TBU in (2e) is the
8 mora. Specifically, (2a) represents the contour tone as a single unit with a [+fall] feature
9 (Wang 1967); (2b)-(2d) assume two levels of tonal representation — Register (H/L) and
10 Contour (h/l), and they are in an independence (Yip 1980), dominance (Yip 1989, 1995),
11 or sisterhood relation (Bao 1990, 1999), respectively; (2e) represents the contour tone as
12 a sequence of two level tones with no contour tone unit (Duanmu 1990, 1994). In (2b)-
13 (2e), the Register and Contour features may take on different numbers of levels, but
14 binary distinctions H/L and h/l are the most commonly assumed.
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3 1 2.2 TONE SANDHI IN CHINESE DIALECTS
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9 The arguments for a specific tonal representation primarily come from patterns of
10 tone sandhi in Chinese languages, which refers to tonal alternations caused by the
11 juxtaposition of tones or by placing a tone in a particular prosodic or morphosyntactic
12 environment.
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17 The typology of tone sandhi in Chinese languages is well studied. This is due to
18 collective efforts from both Chinese dialectologists who publish careful descriptions of
19 the dialects, most notably in two eminent Chinese journals *Fangyan (Dialects)* and
20 *Zhongguo Yuwen (Chinese Philology)*, and theoretical linguists who generalize the
21 patterns observed in these descriptions. Influential dissertations by Yip (1980), Wright
22 (1983), Bao (1990), and Duanmu (1990), typological works by Yue-Hashimoto (1987)
23 and Bao (2004), as well as a long line of work by Chen (1991, 1992, 1996) that
24 culminated in his seminal tome on tone sandhi (Chen 2000) have all made important
25 contributions to our understanding of tone sandhi patterns.
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39 Crudely speaking, tone sandhi patterns in Chinese fall under two types: “right-
40 dominant” and “left-dominant” (Yue-Hashimoto 1987, Chen 2000, Zhang 2007). A right-
41 dominant sandhi system, found in most Min, Southern Wu, and Mandarin dialects,
42 preserves the base tone on the final syllable in a sandhi domain and changes the tones on
43 nonfinal syllables. In a left-dominant system, on the other hand, the initial syllable in a
44 sandhi domain preserves its base tone while noninitial syllables undergo sandhi. This is
45 typified by Northern Wu dialects. Zhang (2007) argues that there is a systematic
46 asymmetry in how the sandhi behaves based on directionality, in that right-dominant
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1 sandhi tends to involve local or paradigmatic tone change, while left-dominant sandhi
 2 tends to involve the extension of the initial tone rightward. This asymmetry can be seen
 3 in the right-dominant sandhi examples in (3) and the left-dominant sandhi examples in
 4 (4): both the tonally induced “third-tone sandhi” in Mandarin Chinese (3a) and the
 5 positionally induced “tone circle” in Taiwanese (3b) (Chen 1987, Lin 1994) involve local
 6 paradigmatic tone change, while the tone sandhi in Changzhou generally spreads the tone
 7 on the first syllable across the entire di- or trisyllabic sandhi domain, taking over the
 8 original tones of the noninitial syllables (Wang 1988).

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 10 (3) Right-dominant sandhi:

11 a. Tonally induced tone sandhi — Mandarin “third-tone sandhi”:

12 213 → 35 / ___ 213

13 b. Positionally induced tone sandhi — Taiwanese “tone circle”:

14 51 → 55 → 33 ← 24 in non-XP-final positions

15 ↖ ↗

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1 (4) Left-dominant sandhi — Changzhou:

σ_1	$\sigma_1\sigma$	$\sigma_1\sigma\sigma$
55	33-33	33-33-33
13	11-33	11-33-55
45	45-55	45-55-55
523	55-23	52-22-33
24	11-24	11-11-24

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3 2.3 TONE SANDHI AND TONAL REPRESENTATION

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5 As stated above, patterns of tone sandhi play an important role in the theoretical
6 treatment of tonal representation. For instance, whether contour tones should be treated as
7 units in the representation depends on whether we can find cases of tone sandhi in which
8 the whole contour tone spreads onto adjacent syllables, and the formal relation between
9 Register and Contour features rests on whether the register and contour shape of the tone
10 can spread independently from one another in tone sandhi behavior. A review of these
11 issues can be found in Yip (1995).

12 In the backdrop of these representational issues, significant progress was made in
13 identifying the differences between tone in Chinese and tone in African languages. These
14 differences are aptly summarized in Wan and Jaeger (1998: 426-427): for African
15 languages, tone patterns are often associated with polysyllabic phonological words, and
16 they often serve grammatical functions, but for Asian languages like Chinese, tones are
17 associated with individual syllables and predominantly serve a lexical function;

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3 1 moreover, African languages typically have a register-based tone system with two or
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5 2 three tonal levels, while Chinese languages usually have a contour-based system with
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7 3 multiple contour tones in the tonal inventory. However, the field eventually did not reach
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9 4 a consensus on any aspect of the representation of tone in Chinese languages, from the
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11 5 existence of a contour tone unit to the relation between Register and Contour. This is
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13 6 likely due to the following three reasons.
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18 7 First, the data sources for Chinese tone sandhi often come from field descriptions
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20 8 of Chinese dialects done by traditionally trained dialectologists. These descriptions,
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22 9 though often detailed and careful, are primarily based on impressionistic transcriptions.
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24 10 The transcription of tones is notoriously difficult, and even seasoned fieldworkers often
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26 11 have disagreements on how to transcribe the tones of the same language. For example,
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28 12 the tonal inventory of Tianjin Chinese has been described in three different ways by three
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30 13 different sources, as shown in (5). In Shi's (1990) description, Tone 1 and Tone 2 are
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32 14 considered level tones, while the other two descriptions treat them as contour tones; in Li
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34 15 and Liu's (1985) description, Tone 3 is treated as a complex concave contour, while the
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36 16 other two descriptions treat it as a simple contour. These discrepancies have profound
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38 17 effects on how the tonal patterns are analyzed. For instance, in Tianjin, Tone 4 becomes
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40 18 Tone 2 before Tone 1. This can be interpreted as a markedness restriction against two
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42 19 falling contours according to Yang, Guo, and Shi (1999) and Li and Liu (1985) or against
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44 20 two low pitch targets according to Shi (1990), and the structural change can be
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46 21 interpreted as the metathesis of two Contour features (Yang, Guo, and Shi 1999, Li and
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48 22 Liu 1985) or simply the deletion of one of them (Shi 1990). In other words, an arbitrary
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50 23 choice of which source to consult can completely change the nature of the analysis and
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1 hence the tonal representation that it supports or rejects. Consequently, theorists
 2 (secretly) know that arguments purely based on these secondary sources must be taken
 3 with a grain of salt, and it is therefore unsurprising that they find it difficult to reconcile
 4 with each other's arguments!

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 6 (5) Tianjin tonal inventory:

	Tone 1	Tone 2	Tone 3	Tone 4
Shi (1990)	11	55	24	53
Yang, Guo, and Shi (1999)	21	45	13	53
Li and Liu (1985)	21	45	213	53

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 8 Relatedly, the distinction between level tones and contour tones that is so
 9 important to the representation issue may simply be ill-conceived due to this very reason.
 10 In Chinese languages, it is often difficult to argue for this distinction based on
 11 independent phonetic criteria alone. The choice then comes down to the what makes the
 12 analysis workable and typologically sound, which to some extent depends on how tones
 13 are represented. To use these analyses to argue for tonal representations, then, runs the
 14 risk of being circular. This circularity is the point of contention on the representation of
 15 tones on obstruent-closed syllables (CVO) in Chinese dialects, for example. Duanmu
 16 (1990, 1994) argues that these syllables, like all other syllables in Chinese, are bimoraic.
 17 But due to the phonetic inability of obstruents to bear tone, these syllables only carry
 18 level tones on the surface. Zhang (2004), however, observes that tones on this type of
 19 syllables in dialects like Pingyao are in fact phonetically contour tones, only that the tonal

1 contours are not as pronounced as those on open (CVV) and sonorant-closed (CVR)
2 syllables. Consequently, bimoraicity cannot properly capture the tone bearing ability
3 difference between CVO and CVV/CVR in these dialects.

4 Third, tone sandhi patterns are often extremely complex. This may have been
5 caused by a number of internal and external factors. Internally, since tones are primarily
6 implemented with one articulator — the vocal folds, they are easily influenced by
7 adjacent tones due to the difficulty in fast transitions from one vocal fold state to the next;
8 tones are also easily influenced by segmental features due to properties of laryngeal
9 anatomy. These factors determine that tones are inherently amenable to change.
10 Externally, the close contacts among different tonal dialects in China as well as the
11 propagation of Mandarin Chinese as the standard language also cause mutual influence of
12 the already complicated tone patterns. Intentionally or unintentionally, the tone sandhi
13 patterns that have been used to argue for particular tonal representations are carefully
14 selected by the theorists, and they often only represent a small corner of the entire sandhi
15 system of the language. As a consequence, even if the tonal representation helps the
16 analysis of, sometimes even predicts the sandhi patterns in question, it is not clear that it
17 will guarantee the analytical success of the entire sandhi system of the language. It is with
18 this type of hesitance that scholars who are well-versed in Chinese dialectology approach
19 these theoretical enterprises, and it is no surprise that they very often remain
20 unconvinced. This goes to the heart of what theoretical phonologists aspire to do. If the
21 goal of theoretical apparatus is to eventually account for real data, then studies of formal
22 tonal representation cannot be considered very successful. It is then understandable that
23 the dismay over the lack of success in accounting for real data eventually prevailed over

1 the excitement of theory internal advances such as the exact formalism of autosegmental
2 and feature-geometric representations.

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4 2.4 TONE SANDHI AND OPTIMALITY THEORY

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6 Theoretical fads come and go, but the objects of explanation remain the same.
7 During the 1990's, Optimality Theory brought to the forefront the issues of markedness
8 and constraint interaction, while representational issues such as the feature-geometric
9 structure of segments and tones somewhat receded to the background. The field of
10 Chinese tonology, likewise, was excited to see whether OT brought new possibilities in
11 accounting for the complex tone sandhi patterns in synchronic phonology. The many
12 gallant attempts (e.g., Chen 2000, Hsiao and Chu 2006, Jiang-King 1996, Lin 2008,
13 Zhang 1999, Wang 2002, Wee 2004, 2010, Yip 1999, 2004) however, were only met
14 with limited success. Many scholars remain unconvinced that OT is an appropriate model
15 for complex sandhi processes (e.g., see Bao 2003), and synchronic analysis remains
16 lacking for many sandhi systems. Chen (2004), for instance, shows that the complex
17 sandhi system in Changting Hakka cannot be reasonably analyzed with current
18 theoretical apparatuses at the disposal of an OT phonologist.

19 The reason for the lack of success and prevailing pessimism is related to a point
20 already raised: due to tone's fickle nature, diachronic sound changes have often wiped
21 out the markedness motivations for the present-day tone sandhi, and as a result, many
22 sandhi processes appear phonetically arbitrary from a synchronic standpoint. For
23 instance, the "third-tone sandhi" in Mandarin Chinese corresponds to a historical sandhi

1 pattern in Chinese, namely, *shang* → *yang ping* / __ *shang*, where *shang* and *yang ping*
2 refer to the historical tonal categories from which 213 and 35 descended, respectively.
3 This historical sandhi pattern dates back to at least the 16th century (Mei 1977) and has
4 different synchronic renditions in related Mandarin dialects: for example, in Jinan, it is 55
5 → 42 / __ 55 (Qian and Zhu 1998), and in Taiyuan, it is 53 → 11 / __ 53 (Wen and Shen
6 1999). This makes markedness motivations in synchronic sandhi systems difficult to
7 come by. Consequently, if we look for generalizable markedness constraints that OT relies
8 on for the synchronic analysis of tone sandhi, we tend not to get very far. Put broadly, the
9 recent theoretical development, though fruitful in many areas of phonology, does not
10 seem to have effectively benefited the analysis of tone sandhi in any revolutionary way.

12 3. *Directions for Chinese tone research*

14 The previous section summarizes the recent research development of Chinese
15 tone and outlines the possible reasons that the research has somewhat stagnated. In this
16 section, I discuss the directions that I see Chinese tone research may move towards in
17 order to make theoretical and analytical progress.

19 3.1 REBUILDING AN EMPIRICAL FOUNDATION

21 The most urgent and fruitful step in my opinion that Chinese tonologists should
22 currently take is to rebuild an empirical foundation from which theoretical analyses may
23 proceed. This has two connotations.

1 First, due to the uncertainty of impressionistic transcription of tones mentioned
2 above, the field needs carefully designed acoustic studies that systematically look at the
3 realizations of tones in tone sandhi behavior. The advantage of such data is not simply in
4 the confirmation or revision of existing documentations based on transcriptions, but more
5 importantly, they can sometimes reveal nature of the data that has escaped the attention
6 of fieldworkers due to biases that they unintentionally bring to the task, such as the
7 categorical nature of tone sandhi. For example, acoustic results from Peng (2000) and
8 Myers and Tsay (2003) have shown that the “third-tone sandhi” in Mandarin Chinese in
9 fact does not create a sandhi tone that completely neutralizes with Tone 2. Without
10 detailed acoustic studies, such incomplete neutralization would not have come to light,
11 and its theoretical consequences would have also not been discovered. Furthermore,
12 careful phonetics studies are also helpful in our search for the formal representation of
13 tone. For instance, based on a series of work that investigates the detailed phonetic
14 realizations of Mandarin tones under different tonal contexts and speaking rates, Xu
15 argues that the pitch results such as coarticulation and peak delay are better accounted for
16 if the contour tone targets are in fact unitary [fall] and [rise], not a concatenation of [high]
17 and [low] (e.g., Xu 1998, 2001, Xu and Wang 2001).

18 The second and possibly more important connotation for rebuilding an empirical
19 basis stems from the classic point made by Kenswoticz and Kisseberth (1979, Ch. 5):
20 *corpus-internal evidence* such as sound distributions and lexical alternations, though
21 highly practical, only indirectly reflects the speakers’ phonological knowledge and
22 should be complemented by *corpus-external evidence* gleaned from non-traditional
23 sources such as language games, speech errors, loanwords, and phonetic and

1 psycholinguistic experimentation that demonstrates the psychological reality of the
2 elicited sound patterns. Crucially, recent studies have shown that speakers' phonological
3 knowledge does not always match the lexical patterns. For instance, Zuraw (2007), in
4 both a corpus study on loans and a web-based survey on novel words, showed that
5 Tagalog speakers possess knowledge of the splittability of word-initial consonant clusters
6 that is not present in the lexicon, and they can apply the knowledge to infixation in stems
7 with novel initial clusters. On the other hand, Sanders (2001) demonstrated that in Polish,
8 the counterbleeding interaction between o-Raising and Final Devoicing in nominative
9 singular nouns is not productive in novel words, even though the pattern is well
10 established by many items in the Polish lexicon. Provided that our goal is to understand
11 the speakers' tacit knowledge of sound patterning, the testing of the productivity of
12 phonological patterns and processes is then an indispensable aspect of phonological
13 research.

14 We can illustrate the this point using Taiwanese tone sandhi as an example. The
15 circular chain shift pattern of Taiwanese tone sandhi in (3b) has presented a serious
16 challenge to both rule-based and constraint-based frameworks. The earliest generative
17 analysis of Taiwanese tone sandhi appeared in Wang (1967), who accounted for the entire
18 sandhi pattern by one single rule $[\alpha_{\text{high}}, \beta_{\text{fall}}] \rightarrow [\beta_{\text{high}}, -\alpha_{\text{fall}}]$. However, Wang's
19 analysis was criticized by Anderson (1978, 157) as "remarkably ingenious," but
20 expressing no "linguistically significant generalization," and this sentiment was echoed in
21 Chen (2000, 43). This is due to the fact that the use of variable feature coefficients in
22 Wang's rule is typologically extremely rare, even in the context of Chinese tone sandhi
23 systems.

1 In constraint-based OT, patterns of circular chain shift have been shown to be
2 incomputable by a “conservative” OT grammar that uses only IO-faithfulness and
3 markedness constraints (Moreton 2004). Using additional mechanisms such as anti-
4 faithfulness (Alderete 2001) and contrast preservation (Lubowicz 2003), various analyses
5 have also been proposed (Hsieh 2005, Barrie 2006, Thomas 2008). For example, we may
6 utilize constraints that ban the merge of two base tones (Hsieh 2005, Thomas 2008) or the
7 neutralization of certain tone features such as Register and Contour (Barrie 2006). A chain
8 shift is triggered when a markedness constraint *RISE, which bans 24 in nonfinal position,
9 is highly ranked; the rest of the tonal inventory then shuffles to avoid further
10 neutralization. The exact way in which the chain is formed is determined by lower ranked
11 markedness constraints such as *CONTOUR and *HIGH (Barrie 2006) or faithfulness
12 constraints such as IDENT(Pitch) and IDENT(Shape) (Thomas 2008). A problem with these
13 types of analyses, as pointed by Chen (2000) as well as Zhang, Lai, and Sailor
14 (forthcoming), is that many Southern Min dialects of Chinese have essentially the same
15 tone circle pattern as Taiwanese, but different tonal values at each point in the chain shift;
16 e.g., Longxi, as in (6). The pattern similarity among these dialects originated from the
17 proto-language that had the same tone circle pattern in the historical tonal categories.
18 Given that the analyses based on anti-faithfulness and contrast preservation for Taiwanese
19 crucially depend on the tonal values of Taiwanese, they are not easily generalizable to
20 these other dialects, which means that the tonal grammar of these other dialects will be
21 drastically different from Taiwanese despite the similarity of their overall patterns and
22 their close genetic affinity. This seems counterintuitive.

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3 1 (6) Longxi tone sandhi (Chen 2000):
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15 6 The inability for a synchronic analysis to capture both the pattern in Taiwanese
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17 7 and the parallel among Southern Min dialects has prompted some researchers to take a
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19 8 somewhat fatalistic approach. Chen, for example, argues that the tone circle is better
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21 9 stated in terms of the tonal categories in the proto-language from which these dialects
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23 10 descended, and any markedness motivations for the tone circle must also be sought in the
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25 11 proto-language; any attempts to motivate the sandhi from the tonal values of modern-day
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27 12 dialects are destined to fail. The state of affairs of the phonological analysis of Taiwanese
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29 13 tone sandhi is in fact representative of research on many Chinese dialects with complex
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31 14 tone sandhi patterns.
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36 15 However, if we look at the tone sandhi from the perspective of the speakers'
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38 16 knowledge, we realize that the picture is very different from the tone circle in (3b). Early
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40 17 experimental works by Hsieh (1970, 1975, 1976) and Wang (1993) have shown that
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42 18 despite the exceptionlessness of the sandhi pattern in the Taiwanese lexicon, the sandhis
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44 19 are largely unproductive when speakers are tested with novel words in a “wug” test
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46 20 (Berko 1958). A series of new experiments by Zhang and colleagues (Zhang and Lai
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48 21 2008, Zhang, Lai, and Sailor 2009, forthcoming) further quantified the productivity
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50 22 results in a number of morphological contexts (disyllabic words, reduplication and double
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52 23 reduplication of monosyllabic words) and showed that sandhi productivity is not only
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1 negatively affected by the opacity of the pattern, but also influenced by the frequency of
2 usage and the phonetic nature of the pattern. To this end, Zhang and colleagues proposed
3 both stochastic synchronic grammars and models of learning that captured both the
4 exceptionless sandhi behavior in the Taiwanese lexicon and the variable sandhi
5 productivity in novel words using extensive lexical listing constraints. The approach
6 echoes Tsay and Myer's (1996) theory of allomorph selection for Taiwanese tone sandhi
7 and Yip's (2004) analysis for tone sandhi in Zhaoh, a Tibeto-Burman language that has
8 similar tone and syllable properties to southern dialects of Chinese.

9 The lesson that we learned from these experimental works is that what the
10 synchronic phonology needs to account for can be very different from the sandhi patterns
11 observed in the lexicon. The current research of these complex systems either takes the
12 systems at face value and devises theoretical machineries so intricate that they “strike
13 students of human language as essentially arbitrary and fortuitous” (Chen 2000, 43), or
14 takes a somewhat pessimistic approach that declares the irrelevance of the phonetic
15 renditions of the tones in present-day dialects due to the fickle nature of historical tone
16 changes. But as we have seen, neither the complacency of working out an ingenious
17 analysis for a sandhi pattern nor the pessimistic admission of defeat is terribly warranted.
18 It may be the case that there is good reason for the lack of a straightforward synchronic
19 analysis for a pattern, as the pattern is unproductive and hence does not warrant a
20 generative explanation! Even for those lexical patterns for which an analysis seems
21 readily available, we still need to ask the question whether they are a true reflection of the
22 speakers' knowledge, with the understanding that they might be different. In other words,

1 we need to go back and ask a more basic question about the empirical data: which parts
2 of the patterns are productive, and which parts are not?

3 Like acoustic phonetic research, psycholinguistic experimentation is also useful in
4 our understanding of tonal representation. For instance, based on the tonal errors
5 observed in a corpus of Mandarin speech errors, Wan and Jaeger (1998) argued that
6 Mandarin tones are unitary and not composed of sequences of tones or different levels of
7 tonal representations. This proposal is supported by the predominance of whole-tone
8 substitution errors, the lack of tone splitting or hybrid tones in word-blend and
9 telescoping errors, and the lack of errors that must be accounted for by register or tone
10 feature spreading. These properties of Mandarin tone would not have been discovered
11 had we only focused on observable sandhi patterns in the language itself to the exclusion
12 of such “external” evidence.

13 3.2 VARIATION, GRADIENCE, AND EXCEPTIONS IN CHINESE TONE

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16 In a recent trend, phonological research is paying increasingly close attention to
17 the roles of variation, gradience, and exceptions in the grammar. Observations that many
18 phonological patterns are variable (e.g., Labov 1972, 1994), gradient (e.g., Bolinger
19 1961), and full of exceptions (e.g., Zimmer 1969) have been long standing, but only
20 recently did experimental and theoretical works start to show that the variability,
21 gradience, and patterns of exceptionality observed in language are reflected in the
22 speakers’ phonological knowledge and warrant formal phonological analyses. For
23 example, Zuraw (2000) showed that although Nasal Substitution is riddled with

1 exceptions in the Tagalog lexicon, Tagalog speakers are nonetheless able to detect
2 patterns within the exceptions such as the greater tendency for a front stem-initial
3 consonant (*p* or *b*) to trigger Nasal Substitution than a back consonant (*k* or *g*) and apply
4 the patterns to novel words. Frisch and Zawaydeh (2001) showed that Arabic speakers'
5 knowledge of root-internal consonant cooccurrence restrictions, as indicated by
6 wordlikeness ratings of novel forms, reflects gradient patterns in the lexicon that closely
7 relate to consonant similarity. Hayes and colleagues (Hayes and Londe 2006, Hayes,
8 Zuraw, Sitpár, and Londe 2009) demonstrated that Hungarian speakers can apply the
9 statistical knowledge of vowel harmony gleaned from lexical alternations to novel forms,
10 regardless of the naturalness condition of the harmony pattern (whether the harmony is
11 backed by UG principles), although unnatural harmony may be underlearned. To capture
12 these variable and gradient effects, variations of Optimality Theory such as Stochastic
13 OT (Boersma 1998, Boersma and Hayes 2001, Harmonic Grammar (Smolensky and
14 Legendre 2006), and Maximum Entropy Grammar (Goldwater and Johnson 2003, Jäger
15 2007) have been developed, and they have been applied successfully to some of the
16 experimental results (e.g., Zuraw 2000, 2007, Hayes and Londe 2006, Hayes, Zuraw,
17 Sitpár, and Londe 2009). For a survey of issues related to the place of variation in
18 phonological theory, see Coetzee and Pater (forthcoming).

19 The study of Chinese tone is well situated in the investigation of variation,
20 gradience, and exceptions in phonological theory. The following three properties of the
21 Chinese dialects are responsible for the prevalence of variation and exceptions in their
22 tonal patterns. First, different Chinese dialects have drastically different tonal inventories
23 and tone sandhi systems, but the vast improvement in transportation and media outreach

1 as well as the mobility of the large migrant worker population in China have brought
2 different dialects to be in considerably closer contact with each other than in the past. The
3 increased dialectal contact has caused greater instability of the phonological systems and
4 created a fertile ground for variation and exceptions to appear in these systems. Second,
5 with the promulgation of Mandarin Chinese as the standard language in Mainland China,
6 the phonological system of Mandarin has had a strong influence on many Chinese
7 dialects, especially Northern dialects that are similar to Mandarin Chinese to begin with.
8 Third, the difference between written and spoken Chinese has had a long history in China,
9 and many dialects have lexical items with different pronunciations depending on the
10 colloquial or literary style, causing variation. This is related to the two points above, as
11 the literary pronunciation was often borrowed from a dominant dialect or *lingua franca*
12 (Wang, F.-T. 2009).

13 Chinese linguists have long noted the effects of dialectal contact and the influence
14 a dominant standard language, and descriptive works that carefully outline dialectal
15 changes due to these two factors abound. For example, the changes within the Shanghai
16 dialect from older to newer generations as a result of influence from other dialects were
17 extensively documented in Xu and Tang (1988), Zhu (2006), You (2006a, b), among
18 others. Based on acoustic phonetic results, Shi and Wang (2004) and Zhang and Liu
19 (2009) have discussed the variable changes in both the shapes of the lexical tones and
20 tone sandhi patterns in the Tianjin dialect and how the changes may have derived from
21 the dialect's close interaction with Mandarin Chinese. The implication of these data to
22 phonological theory, however, remains largely unexplored. It would be interesting to
23 understand what the synchronic grammar would look like to allow the variable patterns to

1 surface and whether we can have a model of the speaker that predicts the effects of
2 contact on the phonological systems of the dialects in question.

3 The variable pronunciation based on style has also been a steady focus of research
4 by Chinese linguists. Descriptive works for individual dialects and theoretical works both
5 exist, but the theoretical works primarily have a historical focus (e.g., Liu 2003, Wang,
6 H.-J. 2006, Wang, F.-T. 2009). It would be interesting to explore how the synchronic
7 speakers have internalized the literary and colloquial lexical strata and construct a
8 grammatical model accordingly.

9 The points made in this section echo the earlier point that phonological research
10 on Chinese tone can significantly benefit from a rebuilt empirical basis: variation,
11 gradience, and exceptions are par for the course for phonological patterns, and tonal
12 patterns in Chinese are no exception. Theoretical Chinese phonologists should cultivate a
13 new respect for carefully executed descriptive and experimental work and proceed with
14 analyses that take nothing for granted. The variable and gradient nature of the patterns
15 that empirical research reveals for Chinese tone presents an excellent opportunity for its
16 contributions to current phonological theory.

17 18 3.3 THE SEARCH FOR MARKEDNESS

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20 As I have mentioned in §2.4, due to the phonetic nature of tone, the search for
21 markedness principles that motivate synchronic tone sandhi patterns has proven difficult.
22 In this section, I suggest two strategies for the search for markedness amid the myriad of
23 infinitely complex tone sandhi patterns.

1 The first suggestion is that the markedness search needs to be *less ambitious*. In
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6 2 typological works on Chinese tone and tone sandhi (e.g., Yue-Hashimoto 1987, Chen
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8 3 1991, 1992, 1994, 2000, Bao 1992, Chang 1992, Jiang-King 1999, Zhang 2002), many
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10 4 markedness tendencies have been identified, but only one comes close to being a true
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12 5 universal: syllables that are rich in duration in their sonorous rhyme portion are better
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14 6 bearers of tonal contrasts. In other words, the following implicational statement seems
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16 7 universally true: if a syllable type with sonorous rhyme duration d can carry n tonal
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18 8 contrasts, then a syllable type with sonorous rhyme duration $d+d_0$ can carry at least n
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20 9 tonal contrasts. The syllable type parameters that may have an influence on the sonorous
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22 10 rhyme duration of the syllable include the syllable's segmental composition, stress
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24 11 property, position in the word (final vs. nonfinal), and the number of syllables in the word
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26 12 that the syllable belongs to (Zhang 2002).

27 13 An eminent example that illustrates this point in Chinese is the comparison
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29 14 between obstruent-closed syllables (CVO) and open/sonorant closed syllables
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31 15 (CVV/CVR) in the size of their tonal inventories. In Chinese dialects with CVO
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33 16 syllables, the number of tones that they can carry is generally one or two, and very
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35 17 occasionally three, but the number of tones that can appear on CVV and CVR syllables is
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37 18 invariably larger. This finds correspondence in historical Chinese as well: there were only
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39 19 two tonal categories for CVO syllables (*yin ru* and *yang ru*), while there could be a
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41 20 maximum of six tonal categories on CVV/CVR syllables (*yin* and *yang* crossclassified
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43 21 with *ping*, *shang* and *qu*).

44 22 The relation between the size of the tonal inventory and syllable duration is also
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46 23 manifested in the two types of tone sandhi systems discussed in §2.2. Right-dominant
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1 sandhi systems often involve tonal neutralization in nonfinal syllables due to their lack of
 2 final lengthening effects (Zhang 2002). Both the Mandarin and Taiwanese sandhi patterns
 3 in (3a) and (3b) involve the reduction of tonal contrasts by one in nonfinal position.²
 4 More drastic inventory reductions can also be found. For instance, in the Southern Wu
 5 dialect Wuyi, the final syllable of a disyllabic word preserves the six-tone tonal inventory
 6 24, 213, 53, 31, 55, and 13, while the inventory is neutralized to two tones 55 and 11 in
 7 nonfinal positions, as shown in (7) (Fu 1984).³ In the Changzhou sandhi pattern in (4),
 8 the rightward tone spreading causes syllables in di- and trisyllabic words to lose the
 9 original tone contrasts except for the initial syllable, while monosyllabic words preserve
 10 all tonal contrasts.⁴

12 (7) Wuyi tone sandhi:

$\sigma_1 \backslash \sigma_2$	24	213	53	31	55	13
24	55-T σ_2					
213						
53						
31	11-T σ_2					
55						
13						

13
 14 However, what often remains unpredictable is what that the original tonal
 15 inventory will *neutralize to* under short sonorous rime duration in the synchronic
 16 grammar. In both Mandarin and Taiwanese, the historical basis for the tone sandhi is

1 clear, but why a concave tone 213 must neutralize to a rising 35 in Mandarin or why 24
2 and 55 must neutralize to 33 in Taiwanese is less so, as even if markedness principles can
3 be proposed, they will not be easily generalizable to related dialects that have the same
4 historical sandhi. For Wuyi, likewise, it is not clear why 24, 213, and 53 will neutralize to
5 55, while 31, 55, and 13 will neutralize to 11 — neither group forms any clear natural
6 class.

7 Therefore, the suggestion is for tonal markedness principles (and their interaction
8 with tonal faithfulness) to not be so ambitious as to predict the exact tones that will
9 surface under sandhi, but be content with predicting neutralization under adverse
10 durational conditions. The smaller inventory may be derived *à la* Flemming's (1995,
11 2003) Dispersion Theory. But the exact tone to surface for a particular sandhi may be the
12 result of allomorph listing — an approach championed by Tsay and Myers (1996), Yip
13 (2004), and a series of works by Zhang and colleagues (Zhang and Lai 2008, Zhang, Lai,
14 and Sailor 2009, forthcoming).

15 The second suggestion for the search for tonal markedness is for it to be *more*
16 *ambitious*. This may sound contradictory to my earlier suggestion that the search needs to
17 be less ambitious. Let me explain.

18 As I have stated, many tendencies, or soft universals, have been identified in
19 typological works on tone and tone sandhi. For instance, in terms of tonal inventories,
20 High tone is less marked than Low tone, simple contours are less marked than complex
21 contours (Jiang-King 1999), and falling tones are less marked than rising tones (Zhang
22 2002). In terms of sandhi directions, right-dominant sandhi tends to involve paradigmatic
23 tone change, while left-dominant sandhi often involves tone spreading (Zhang 2007). In

1 paradigmatic tone change, contour tone leveling or simplification is common, while
2 contouring or contour complication is rare (Yue-Hashimoto 1987). In terms of the
3 assimilatory/dissimilatory nature of the sandhi, tone level assimilation is typically
4 perseverative and quite common, while tone level dissimilation is typically anticipatory
5 and much rarer; contour dissimilation (e.g., Rise-Rise → Fall-Rise), however, is
6 considerably more common than contour assimilation (e.g., Rise-Fall → Fall-Fall)
7 (Chang 1992, Chen 2000). All of these tendencies can find phonetic bases, from the
8 dispreference for contour tones over a short duration (Zhang 2002) to the asymmetric
9 properties of tonal coarticulation between assimilation and dissimilation (e.g., Gandour,
10 Potisuk and Dechongkit 1994, Xu 1997). But all these tendencies also have many
11 exceptions. Does this then mean that no synchronically useful markedness principles can
12 be formulated?

13 This question goes to the heart of the debate on the relevance of phonetics to
14 synchronic phonology. The exceptions rule out the hard-line position that phonetically
15 based constraints, intrinsic rankings, grounding conditions, or other formal mechanisms
16 are hardwired, and many have taken them as evidence that the effect of phonetics on
17 phonological typology takes place in the realm of diachronic sound change (e.g., Hyman
18 2001, Yu 2004, Blevins 2006). But it is also possible that the design scheme of the
19 grammar only includes an *analytical bias* that favors the learning of patterns with
20 stronger phonetic bases (Wilson 2006). This type of approach predicts strong universal
21 tendencies in favor of phonetically motivated patterns, but allows “unnatural” patterns to
22 surface in grammars and be learned by speakers.

1 Tone sandhi patterns in Chinese dialects provide us with many opportunities to
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4 1 test the analytical bias hypothesis: if the productivity of a sandhi pattern in novel words is
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6 2 correlated with the phonetic nature of the sandhi, in that a pattern with a stronger
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8 3 phonetic basis is more productive than one with a weaker phonetic basis, then despite the
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10 4 exceptions to the markedness generalizations, there is still an analytical bias in favor of
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12 5 the phonetically unmarked pattern.
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17 To conduct this type of studies, we need two tone sandhi patterns in a Chinese
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19 8 dialect that satisfy the following conditions: (a) they have comparable triggering
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21 9 environments; (b) they are of comparable productivity in the native lexicon; (c) they have
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23 10 comparable frequencies of occurrence in the native lexicon; and (d) they differ in their
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25 11 degrees of phonetic motivation. Zhang and Lai (2010) investigated the productivity
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27 12 difference between the “third-tone sandhi” (213 → 35 / __ 213) and the “half-third
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29 13 sandhi” (213 → 21 / __ T, T ≠ 213) in Mandarin Chinese with promising results. Upon
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31 14 arguing that the “half-third sandhi” has a stronger phonetic basis than the “third-tone
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33 15 sandhi,” Zhang and Lai showed that the former applies more productively to novel words
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35 16 than the latter in two wug-test experiments, thus supporting the analytical bias approach
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37 17 to phonetically based markedness. There are many other Chinese dialects, especially the
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39 18 Wu and Min dialects, that have considerably more intricate patterns of tone sandhi than
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41 19 Mandarin, and we can often find differences in the degree of phonetic motivation among
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43 20 the sandhi patterns in these dialects. The productivity of the sandhi patterns may be
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45 21 investigated by wug tests in these dialects as well to further shed light on the issue of
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47 22 tonal markedness and the phonetics-phonology interface debate. The suggestion, then, is
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49 23 to be more ambitious in the *methodology* of data collection to allow data that are
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3 1 informative to the markedness issue to surface. The likely theoretical consequence is that
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5 2 although many sandhi patterns may still need to listed, there may be analytical biases in
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7 3 favor of the less marked ones in the learning process, thus giving them an advantage in
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9 4 typological occurrence and productivity, but in the meantime allowing marked patterns to
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11 5 exist (see for example, Zhang and Lai 2008, Zhang, Lai, and Sailor 2009, forthcoming).
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18 3.4 OTHER ISSUES

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22 9 In this section, I briefly outline a number of other unresolved issues that are
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24 10 important to the study of Chinese tone and tone sandhi.
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29 12 3.4.1 Structure-sensitive tone sandhi

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34 14 The tone sandhi behavior in Chinese dialects is often sensitive to the
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36 15 morphosyntactic structure of the word. For example, in Shanghai, modifier-noun
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38 16 disyllabic words invariably have a left-dominant sandhi pattern that involves tone
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40 17 spreading from the first syllable; but verb-object disyllabic words, especially ones with
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42 18 low frequencies of occurrence, often have a right-dominant sandhi pattern that involves
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44 19 contour reduction on the initial syllable (Xu 1988, Zhu 2006). In Pingyao, words with a
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46 20 subject-predict or verb-object structure also have a different set of tone sandhi behavior
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48 21 from words with other structures, such as modifier-noun (Hou 1980). Whether the sandhi
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50 22 difference is morphosyntactically based or prosodically based is controversial, and the
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52 23 productivity of these sandhi patterns in novel contexts is largely unknown. The
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1 investigation of this issue will shed light on the interface between phonology and
2 morphosyntax.

3 4 3.4.2 The relation between tone sandhi and stress

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6 Related to the morphosyntactic dependency in tone sandhi is the relation between
7 tone sandhi and stress. Duanmu (2007) argued that compounds in Mandarin Chinese have
8 grammatical stress determined by the “Nonhead Stress” principle of Cinque (1993); e.g.,
9 a disyllabic modifier-noun compound has stress on the initial syllable, while a disyllabic
10 verb-object compound has stress on the final syllable. Despite the fact that such stress has
11 no clear acoustic correlates in duration or pitch due to the tonal nature of the language,
12 Duanmu showed that it must exist based on generalizations about the length and ordering
13 of different grammatical components in compounds in Mandarin. Duanmu (1995) applied
14 similar arguments to Shanghai and Taiwanese and showed that modifier-noun
15 compounds have initial stress in Shanghai, but final stress in Taiwanese. In dialects with
16 structure-sensitive tone sandhi, the directionality of the sandhi is often correlated with the
17 location of grammatical stress, such as the Shanghai pattern mentioned above. It remains
18 to be seen whether grammatical stress similarly established in other dialects of Chinese
19 also lacks acoustic correlates typically associated with stress (but see Zhu 1999 for
20 Shanghai), but in any event, the relevance of this prosodic factor complicates the search
21 for the cause of structure-sensitive tone sandhi.

22 Stress that is independent of morphosyntactic structure has also been reported in
23 Chinese dialects, and its relation to tone sandhi has been an uncomfortable one in the

1 study of Chinese tone. For example, Rose (1990) reported that in the Northern Wu dialect
2 Zhenhai, disyllabic words with MH or H on the first syllable have initial stress, while
3 those with ML or L on the first syllable have final stress; this stress pattern was
4 confirmed by native speaker perception. The tone sandhi pattern in Zhenhai, however, is
5 not easily predicted by this stress pattern, and Li (2003, 2005) showed that a good
6 understanding of the pattern can only be achieved when we carefully tease apart the
7 interaction between this tonally induced stress and initial prominence, which provides the
8 initial syllable with a longer duration. In the Southern Wu dialect Wenzhou, both an
9 experience fieldworker (Zhengzhang 1964) and a native speaker (Cao 2003) reported
10 initial stress, yet the tone sandhi pattern of the language is largely right-dominant with
11 tonal neutralization on the initial syllable. In Danyang, a Northern Wu dialect, stress is
12 initial, as reported by Lü (1980), yet a subset of the sandhi patterns is right-dominant, as
13 argued by Chan (1991). Chan (1995) subsequently offered a diachronic explanation for
14 the mismatch between stress and sandhi direction: the right-dominant sandhi pattern is a
15 vestige of a historical stage of the language with final stress.

16 What is often lacking in these sources is again careful phonetic descriptions of the
17 acoustic correlates for stress and tone like Rose did for Zhenhai. A comparison of
18 productivity between sandhi patterns that agree with stress assignments and those that do
19 not will likely also be enlightening. It is hoped that careful empirical studies will go
20 hand-in-hand with theoretical advances to shed light on the relation between stress and
21 tone, especially in languages where they seem to conflict with each other.

22 Finally, many Chinese dialects also have lexically specified stressless syllables.
23 These syllables are often referred to as “*qing sheng*” (“light sound”) and bear the “neutral

1 tone.” For example, in Beijing Chinese, *qing sheng* can appear with both grammatical
2 morphemes (*tjow55 le0* “lose-perf.”) and lexical morphemes (*ts^huŋ55 miŋ0* “smart”).
3 These stressless syllables usually have a drastically reduced duration, and
4 correspondingly, drastically reduced tonal inventories. Beijing Chinese, for example, has
5 no contrastive tone on this type of syllables. There does not seem to be a mismatch
6 between this type of stress, or rather, stresslessness, and tone. This is another indication
7 that a good understanding of tonal behaviors needs to come from empirical phonetic data
8 beyond pure transcription labels such as [-stress].

9 10 3.4.3 Tone sandhi in longer sequences

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12 Tone sandhi often applies to sequences longer than two syllables. This is well
13 documented in many Chinese dialects, e.g., Mandarin (Shih 1986), Taiwanese (Chen
14 1987, Lin 1994), Pingyao (Hou 1982a, b), Shanghai (Xu and Tang 1988, Zhu 2006), and
15 Tianjin (Li and Liu 1985). The sandhi behavior may be sensitive to the morphosyntactic
16 structure of the sequence (Mandarin, Taiwanese, Pingyao, Shanghai), but may not
17 (Tianjin). The analysis of this type of sandhi has significant implications for our
18 understanding of tone sandhi domain, the correspondence between morphological related
19 forms, and the structure of the grammar as either derivational or parallel. For example,
20 the tone sandhi behavior in trisyllabic words and phrases in Tianjin has garnered
21 considerable attention in recent years due to its conflicting directionality in sandhi
22 application and contributed to the theories of markedness and correspondence (e.g., Chen
23 2000, Lin 2008, Wee 2010). Many of the longer sequences are phrases, therefore, the

1 productivity of the sandhi pattern is less in doubt. But the field still has much to gain
2 from careful phonetic and psycholinguistic testing of the patterns without purely relying
3 on impressionistic transcriptions of the original fieldworkers.

4

5 *4. Summary*

6

7 I have reviewed some past and current issues in the analysis of Chinese tone in
8 this article. In particular, I have pointed out how the development of theoretical
9 phonology has shaped the highs and lows of this research enterprise and how the research
10 may fruitfully proceed into the future. My plea to phonologists working in this area is for
11 them to cultivate a new respect for empirical data based on well designed phonetic and
12 psycholinguistic studies. Speakers' knowledge of tone and tone sandhi may not be
13 identical to their patterns in the lexicon, and impressionistic transcriptions, no matter how
14 careful, have their limitations. Patterns of tone in Chinese are rich in variation, gradience,
15 and exceptions due to dialectal contact and the influence from the dominant Standard
16 Chinese, and existing research has shown that the productivity of Chinese tone sandhi
17 patterns is influenced by both categorical factors such as phonological opacity and
18 gradient factors such as the phonetic nature and the frequency of usage of the sandhi.
19 With a renewed interest in the nature of the data, the study of Chinese tone is poised to
20 make continued contributions to the development of phonological theory, and more
21 importantly, to our understanding of speakers' phonological knowledge.

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 11 4 *Notes*

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 14 ¹ Tones here are transcribed in Chao numbers (Chao 1948, 1968), where “5” and
 15 “1” indicate the highest and lowest pitches in the speaker’s pitch range, respectively.

16
 17 Juxtaposed numbers represent contour tones; e.g., “51” indicates a falling tone from the
 18 highest pitch to the lowest pitch. The glossaries for the examples are:

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 23 *ma55/ma35/ma213/ma51*: mother/hemp/horse/to scold

24
 25
 26 *sow55/sow35/sow213/sow51*: to collect/ripe/hand/to receive

27
 28
 29 *t^haŋ55/t^haŋ35/t^haŋ213/t^haŋ51*: soup/sugar/to lie down/hot (in temperature)

30
 31
 32 *ci55/ci35/ci213/ci51*: west/mat/to like/opera

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 34
 35 ² Although this sandhi involves incomplete neutralization production-wise, the
 36 difference between the sandhi tone and Tone 2 cannot be reliably perceived by native
 37 adult listeners (Peng 2000). The neutralization is therefore real in the perceptual domain.

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4 Even this markedness generalization may arguably have exceptions. There are occasional Chinese dialects whose full tonal inventory is only realized in sandhi forms, but partly neutralized in monosyllabic isolation forms. For example, in Pingyao (Hou 1980), the tone 13 has two different sets of sandhi behavior when appearing on the initial syllable of disyllabic words with certain grammatical structures. Essentially, the analysis needs to recognize that two different underlying tones are neutralized in monosyllabic forms, but surface distinctly in disyllabic forms. However, Pingyao is not a typical right-dominant language — the second syllable of disyllabic words also undergoes sandhi in Pingyao. Therefore, the realization of the tonal contrast on the first syllable is not confined to the duration of the first syllable. In fact, only a limited number of di-tonal combinations occur in disyllables, indicating neutralization of tonal patterns found in disyllable. Whether there exist true exceptions to the durationally based markedness generalization requires further research.