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Issues in the Analysis of Chinese Tone

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Abstract

Chinese tone has played an important role in the development of phonological theory from distinctive features and autosegmental phonology to Optimality Theory and its various adaptations. This article reviews some past and current issues in the analysis of Chinese tone and points out how the development of theoretical phonology has shaped the highs and lows of this research enterprise. To fruitfully proceed into the future, I plead to phonologists working in this area to cultivate a new respect for empirical data based on well-designed phonetic and psycholinguistic studies. This is necessitated by the observations that speakers' knowledge of tone and tone sandhi may not be identical to their patterns in the lexicon, and impressionistic transcriptions, no matter how careful, can be inaccurate. Moreover, patterns of tone in Chinese are rich in variation, gradience, and exceptions due to dialectal contact and the influence from the dominant Standard Chinese, and existing research has shown that the productivity of Chinese tone sandhi patterns is influenced by both categorical factors such as phonological opacity and gradient factors such as the phonetic nature and the frequency of usage of the sandhi. An empirical basis built around these issues will allow the study of Chinese tone to make continued contributions to the development of phonological theory and our understanding of speakers' phonological knowledge.

1. Introduction

It is well known that Chinese languages are tonal, in that the pitch with which a syllable is uttered can cue meaning differences. This is aptly illustrated by the familiar quadruplet *ma55/ma35/ma213/ma51* 'mother/hemp/horse/to scold' as well as many other examples in Standard Chinese (henceforth SC).[1]

Chinese tone has also played an important role in the development of phonological theory. Its significance to generative phonology was first noted by 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 derivation. With the advent of autosegmental phonology (Goldsmith 1976) and feature geometry (Clements 1985; Sagey 1990), a large body of literature on Chinese tone 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 theoretical phonology readership (e.g. Bao 1990, 1999; Chan 1985, 1991; Chen 1996; Duanmu 1990, 1994; Yip 1980, 1989, 1995). The field of phonology continued to develop, most notably with Optimality Theory (Prince and Smolensky 1993/2004) and its various renditions such as Stochastic OT (Boersma and Hayes 2001), Harmonic Grammar (Smolensky and Legendre 2006), and Maximum Entropy Grammar (Goldwater and Johnson 2003; Jäger 2007), but the study of Chinese tone somehow stagnated. In this review article, I discuss a number of reasons for this hopefully temporary stagnation and point to a few directions in which the analysis of Chinese tone may fruitfully proceed.

2. Chinese Tone in Generative Phonology

2.1. REPRESENTATION ISSUES

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

(1) a. What is the Tone Bearing Unit (TBU)? Is it the syllable, the rhyme, the sonorous portion of the rhyme, or the mora?
b. What are the primitive features of tone? How many level-tone features are needed, and are contour tones represented by unitary features or sequences of level features?
c. If there are different layers of tonal features such as Register (representing the overall pitch height) and Contour (representing TBU-internal pitch change), what is the geometric relation among the features – independence, dominance, or sisterhood?

Based on answers to these questions, a high falling tone over a syllable can be represented as one of the five representations in (2). The TBU in (2a)–(2d) can be the syllable, the rhyme, or the sonorous portion of the rhyme, whereas the TBU in (2e) is the mora. (2a) represents the contour tone as a single unit with a [+fall] feature (Wang 1967). (2b)–(2d) assume two levels of tonal representation – Register (High/Low) and Contour (high/low). These two features may be in an independence [(2b); Yip 1980], dominance [(2c); Yip 1989, 1995], or sisterhood relation [(2d); Bao 1990, 1999]. (2e) represents the contour tone as a sequence of two level tones with no contour tone unit (Duanmu 1990, 1994). In (2b)–(2e), the Register and Contour features may take on different numbers of levels, but binary distinctions H/L and h/l are the most commonly assumed.

(2) a. TBU
[+fall]

b. H
TBU
h l

c. TBU
H
h l

d. TBU
r c
H h l

e. TBU TBU
H h H l

2.2. TONE SANDHI IN CHINESE DIALECTS

The arguments for a specific tonal representation primarily come from tone sandhi patterns in Chinese dialects, which are tonal alternations caused by the juxtaposition of tones or by placing a tone in a particular prosodic or morphosyntactic context. For example, in SC, 213 becomes 35 before another 213 (3a), and in Taiwanese, a tone undergoes regular changes whenever it appears in non-XP-final positions (3b) (Chen 1987; Lin 1994).

(3) Tone sandhi examples:

a. Tonally induced tone sandhi — SC "third-tone sandhi":
213 → 35 / ___ 213

b. Positionally induced tone sandhi — Taiwanese "tone circle":
51 → 55 → 33 ← 24 in non-XP-final positions
↖ ↙
21

The typology of tone sandhi in Chinese languages is well studied. This is due to collective efforts from both Chinese dialectologists who publish careful descriptions of the dialects[2] and theoretical linguists who make generalizations of the patterns observed in these descriptions. Influential dissertations by Yip (1980), Wright (1983), Bao (1990), and Duanmu (1990), typological works by Yue-Hashimoto (1987) and Bao (2004), as well as a long line of work by Chen (1991, 1992, 1996) that culminated in his seminal tome on tone sandhi (Chen 2000) have all made important contributions to our understanding of Chinese tone sandhi.

Crudely speaking, tone sandhi patterns in Chinese fall under two types: 'right-dominant' and 'left-dominant' (Yue-Hashimoto 1987; Chen 2000; Zhang 2007). Right-dominant sandhi, found in most Min, Southern Wu, and Mandarin dialects,[3] preserves the base tone on the final syllable in a sandhi domain – the grammatical domain over which sandhi generalizations are stated – and changes the tones on nonfinal syllables. Left-dominant sandhi, typified by Northern Wu dialects, preserves the tone on the initial syllable. Zhang (2007) argues that there is an asymmetry in how the sandhi behaves based on directionality, in that right-dominant sandhi tends to involve local or paradigmatic tone change, while left-dominant sandhi tends to involve the extension of the initial tone rightward. This asymmetry can be seen in the right-dominant examples in (3) and the left-dominant examples in (4): both the tonally induced 'third-tone sandhi' in SC (Mandarin) and the positionally induced 'tone circle' in Taiwanese (Min) involve local paradigmatic tone change, whereas the sandhi in Changzhou (Northern Wu) spreads the tone on the first syllable across the entire sandhi domain (Wang 1988).[4]

(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

2.3. TONE SANDHI AND TONAL REPRESENTATION

The influence of tone sandhi patterns on decisions of tonal representation is multilayered. For instance, whether contour tones should be treated as representational units depends on whether there are cases of tone sandhi where the whole contour tone spreads onto adjacent syllables; the formal relation between Register and Contour rests on whether the

register and contour shape of the tone can spread independently in tone sandhi. A review of these issues can be found in Yip (1995).

In the backdrop of these representational issues, significant progress was made in identifying the differences in tonal properties between Chinese and African languages. These differences are aptly summarized in Wan and Jaeger (1998:426–7): for African languages, tone patterns are often associated with polysyllabic phonological words and serve grammatical functions, but for Asian languages like Chinese, tones are associated with individual syllables and predominantly serve a lexical function; African languages typically have a register-based tone system with two or three tonal levels, while Chinese languages usually have a contour-based system with multiple contour tones. However, the field eventually did not reach a consensus on any aspect of tonal representation in Chinese languages. This is likely due to the following reasons.

First, the data sources for Chinese tone sandhi often come from field descriptions done by traditionally trained dialectologists. These descriptions, though detailed and careful, are primarily based on impressionistic transcriptions. The transcription of tones is notoriously difficult, and even seasoned fieldworkers may disagree on transcriptions in the same language. For example, the tonal inventory of Tianjin Chinese has been described in three different ways by three different sources, as shown in (5). In Shi's description, Tones 1 and 2 are considered level tones, whereas the other two descriptions treat them as contour tones; in Li and Liu's description, Tone 3 is treated as a complex concave contour, whereas the other two descriptions treat it as a simple contour. These discrepancies have profound effects on how the tonal patterns are analyzed. For instance, the sandhi Tone 4 → Tone 2/__ Tone 1 can be interpreted as resulting from a markedness restriction against two falling contours (5b, c) or two adjacent low pitch targets (5a), and the structural change can be interpreted as the metathesis of two Contour features (5b, c) or simply the deletion of one of them (5a). In other words, an arbitrary choice of which source to consult can completely change the analysis and hence the tonal representation that it supports or rejects.[5]

(5) Tianjin tonal inventory:

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

Furthermore, tone sandhi patterns are complex both in individual languages and typologically. Phonologists who use sandhi patterns to argue for particular tonal representations are often content with accounting for a small corner of the entire sandhi system of the language. Consequently, even if the tonal representation helps the analysis of the sandhi patterns in question, it often does not guarantee the analytical success of the entire sandhi system, nor does it necessarily guarantee that the tone sandhi typology overall will benefit from the representation. Therefore, for both theoretical phonologists and Chinese dialectologists alike, such theoretical attempts are often met with hesitance, leading to the lack of consensus.

2.4. TONE SANDHI AND OPTIMALITY THEORY

During the 1990s, Optimality Theory brought to the forefront the issues of markedness and constraint interaction, whereas representational issues such as the feature-geometric structure of segments and tones somewhat receded to the background. The field of Chinese tonology was excited to see whether OT brought new possibilities in accounting for the complex tone sandhi patterns in synchronic phonology. The many gallant attempts (e.g. Chen 2000; Hsiao and Chiu 2006; Jiang-King 1996; Lin 2008; Wang 2002; Wee 2004, 2010; Yip 1999, 2004; Zhang 1999), however, were only met with limited enthusiasm in the field. Many scholars remain unconvinced that OT is an appropriate model for complex sandhi processes (e.g. see Bao 2003), and synchronic analysis remains lacking for many sandhi systems. Chen (2004), for example, goes on to show that Changting Hakka tone sandhi cannot be reasonably analyzed with current theoretical apparatuses available to an OT phonologist.

One reason for the lack of success is that, due to tone's fickle phonetic nature, diachronic sound changes have often wiped out the markedness motivations for the present-day tone sandhi; consequently, many sandhi processes appear phonetically arbitrary synchronically. For instance, the 'third-tone sandhi' in SC corresponds to a historical sandhi pattern *shang* → *yang ping*/__ *shang*, where *shang* and *yang ping* refer to the historical tonal categories from which 213 and 35 descended, respectively.[6] This pattern dates back to at least the 16th century (Mei 1977) and has different synchronic renditions in other Mandarin dialects: e.g. in Jinan, it is 55 → 42/__ 55 (Qian and Zhu 1998), and in Taiyuan, it is 53 → 11/__ 53 (Wen and Shen 1999). This makes markedness motivations in synchronic sandhi systems difficult to come by. Therefore, if we look for generalizable markedness constraints that OT relies on for the synchronic analysis of tone sandi, we tend not to get very far. Put broadly, the recent theoretical development, though fruitful in many areas of phonology, does not seem to have effectively benefited the analysis of Chinese tone sandhi.

3. Directions for Chinese Tone Research

3.1. REBUILDING AN EMPIRICAL FOUNDATION

In order to make theoretical and analytical progress in Chinese tone research, the most urgent and fruitful step in my opinion is to rebuild an empirical foundation from which theoretical analyses may proceed. This has two connotations.

First, due to the uncertainty of impressionistic transcription of tones mentioned above, we need carefully designed phonetic studies that systematically look at the realizations of tones in tone sandhi behavior. Such studies are not only helpful in clarifying the facts, but also useful in our search for the formal representation of tone. For instance, based on a series of work that investigates the detailed phonetic realizations of SC tones under different tonal contexts and speaking rates, Xu argues that phenomena such as coarticulation and peak delay are better accounted for if the contour tone targets are unitary [fall] and [rise], not a concatenation of [high] and [low] (Xu 1998, 2001; Xu and Wang 2001).

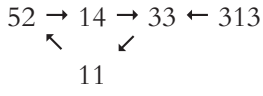
The second and possibly more important connotation stems from the classic point raised by Kenstowicz and Kisseberth (1979:Ch. 5): *corpus-internal evidence* such as sound distributions and lexical alternations, though highly practical, only indirectly reflects the speakers' phonological knowledge and should be complemented by *corpus-external evidence* gleaned from language games, speech errors, loanwords, and phonetic and

psycholinguistic experimentation that demonstrates the psychological reality of the elicited sound patterns. Crucially, recent studies have found that speakers' phonological knowledge does not always match the lexical patterns. For example, Zuraw (2007) showed that Tagalog speakers possess knowledge of the splittability of word-initial consonant clusters that their lexicon does not inform them of, and they can apply the knowledge to infixation to stems with novel initial clusters; on the other hand, Sanders (2001) demonstrated that in Polish, the counterbleeding interaction between o-Raising and Final Devoicing is not productive in novel words, even though the pattern is well established in the Polish lexicon. Provided that our goal is to understand the speakers' tacit knowledge of sound patterning, the testing of the productivity of phonological patterns is then an indispensable aspect of phonological research.

We can further illustrate this point with Taiwanese tone sandhi. The circular chain shift pattern in (3b) has presented serious challenges to both rule- and constraint-based frameworks. The earliest generative analysis of Taiwanese tone sandhi appeared in Wang (1967), who accounted for the entire sandhi pattern by one single rule [αhigh, βfall] $\rightarrow$ [βhigh, -αfall]. However, the use of variable feature coefficients is typologically extremely rare, even in the context of Chinese tone sandhi systems (Chen 2000: 43), and the analysis was criticized by Anderson (1978:157) as 'remarkably ingenious', but expressing no 'linguistically significant generalization'.

In a constraint-based framework, circular chain shift has been shown to be incomputable by a 'conservative' OT grammar that uses only IO-faithfulness and markedness constraints (Moreton 2004). Using additional mechanisms such as anti-faithfulness (Alderete 2001) and contrast preservation (Lubowicz 2003), various analyses have also been proposed (Hsieh 2005; Barrie 2006; Thomas 2008). But these analyses invariably rely on the tonal values of Taiwanese in order to predict the exact way the chain is formed. A problem with these analyses, as pointed out by Chen (2000), is that a number of Southern Min dialects have essentially the same tone circle pattern as Taiwanese, but different tonal values at each point in the chain; e.g. Longxi, as in (6). The similarity among these dialects originated from the proto-language that had the same tone circle pattern in the historical tonal categories. But given that the Taiwanese analyses crucially rely on the tonal values of Taiwanese, this means that the tonal grammar of these other dialects will be drastically different from Taiwanese despite the similarity of their overall patterns and their close genetic affinity. This seems counterintuitive.

(6) Longxi tone sandhi:



However, if we look at the tone sandhi from the perspective of the speakers' knowledge, we realize that the picture is very different from the tone circle in (3b). Early experimental works by Hsieh (1970, 1975, 1976) and Wang (1993) showed that despite the exceptionlessness of the sandhi pattern in the Taiwanese lexicon, the sandhis are largely unproductive when speakers are tested with novel words in a 'wug' test (Berko 1958). A series of new experiments by Zhang and colleagues (Zhang and Lai 2008; Zhang et al. 2009, forthcoming) further quantified the productivity results in a number of morphological contexts and showed that sandhi productivity is not only negatively affected by the opacity of the pattern, but also influenced by the lexical frequency and

phonetic nature of the pattern. To this end, Zhang and colleagues proposed stochastic grammars and learning models that can capture both the exceptionless sandhi behavior in the Taiwanese lexicon and the variable sandhi productivity in novel words using extensive lexical listing constraints. The approach echoes Tsay and Myers' (1996) theory of allomorph selection for Taiwanese tone sandhi and Yip's (2004) analysis for tone sandhi in Zahao, a Tibeto-Burman language that has similar tonal properties to southern dialects of Chinese.

The lesson that we learned from these experimental works is that what synchronic phonology needs to account for can be very different from the sandhi patterns observed in the lexicon. The current research into these complex systems often either takes the systems at face value and devises intricate theoretical machineries that 'strike students of human language as essentially arbitrary and fortuitous' (Chen 2000:43), or takes a somewhat pessimistic approach that declares the irrelevance of the phonetic renditions of the tones in present-day dialects. But as we have seen, neither the complacency from an ingenious analysis nor the admission of defeat is terribly warranted. It may be the case that there is good reason for the lack of a straightforward synchronic analysis for a pattern, as the pattern is simply unproductive! Even for those lexical patterns for which an analysis seems readily available, the question of whether they are a true reflection of the speakers' knowledge is still relevant. In other words, we need to go back and ask a more basic question about the empirical data: which parts of the patterns are productive, and which parts are not?

Like phonetic research, psycholinguistic experimentation is also useful in our understanding of tonal representation. For instance, based on the tonal errors observed in a corpus of Taiwan Mandarin speech errors, Wan and Jaeger (1998) argued that Mandarin tones are unitary and not composed of tonal sequences or different levels of tonal representations, as the tonal errors are characterized by a predominance of whole-tone substitution errors, a lack of tone splitting or hybrid tones in word-blend and telescoping errors, and a lack of errors that must be accounted for by register or tone feature spreading. These properties of Mandarin tone would not have come to the surface had we only focused on observable sandhi patterns in the language itself to the exclusion of such 'external' evidence.

3.2. VARIATION, GRADIENCE, AND EXCEPTIONS IN CHINESE TONE

In a recent trend, phonological research is paying increasingly close attention to the roles of variation, gradience, and exceptions in the grammar. Observations that many phonological patterns are variable (e.g. Labov 1972, 1994), gradient (e.g. Bolinger 1961), and full of exceptions (e.g. Zimmer 1969) have been long-standing, but only recently did experimental works start to show that the observed variability, gradience, and patterns of exceptionality are reflected in the speakers' phonological knowledge and warrant formal phonological analyses (e.g. Zuraw 2000, 2007; Frisch and Zawaydeh 2001; Hayes and Londe 2006; Hayes et al. 2009), and variations of Optimality Theory such as Stochastic OT (Boersma and Hayes 2001), Harmonic Grammar (Smolensky and Legendre 2006), and Maximum Entropy Grammar (Goldwater and Johnson 2003; Jäger 2007) have been successfully applied to some of the experimental results to capture them formally. For a survey of issues related to the place of variation in phonological theory, see Coetzee and Pater (forthcoming).

The study of Chinese tone is well situated in the investigation of variation, gradience, and exceptions in phonological theory. As in other languages, the reasons for the

presence of these properties in Chinese are complex, but the following characteristics of modern Chinese dialects particularly stand out as factors that encourage variation and exceptions in their tonal patterns. First, different Chinese dialects may have very different tonal inventories and tone sandhi systems, but the vast improvement in transportation and media outreach as well as the mobility of a large migrant worker population have brought different dialects considerably closer to each other than in the past. The increased dialectal contact has caused greater instability of the phonological systems and created a fertile ground for variation and exceptions to appear in these systems. Second, with the promulgation of SC as the standard language in Mainland China, the phonological system of SC has had a strong influence on many Chinese dialects, especially Mandarin dialects that are similar to SC to begin with. Third, the difference between written and spoken Chinese has had a long history in China, and many dialects have lexical items with different pronunciations depending on the colloquial or literary style, causing variation.

Chinese linguists have long noted the effects of dialectal contact and the influence of a dominant standard language, and descriptive works that outline dialectal changes due to these two factors abound. For example, the changes within the Shanghai dialect from older to newer generations as a result of influence from other dialects were extensively documented in Xu and Tang (1988), Zhu (2006), You (2006a,b), among others. Based on acoustic results, Shi and Wang (2004) and Zhang and Liu (2009) discussed the variable changes in both the shapes of the lexical tones and tone sandhi patterns in Tianjin and how the changes may have derived from the dialect's close interaction with SC. The implications of these data for phonological theory, however, remain largely unexplored. It would be interesting to investigate what the synchronic grammar looks like to allow the variable patterns to surface and whether there is a model of the speaker that can predict the effects of contact on the phonological systems of the dialects in question.

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

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

3.3. THE SEARCH FOR MARKEDNESS

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

The first suggestion is that the markedness search needs to be *less ambitious*. In typological works on Chinese tone and tone sandhi (e.g. Yue-Hashimoto 1987; Chen 1991, 1992, 1996, 2000; Bao 1992; Chang 1992; Jiang-King 1999; Zhang 2002), many

markedness tendencies have been identified, but only one comes close to being a true universal: syllables that are rich in duration in their sonorous rhyme portion are better bearers of tonal contrasts. In other words, the following implicational statement seems universally true: if a syllable type with sonorous rhyme duration *d* can carry *n* tonal contrasts, then a syllable type with sonorous rhyme duration $d + d_0$ can carry at least *n* tonal contrasts. The syllable type parameters that may influence the sonorous rhyme duration of a syllable include the syllable's segmental composition, stress property, position in the word (final vs. nonfinal), and the number of syllables in the word that the syllable belongs to (Zhang 2002).

An example that illustrates this is the comparison between obstruent-closed syllables (CVO) and open/sonorant-closed syllables (CVV/CVR) in the size of their tonal inventories. In Chinese dialects with CVO syllables, the number of tones that they can carry is generally one or two, but the number of tones that can appear on CVV and CVR syllables is invariably larger. This finds correspondence in historical Chinese as well: there were only two tonal categories for CVO syllables (*yin ru* and *yang ru*), whereas there could be a maximum of six tonal categories on CVV/CVR syllables (*yin* and *yang* crossclassified with *ping*, *shang*, and *qu*).

The relation between the size of the tonal inventory and syllable duration is also manifested in tone sandhi patterns. Right-dominant sandhi systems often involve tonal neutralization in nonfinal syllables due to their lack of final lengthening effects (Zhang 2002). Both the SC and Taiwanese sandhi patterns in (3a) and (3b) involve the reduction of tonal contrasts by one in nonfinal position. In the Changzhou sandhi pattern in (4), the rightward tone spreading causes syllables in di- and trisyllabic words to lose the original tone contrasts except for the initial syllable, whereas monosyllabic words preserve all tonal contrasts.[7]

However, what often remains unpredictable is what the original tonal inventory will *neutralize to* under short duration. In both SC and Taiwanese, the historical basis for the tone sandhi is clear, but why 213 must neutralize to 35 in SC or why 24 and 55 must neutralize to 33 in Taiwanese is less so, as even if markedness principles can be proposed, they will not be easily generalizable to related dialects that have the same historical sandhi.

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

The second suggestion for the search for tonal markedness is for it to be *more ambitious*. As I have stated, many soft universals have been identified in typological works on tone and tone sandhi. For instance, (a) High tone is less marked than low Tone, simple contours are less marked than complex contours (Jiang-King 1999), and falling tones are less marked than rising tones (Zhang 2002); (b) right-dominant sandhi tends to involve paradigmatic tone change, whereas left-dominant sandhi often involves tone spreading (Zhang 2007); (c) contour tone leveling or simplification is common, whereas contouring or contour complication is rare (Yue-Hashimoto 1987); (d) tone-level assimilation is typically perseverative and quite common, whereas tone-level dissimilation is typically anticipatory and much rarer; (e) contour dissimilation (e.g. Rise-Rise → Fall-Rise) is considerably more common than contour assimilation (e.g. Rise-Fall → Fall-Fall) (Chang

1992; Chen 2000). All of these tendencies can find phonetic bases, from the dispreference for contour tones over a short duration (Zhang 2002) to the asymmetric properties of tonal coarticulation between assimilation and dissimilation (e.g. Gandour et al. 1994; Xu 1997). But all these tendencies also have many exceptions. Does this then mean that no synchronically useful markedness principles can be formulated?

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

Chinese tone sandhi provides us with many opportunities to test the analytical bias hypothesis: if the productivity of a sandhi pattern in novel words is correlated with the phonetic nature of the sandhi in that a pattern with a stronger phonetic basis is more productive than one with a weaker phonetic basis, then despite the exceptions to the markedness generalizations, there is still an analytical bias in favor of the phonetically unmarked pattern.

To conduct this type of study, we need two sandhi patterns that satisfy the following conditions: (a) they have comparable triggering environments; (b) they are of comparable productivity in the lexicon; (c) they have comparable lexical frequencies in the lexicon; and (d) they differ in their degrees of phonetic motivation. Zhang and Lai (2010) investigated the productivity difference between the 'third-tone sandhi' (213 → 35/__ 213) and the 'half-third sandhi' (213 → 21/__ T, T ≠ 213) in SC with promising results. Upon arguing that the 'half-third sandhi' has a stronger phonetic basis than the 'third-tone sandhi', Zhang and Lai showed that the former applies more productively to novel words than the latter in two wug-test experiments, thus supporting the analytical bias approach to phonetically based markedness.[8] There are likely many other Chinese dialects in which we can find sandhi patterns with different degrees of phonetic motivation, and testing the productivity of these sandhi patterns may further shed light on the issue of tonal markedness and the phonetics–phonology interface debate. The suggestion, then, is to be more ambitious in the *methodology* of data collection to allow data that are informative to the markedness issue to surface. The likely theoretical consequence is that although many sandhi patterns may still need to be listed, there may be analytical biases in favor of the less-marked ones in the learning process, thus giving them an advantage in typological occurrence and productivity, but in the meantime allowing marked patterns to exist.

3.4. OTHER ISSUES

3.4.1. Structure-sensitive tone sandhi

The tone sandhi behavior in Chinese dialects is often sensitive to the morphosyntactic structure of the word. For example, in Shanghai, modifier-noun disyllabic words have a left-dominant sandhi pattern that involves tone spreading from the first syllable; but verb-object disyllabic words, especially ones with low lexical frequencies, often have a right-dominant sandhi pattern that involves contour reduction on the initial syllable (Xu and Tang 1988; Zhu 2006). In Pingyao, words with a subject-predicate or verb-object structure also have a different set of tone sandhi behavior from words with other structures,

such as modifier-noun (Hou 1980). Whether the sandhi difference is morphosyntactically based or prosodically based is controversial, and the productivity of these sandhi patterns in novel contexts is largely unknown. The investigation of this issue will shed light on the interface between phonology and morphosyntax.

3.4.2. The relation between tone sandhi and stress

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

Stress that is independent of morphosyntactic structure has also been reported in Chinese dialects, and its relation to tone sandhi has been an uncomfortable one in the study of Chinese tone. For example, Rose (1990) reported that in the Northern Wu dialect Zhenhai, disyllabic words with MH or H on the first syllable have initial stress, whereas those with ML or L on the first syllable have final stress; this stress pattern was confirmed by native speaker perception. The tone sandhi pattern in Zhenhai, however, is not easily predicted by this stress pattern, and Li (2003, 2005) showed that a good understanding of the pattern can only be achieved when we carefully tease apart the interaction between this tonally induced stress and initial prominence, which provides the initial syllable with a longer duration. In the Southern Wu dialect Wenzhou, both an experienced fieldworker (Zhengzhang 1964) and a native speaker (Cao 2003) reported initial stress, yet the tone sandhi pattern of the language is largely right-dominant with tonal neutralization on the initial syllable. In Danyang, a Northern Wu dialect, stress is initial, as reported by Lü (1980), yet a subset of the sandhi patterns is right-dominant, as argued by Chan (1991). Chan (1995) subsequently offered a diachronic explanation for the mismatch between stress and sandhi direction: the right-dominant sandhi pattern is a vestige of a historical stage of the language with final stress.

What is often lacking in these sources is again careful phonetic descriptions of the acoustic correlates for stress and tone like Rose did for Zhenhai. A comparison of productivity between sandhi patterns that agree with stress assignments and those that do not will likely also be enlightening. It is hoped that empirical studies will go hand-in-hand with theoretical advances to shed light on the relation between stress and tone, especially in languages where they seem to conflict with each other.[9]

3.4.3. Tone sandhi in longer sequences

Tone sandhi often applies to sequences longer than two syllables. This is well documented in many Chinese dialects, e.g. SC (Shih 1986), Taiwanese (Chen 1987; Lin 1994), Pingyao (Hou 1982a,b), Shanghai (Xu and Tang 1988; Zhu 2006), and Tianjin

(Li and Liu 1985). The sandhi behavior may be sensitive to the morphosyntactic structure of the sequence (SC, Taiwanese, Pingyao, Shanghai), but may not be (Tianjin). The analysis of this type of sandhi has significant implications for our understanding of tone sandhi domain, the correspondence between morphologically related forms, and the structure of the grammar as either derivational or parallel. Many of the longer sequences are phrases, therefore, the productivity of the sandhi pattern is less in doubt. But the field still has much to gain from careful phonetic and psycholinguistic testing of the patterns without purely relying on impressionistic transcriptions of the original fieldworkers.

4. Summary

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

Short Biography

Jie Zhang is an Associate Professor in the Department of Linguistics at the University of Kansas. He holds an MA and a PhD in Linguistics from the University of California, Los Angeles, and previously worked as a Lecturer in the Department of Linguistics at Harvard University. As a theoretical phonologist, his research investigates the relevance of gradient factors such as phonetics and lexical frequency to speakers' phonological knowledge and aims to understand what a model of phonological competence would look like if the effects of these factors are incorporated. He is particularly interested in tone languages such as Chinese, and the main focus of his current research is on the productivity of complex tone sandhi patterns in a variety of Chinese dialects including Beijing, Tianjin, Shanghai, and Southern Min. His work has been funded by the National Science Foundation and the Chiang Ching-Kuo Foundation for Scholarly Exchange, and he has published in journals such as *Phonology*, *Lingua*, and *Journal of East Asian Linguistics*. A revised version of his dissertation 'The effects of duration and sonority on contour tone distribution' was published by Routledge in 2002.

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Notes

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[1] The segmental materials here are given in *Pinyin*, the official Romanization system used in Mainland China. Tones are transcribed in Chao numbers (Chao 1948, 1968), where '5' and '1' indicate the highest and lowest pitches in the speaker's pitch range, respectively. Juxtaposed numbers represent contour tones; e.g. '51' indicates a falling tone from the highest pitch to the lowest pitch.

[2] Two prominent Chinese journals – *Fangyan (Dialects)* and *Zhongguo Yuwen (Studies of the Chinese Language)* – are particularly instrumental in the publication of these descriptions.

[3] Chinese can be generally classified into seven dialect groups: Mandarin (Northern), Wu, Min, Yue, Keijia (Hakka), Xiang, and Gan (Yuan 1983). Within each dialect group, there are also many distinct dialects. Aside from historical and geographic factors, there are many linguistic criteria for dialectal grouping, from phonological, syntactic, to lexical. Norman (1990, 182), for example, proposes 10 features along which Chinese dialects often differ from each other, such as the pronunciation of the third-person pronoun and whether velars are palatalized before *i*. Most of our data here come from the larger and better studied Mandarin, Wu, Min, and Yue dialect groups. Among these groups, Wu, Min, and Yue have kept the historical obstruent codas whereas most Mandarin dialects have lost them; only Wu dialects have preserved the three-way contrasts in initial stops, whereas in other groups, the initial stop contrasts have generally been reduced to aspirated vs. unaspirated.

[4] As recognized by Zhang (2007: 261), this blanket statement does not account for the nuances of how the initial tone is mapped onto the entire sandhi domain, such as the change in pitch height of an underlying Tone 55. But the prevalence of the spreading pattern in not only Changzhou but also many related Northern Wu dialects indicates that this phenomenon is not purely accidental and deserves an analysis.

[5] Relatedly, the distinction between level tones and contour tones that is crucial to the representation issue may simply be ill-conceived due to this very reason. In Chinese languages, it is often difficult to argue for this distinction based on independent phonetic criteria alone. The choice then comes down to what makes the analysis workable and typologically sound, which to some extent depends on how tones are represented. To use these analyses to argue for tonal representations, then, runs the risk of being circular. This circularity is the point of contention on the representation of tones on obstruent-closed syllables (CVO) in Chinese dialects, for example. Duanmu (1990, 1994) argues that these syllables, like all other syllables in Chinese, are bimoraic. But due to the phonetic inability of obstruents to bear tone, these syllables only carry level tones on the surface. Zhang (2004), however, observes that tones on this type of syllables in dialects like Pingyao are in fact phonetically contour tones, only that the tonal contours are not as pronounced as those on open (CVV) and sonorant-closed (CVR) syllables. Consequently, bimoraicity cannot properly capture the tone bearing ability difference between CVO and CVV/CVR in these dialects.

[6] It is generally believed that Middle Chinese (circa AD 220–960) had four tonal categories *ping*, *shang*, *qu*, and *ru*. These four categories later each split into two according to the voicing of the initial obstruent – *yin* for voiceless and *yang* for voiced. The *yin/yang* distinction became contrastive when the voicing contrast was lost. The eight categories then underwent merging and splitting in different ways in different modern dialects.

[7] 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.

[8] Zhang and Lai (2010) also ruled out alternative approaches such as lexical frequency, priming, and the nature of lexical listing as being solely responsible for the results.

[9] There is another type of stress in Chinese: many Chinese dialects also have a type of lexically specified stressless syllables, referred to as '*qing sheng*' ('light sound'). For example, in Beijing Chinese, *qing sheng* can appear with both grammatical morphemes (*diou55 le0* 'lose-perfective') and lexical morphemes (*cong55 ming0* 'smart'). These stressless syllables usually have a drastically reduced duration, and correspondingly, drastically reduced tonal inventories. Beijing Chinese, for example, has no contrastive tone on this type of syllables. There does not seem to be a mismatch between this type of stress, or rather, stresslessness, and tone. This is another indication that a good understanding of tonal behaviors needs to come from empirical phonetic data beyond pure transcription labels such as [-stress].

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