DIPPING TONES IN MULTI-REGISTER AND FOUR-LEVEL MODEL

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ABSTRACT

This paper classifies dipping tones in the framework of the Multi-Register and Four-Level Model, using new, firsthand acoustic data. Seven dipping types are identified. Four of them are produced in normal clear voice and affiliated with the Modal Register: (1) Central Dipping, typologically transcribed as /323/, (2) Back Dipping /5<u>23</u>/, (3) Front Dipping /<u>32</u>4/, and (4) Double Circumflex /4343/. The remaining three are produced with non-clear voice qualities: (5) Breathy Dipping /**213**/ and (6) Creaky Dipping /**202**/ in the Lower Register, and (7) Discontinuous Fortis Dipping /<u>40</u>5/ in the Upper Register. Each of the seven dipping tones contrasts with one or another with four distinctive features [± RgM, ±RgL, ±H_{front}, ±H_{back}].

KEYWORDS

Tone **T**ypology **T**onotype **D**ipping **D**ouble Circumflex

1. INTRODUCTION

This paper purports (1) to identify and classify seven types of dipping tones in a theoretical framework called the Multi-Register and Four-Level Model (RLM)[2] (Zhu 2012a, 1–17) using our firsthand acoustic data newly collected; and (2) to propose a set of distinctive features to specify the identified dipping tones.

'Dipping' is one of the five major contour classes (Zhu and Yi 2011, 129–141; Cun and Zhu 2013, 1–11; Zhu 2014, 193–205), with the other four being Falling, Level, Rising, and Contour-Unspecified Low. The most familiar Beijing *shang* tone is considered a dipping contour, transcribed as [214] in the Five-Point Scale (FPS) (Chao 1930, 24–27) or {323} in the RLM. Although the dipping tone is not rare and occurs in hundreds of languages/dialects (Zhu and Yang 2010, 134–147; Zhu 2010, 2012a, 1–17), some of which even contain two (Qian 2001; Zhu 2012a, 1–17), and although tono-typological studies started decades ago (Wang 1967, 93–105; Cheng 1973, 222–238; Maddieson 1978, 335–365, etc.), until very recently did we know little, if not nothing, about its types. Recent discoveries of the Back Dipping and Double Circumflex Tone (Zhu and Yi 2012, 81–106), Front Dipping (Zhu, Zhang and Yi 2012, 420–436), Creaky Dipping (Zhu and Yang 2010, 134–147; Zhu 2012a, 1–17) and Discontinuous Fortis Dipping (Zhu, Liu and Hong 2011, 1–9; Zhu et al. 2012, 420–436) make it possible to build up a universal dipping-tone inventory.

This article identifies four clear-voiced dipping tonotypes and another three with non-clear voice, totaling seven. These tones are transcribed and represented in the RLM, which has up to three phonological registers, defined by phonation types. Each register has its own pitch range, which is divided into four levels, with each register one notch lower/higher in pitch than an adjacent one (Zhu 2012a, 1–17). Figure 1 shows a total of three registers and six pitch levels.

The three phonological registers, U(pper), M(odal) and L(ower) are defined by six groups or major types of phonation, which are categorized into 14 (sub-)types, as shown in table 1. All groups but Falsetto occur with dipping tones.
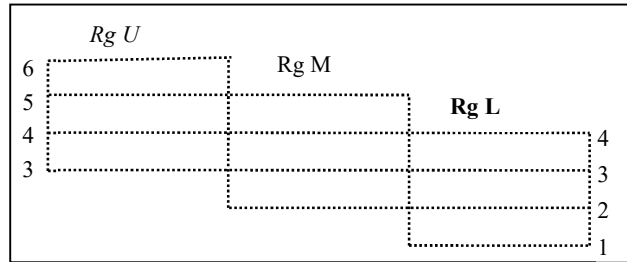
Figure 1 The Multi-Register and Four-Level tonal model (from Zhu (2012a), figure 1)

Table 1 Phonationals: fourteen phonation types and two supra-phonationals (from Zhu (2015), table 1, with adjustments for the terms and the order.)

Major type	Type	Notation	Supra-phonational	
I. Falsetto	1. Falsetto	pá	length	Long
II. Fortis	2. Discontinuous Fortis	pă		Mid-Short
	3. Final glottal stop/Ejective	paʔ/k'		Short
	4. Pre-glottal stop/Implosive	ʔp,ʔm/ɓa	pitch	2-way
III. Clear1	5. Voiceless (Unaspirated)	p,Øa,(ma)		3-degree
	6. Aspirated	pʰ,m̥a		4-level
	7. Weak Aspiration	p'a		
IV. Clear2	8. Modal Voice	b,ma		
VI. Breathy	9. Weak Slack	ṗa̤		
	10. Slack Voice	ṗ,m̤ä		
	11. Voiced Aspiration	b̤⁽ɦ⁾,ṗ⁽ɦ⁾ä		
V. Stiff	12. Checked Creak	p/ba̱		
	13. Creaky Voice	p/ba̱		
	14. Weak Stiff	p/ba̱		

Although neither phonation types nor registers are new in phonetics and phonology, the RL model is new in that the phonological registers in it are defined by phonation types exclusively and unambiguously. The relationships among pitch, registers and phonation types are shown in figure 2. Clear1 defines M Register, Falsetto defines U Register and Breathy defines L Register. The other three usually occur as phonetic variants; they only occasionally define a register alone. Under the framework of RLM, the tonotype builds itself with four parameters: register, length, pitch height and pitch contour.
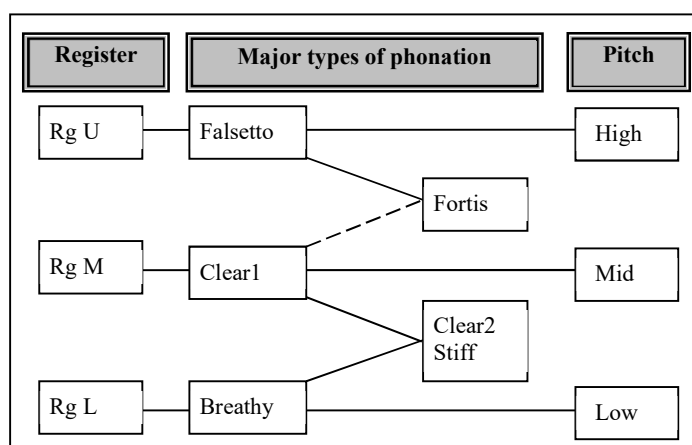
Figure 2 Three tonological registers defined by six phonation groups (from Zhu (2012a), figure 2)

Before proceeding we need to define or explain some terms. First, the 'tonotype', a new concept in phonology and typology, is characterized by three features:

(1) Each tonotype has its own defining acoustic and/or perceptual properties.
(2) A tonotype would contrast another in the same contour class in at least one language.
(3) A tonotype inventory is both adequate and necessary for defining all types of tones in all tone languages.

Tones in upper case such as 'Central Dipping Tone' refer to typological categories, while those in lower case such as 'creaky dipping contour/curve' refer to phonetic realizations.

Along an F0 curve, three parts can be identified, tonal 'head,' 'stem' and 'tail,' defined as the first 20%, the middle part, and the last 20% of the pitch curve, respectively. To follow the terminology of 'front/central/back' vowels, we use these three terms to name three types of dipping tones: Front/Central/Back Dipping, in accordance with the backness or positions of the dipping points along the F0 contour. So Front Dipping means a dipping point at the former part of an F0 curve, Back Dipping, the later part,

and Central Dipping, somewhere in-between. 'H$_{front}$' means the highest F0 value occurs at an earlier part of an F0 contour, and 'H$_{back}$' the later part.

For the purposes of cross-language comparisons and typological and evolutionary studies, tones are referred to in their historical categories: Vietnamese *ngang, huyền, sắc, nặng, hỏi, ngã* are coded as A1, A2, B1, B2, C1, and C2 respectively; Chinese *ping, shang, qu, ru, yin* and *yang* are coded as T1, T2, T3, T4, a and b respectively. Therefore, the language-specific and pedagogical term 'third tone' in Beijing Mandarin is referred to as T2 (*shangsheng*), and the other three Beijing tones as T1a, T1b, and T3, respectively. Tone values are placed in square brackets '[]' if transcribed in FPS. Tone codes are placed between curly brackets '{}' using RLM, and between slashes '//' when a contrastive tonotype has been established. Tone codes in Rg U are italicized, e.g., {*404*}, and boldfaced, e.g., {**212**}, when in Rg L.

2. FOUR DIPPING TYPES IN M REGISTER
2.1 Definition

The dipping tone is defined as having a fall-rise F0 contour with the turning point at the tonal stem, as opposed to the rising tone whose turning point, if any, appears at the tonal head (i.e., at the 20% or earlier of the F0 course). According to the front-back of the turning points, three types have been identified: the Front Dipping whose turning point is around 30% of the tonal duration, the Central Dipping around 40%, and the Back Dipping 50% or further back. Besides, there is a fourth type which has a fall-rise-fall contour with two turning points: the Double Circumflex Tone (DCT). Altogether, there are four dipping types in terms of F0 contour, which are exemplified in the four panels below.

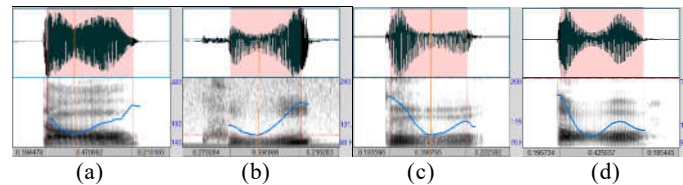(a)   (b)   (c)   (d)

Figure 3 Sample F0 curves for four dipping types (Panels a, b, and c are from Zhu et al. (2012), figure 13, 1, 8 respectively.) Panel (a) represents a Front Dipping T1a word [tau³²⁴]刀 'knife' in Zhongyuan 中原 Mandarin of downtown Zoucheng 邹城,

Shangdong Province, China, (b) a Central Dipping T2 word [xu^{324}]虎 'tiger' in Beijing Mandarin, (c) a Back Dipping T2a word [ku^{423}]古 'ancient' in the Northern Min variety of Dutou village 渡头, Shípí town 石陂镇, Pucheng County 蒲城, Fujian Province, and (d) a DCT T2 word [tau^{4232}]岛 'island' in the Qinjin Mandarin variety of Damajiashan village 大马家山 of Qingjian County 清涧, Shanxi Province 陕西, China.

The Central Dipping is the most common and, thus, the default type in the dipping family. It usually has a turning point around the 40% of its F0 contour (Zhu 1995). A typical example is T2 in Beijing Mandarin (Standard Chinese). Figure 3b gives a sample curve of Beijing T2, taken from Lin, Zhou and Cai (1998).

2.2 Back Dipping and DCT

The DCT and Back Dipping are two newly discovered contour tones (Zhu and Yi 2012, 81–106). The Back Dipping Tone is characterized by two features: (1) a turning point at about mid-way along its F0 contour, further back than that of the Central Dipping; and (2) a higher tonal head than the tail/peak, the third panel in figure 3 gives a sample Back Dipping tone from a Northern Min variety of Dutou.

The Double Circumflex Tone (DCT) has a fall-rise-fall pitch curve with two turning points. It is classified as a dipping tone typologically because it looks and sounds like a dipping tone. Synchronically, it often occurs as a phonemic variant of a dipping tone, and diachronically, it lies in the middle of an evolutionary route between Central Dipping and Back Dipping.

It is extremely rare to find a tripartite dipping contrast in one register. So far two such cases, both Gan varieties in Chaling County, Hunan Province, have been found. A Back Dipping, a DCT and a Central Dipping coexist in the villages of Changyuan 长远村, Majiang town 马江镇 (which has two falling tones besides the three dipping) and Buzhuang village 布庄村, Yaopi town 腰陂镇 (which has a falling and a level tone in addition). Average F0 curves and sample spectrograms of Changyuan are shown below.
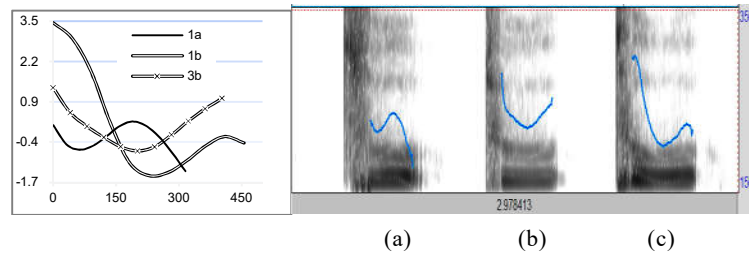
(a)   (b)   (c)

Figure 4 Tripartite dipping contrast in the Gan variety of Changyuan village 长远, Majiang town 马江镇, Chaling County 茶陵, Hunan Province. [Left] Log z-score normalized mean F0 curves of the Central Dipping, Back Dipping and DCT. [Right] Sample words (from left to right): (a) DCT T1a [tsʰu³²³²] 粗 'thick', (b) Central Dipping T3b [tʰu⁴³⁴] 度 'degree', (c) Back Dipping T1b [tʰu⁵²³] 图 'picture'.

Another sample contrast is presented in figure 5 which shows a pair of dipping tones, a Central Dipping {324} vs. a DCT {3232}, in Liyi Mandarin, Lingchuan County.
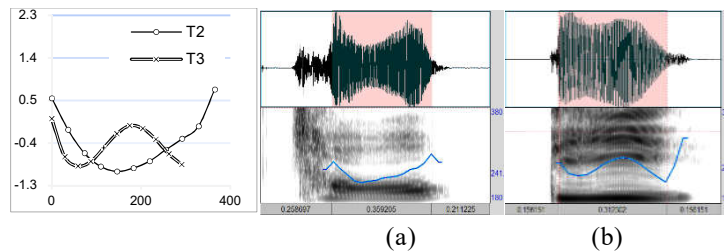

(a)   (b)

Figure 5 Central Dipping T2 {324} vs. DCT T3 {3232} in a Qinjin Mandarin 秦晋官话 variety of Liyi town 礼仪镇, Lingchuan County 陵川, Shanxi Province 山西. [Left] Log z-score normalized mean F0 curves. [Right] two sample words: (a) Central Dipping (phonetically, front dipping) T2 [tsʰau³²⁴] 草'grass', and (b) DCT T3 [ti³²³²] 第 'an auxiliary word for ordinal numbers'.

2.3 Front Dipping

A subtle and unstable type, the Front Dipping is the one between the Rising and the Central Dipping type. It is not rare to see a Front Dipping in contrast to a Back Dipping, as exemplified by figure 6, which contains sample patterns from Mandarin.
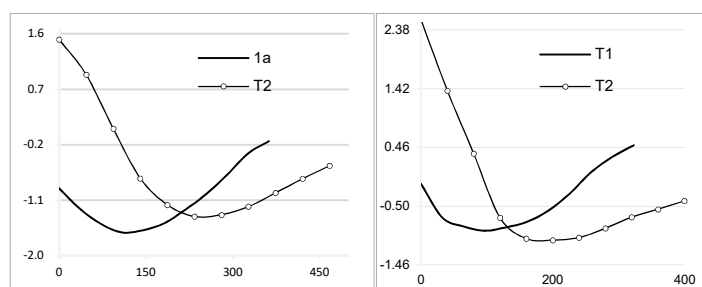
Figure 6 Log z-score normalized mean F0 curves of the Front Dipping {324} and Back Dipping {523} in two Qinjin Mandarin varieties used in Zhaizishan village 寨子山, Qikou town 碛口镇, Lin County 临县 (left panel), and in Nanliangshui village 南两水村, Sanjia-Xiang 三佳乡, Jiexiu County 介休 (right panel), Shanxi Province 山西.

The Zhaizishan and Nanliangshui cases are not decisive evidence to justify the typological status of the Front Dipping, as it could be phonologically analyzed as a phonetic variant of a Central Dipping. In many cases, such as Beijing T2, a Central Dipping tone is often phonetically realized as a front dipping contour. Only in a few cases have we found crucial evidence to justify the typological status of the Front Dipping as it contrasts with a Central Dipping. In figure 7, the first two panels contain two speakers' three F0 contours from Xinghua Mandarin. This Jianghuai Mandarin variety has 7 citation tones, five long and two short. Presented in the left two panels of figure 7 are the three with a rising shape at the rear part: T2 is a Central Dipping {323}, T1a is a Front Dipping {324}, and T1b a High Rising {35/45}, perfectly patterning, for speaker W1 on the left, with a turning point at different positions along their F0 curves: the rising T1b turns its curve at the 20% of the F0 duration, the Front Dipping at the 30%, and the Central Dipping at the 40%. The same pair of Front vs. Central Dipping tones is also shown for speaker M1 in the second panel, but his rising tone is simply rising without a dipping curve. In the right panel is a pair of Front and Central Dipping in the Zhangping-Xiang Mandarin. In a later section (§4.3) when discussing three contrastive dipping tones in a tonal system, we will give one more example of Front Dipping.
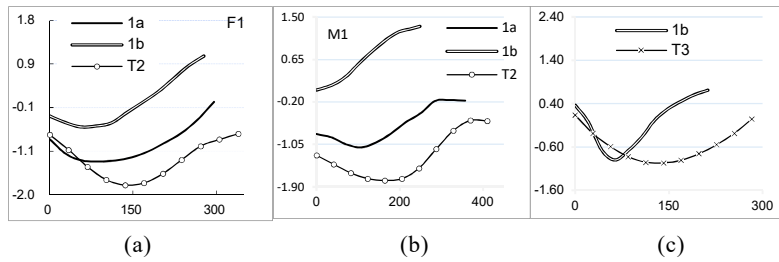
(a)   (b)   (c)

Figure 7 Log z-score normalized mean F0 curves of a Front Dipping T1a and a Central Dipping T2 for speaker F1 (panel a) and speaker M1 (panel b) from a Jianghuai Mandarin variety used in Xinghua 兴化 County, Jiangsu Province. The highest curve is a rising tone. Another pair of Front vs. Central Dipping in the Zhongyuan Mandarin variety of Zhangping-Xiang 张坪乡, Xunyang County 旬阳, Shanxi Province 陕西(panel c).

3. THREE DIPPING TYPES IN L OR U REGISTER

The dipping tones so far discussed have been all produced in clear voice and phonologically placed in the common M Register. This following section presents three dipping types with non-clear voices: Breathy and Creaky Dipping in L Register and Discontinuous Fortis Dipping in U Register.

3.1 Breathy Dipping in L Register

To illustrate the Breathy (or Slack) Dipping, figure 8 shows a pair of sample words from a Wu dialect, used in Kunshan, Jiangsu Province. T3b in Kunshan (on the left) is a Central Dipping *yang* tone with Breathy Voice. T3a (on the right) is a Back Dipping *yin* tone in M Register, produced with normal clear voice. Breathy Voice represents a salient feature for the Wu group of Chinese. As early as the 19th century, Edkins (1868) observed that the so-called "voiced" consonants in Shanghai Wu were, in fact, voiceless; however, they were different from normal voiceless consonants. He transcribed them with italic letters such as *p, t*, and *k*. These sounds were later confirmed by Chao (1928; 1967, 92–107) to be "voiceless…followed by voiced aspiration," or slack-voiced sounds (Cao and Maddieson 1992, 77–92).

The two dipping tones in figure 8 contrast with each other not only from its F0 contour (Central vs. Back Dipping) but phonation types

(Breathy vs. Clear1). The Breathy-voiced T3b is also accompanied by a slight creak. The Back Dipping in the right panel evolved from a DCT.
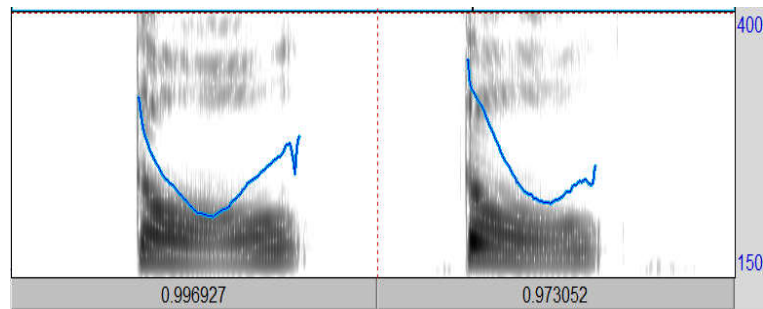

Figure 8 The contrast of two dipping tones in different registers in Kunshan 昆山 Wu, Jiangsu Province: Breathy Dipping T3b [t̪əu³²³] 渡 'ferry crossing' in L Register (left) vs. Back Dipping T3a [təu⁴²³] 妒 'envy' in M Register (right).

3.2 Creaky Dipping in L Register

Creaky or Stiff Dipping was first found in Huangyan Wu Shangsheng by Chao (1928), but termed as a 'broken tone'. Chao regarded it as a 'mid-glottal stop' which makes a syllable sound like two. It was found later not as a glottal stop, but a creaky voice (Zhu 2006, 121–133), usually an associated feature of a dipping tone (Zhu and Yang 2010, 134-147). In Beijing Mandarin, for example, a creaky {303} can be a free phonetic variant of the Central Dipping T2 {323}. This section will show the phonological contrast between two dipping tones in different registers: Central Dipping {323} in Rg M vs. Creaky Dipping {**202/303**} in Rg L. The creaky voice here becomes a distinctive feature. Figure 9 below contains a sample pair of a Central Dipping and a Creaky Dipping from a Jianghuai Mandarin variety, used in Wang'an village, Shou County, Anhui Province. T2 {323} and T1a {**303**} are both dipping tones. Their onset and offset F0 values and their duration are almost the same. The only difference lies in their phonation types: the former is in ordinary clear phonation and the latter creaky voice.
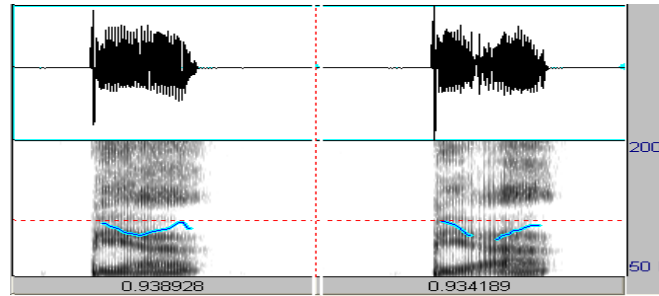
Figure 9 Central Dipping vs. Creaky Dipping in a Jianghuai 江淮 Mandarin variety used in Wang'an village 王安, Zhongxing town 众兴镇, Shou County 寿县, Anhui Province. T2 [piɛn³²³] 扁 'flat' in Rg M (left) vs. T1a [piɛn ³⁰³] 边 'side' in Rg L (right).

It is worthy of noting that in order to enhance the difference between the two dipping tones, a common Central Dipping tone could be produced as a rising-like Front Dipping {324} (figure 10), or even more, a para-rising {³23} or an absolute rising tone {24}. In figure 10, the two contrastive dipping tones from a Zhongyuan Mandarin variety, used in Tongshan County, Jiangsu Province, share the same onset height. The word 'think' (on the left) is produced in clear voice with a more forward turning point {324}, and the word 'rural' (on the right) has creaky voice with broken F0 contour in the middle. The Creaky Dipping in Rg L can be represented as /**202**/, with its phonetic realizations of {**202, 203, 302, 303**}.
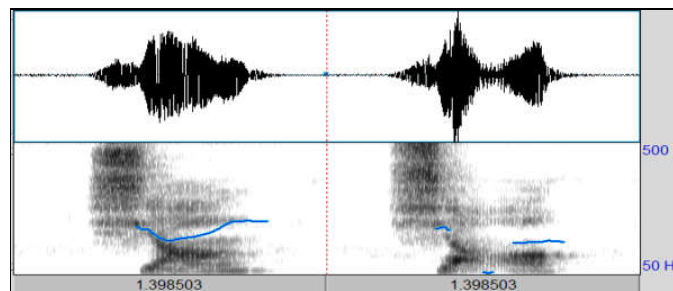

Figure 10 Front Dipping in M Register vs. Creaky Dipping in L Register, in Tongshan 铜山 Mandarin, Jiangsu Province: T2 [ɕiaŋ³²⁴] 想 'think' (left) vs. T1a [ɕiaŋ³⁰³] 乡 'rural' (right).

3.3 Discontinuous Fortis Dipping in U Register

Discontinuous Fortis Dipping in Rg U is the least common type in the dipping family. Below we will present three contrastive cases from an American Indian language, a Mandarin variety, and Vietnamese, respectively.

Dipping tones can occur in any of the three registers, as shown in figure 11. Cocuilotlatzala Mixtec is an American Indian language. Some Mexico and Central American indigenous languages are tonal. A rather rare three-way contrast of dipping tones is found in a Mixtec variety spoken in the city of Cocuilotlatzala. Mixtec belongs to the Otomanguean family used by about 500,000 people in the state of Guerrero, south of Mexico. Most of the Mixtec words are polysyllabic, with a tone on each syllable. There are monosyllabic words too. Figure 11 below presents a minimal set of the three-way contrast. The first sample in figure 11, [ɲia̠^{405}], is a Discontinuous Fortis Dipping in Rg U, typologically represented as /*405*/. The second is a common Central Dipping {323} in Rg M. And the third is a Creaky Dipping in Rg L, typologically /**202**/.
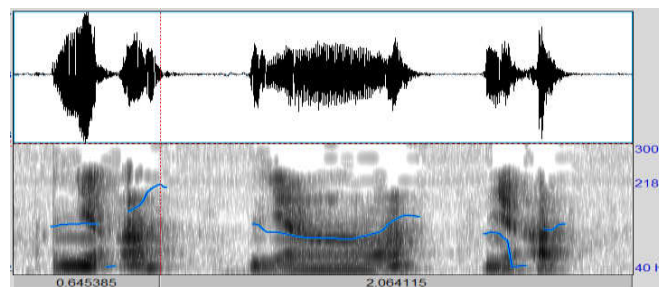
Figure 11 Three contrastive dipping tones in Cocuilotlatzala Mixtec: Discontinuous Fortis Dipping [ɲia̠^{405}] 'woman' in Rg U, Central Dipping [ɲia̠^{323}] 'there' in Rg M, and Creaky Dipping [ɲia̠**^{202}**] 'thing' in Rg L. (Recorded by Dr. Dan Yuan.)

The following two cases both have two contrastive dipping tones. In Vietnamese it is the L Register dipping tone (Creaky Dipping) that contrasts with the U Register Discontinuous Fortis Dipping, and in Tuofeng Mandarin (a male speaker) it is the M Register dipping (Central Dipping) that contrasts with the Discontinuous Fortis Dipping. In a later section, §4.3,

we will see another Discontinuous Fortis Dipping case in a Jianghuai Mandarin variety used in Lianyungang (Zhang and Zhu 2012, 193–199), about 60 kilometers east to Tuofeng.

<div align="center">(a)   (b)</div>

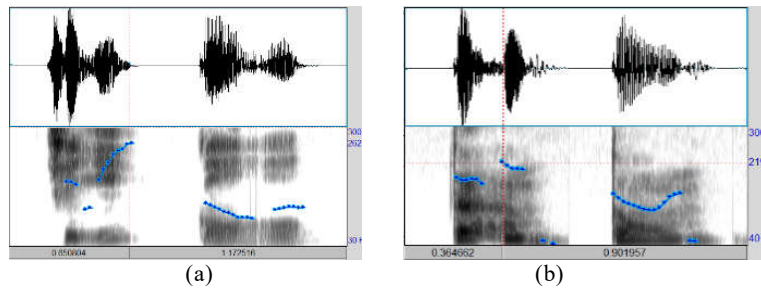**Figure 12** Two contrastive dipping tones from Vietnamese: Ngã tone trĩ[405] 'naive' vs. hỏi tone cổ[202] 'ancient', and Tuofeng 驼峰乡 Mandarin, Donghai County 东海: T1a [təŋ[405]]灯 'lamp' vs. T2 [təŋ [323]] 等 'wait' (panel b). The one on the left of each pair is a Discontinuous Fortis Dipping in Rg U. The right one in panel a is a Creaky Dipping in Rg L. The right one in panel b is a normal Central Dipping in Rg M.

Discontinuous Fortis is no doubt a complex phonation type. Its mechanism of production and physiological state were yet to be clarified during the preparation of this paper, and only acoustic and perceptual manifestations were detected: a relatively high F0 with creak. Just before the completion of the revision it is found to be a very strong glottal stop, rather than a real creak, that blocks normal vocal fords vibration (Cun and Zhu 2017). Its synchronic derivation in phonology is consistent: altering with Creaky Voice or Fortis Voice (syllable-final glottal stop), as observed in Tuofeng, Chaozhou Min (Zhu and Hong 2009, 115–128), Lahu (Zhu et al. 2011, 1-9), and Huihui (Cun and Zhu 2017). In diachronic evolution, it plays a key role in the 'flip-flop' between an original high T4a and low T4b in Southern Min (Wang 1969, 9–25) and other Chinese dialects such as Jianghuai and Qinjin. It is a transitional bridge for T4a's evolution from a final glottal stop to a creaky voice (Zhu, Jiao, Yan and Hong 2008, 324–338; Zhu and Hong 2009, 115–128).

4. TONOTYPE INVENTORY AND DFS
4.1 A Dipping Tone Inventory

Sections 2 and 3 show that there are seven dipping tonotypes, four in Rg M (Central, Front and Back Dipping, and DCT), two in Rg L (Breathy and Creaky Dipping), and one in Rg U (Fortis Dipping), as schematically represented in figure 13. The Central Dipping in Rg M is typologically represented as /323/. Back Dipping is typologically represented as /5<u>23</u>/, Front Dipping /3<u>24</u>/, and DCT /4343/. The Breathy and Creaky Dipping in Rg L is notated as /**213**/ and /**202**/, respectively. Discontinuous Fortis Dipping is represented as /*405*/.
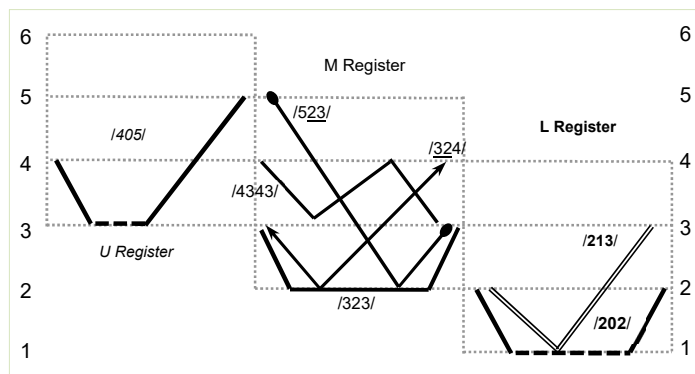
Figure 13 Seven dipping tonotypes represented in the RL model

4.2 Geographical Distribution

According to our processed data from about three hundred Chinese varieties and a few dozen other languages, the default type of Central Dipping is found everywhere. DCT occurs only in 32 varieties of all seven major Chinese dialect groups (Zhu and Yi 2012, 81–106), with Mandarin counts for the most (15 out of 32). Front and Back Dipping types are not common, either, most of which are found in Mandarin.

Breathy Dipping occurs in languages with breathy voice such as Wu, Gan, Xiang, and some varieties of Northern Min, adjacent to Wu and Gan. While dipping tones with a non-distinctive creaky voice are heard everywhere, Creaky Dipping in L Register is only sporadically found. Discontinuous Fortis Dipping, the rarest among the dipping family, is only verified in three languages: Vietnamese, Cocuilotlatzala Mixtec, and Lianyungang

连云港 Mandarin (in some languages/dialects such as Tuofeng Mandarin Discontinuous Fortis Dipping alters with Creaky Dipping or Fortis Voice).

It seems that the same contour type is prone to inhabit in the same languages. While multi-level tones co-occur in Dongtai (Zhu 2012a, 1–17), Miaoyao (Zhu, Shi and Wei 2012, 1–10) and Cantonese, and multi falling tones in Min (Zhu, 2015, 605–637), multi dipping types tend to appear in Mandarin, and perhaps in Wu and Gan as well. More accurate pictures of the distribution will become available with more tonal data being processed and analyzed.

4.3 Distinctive Features

The seven dipping tonotypes can be specified with four distinctive features: [± RgM, ±RgL, ±H_{front}, ±H_{back}], as shown in table 2.

Table 2 A distinctive feature matrix for dipping tones

PHONATION						PITCH	
Type	[+RgM]	Type	[-RgM]	Type	[-RgM]	[H_{front}]	[H_{back}]
			[+**RgL**]		[-**RgL**]		
Central	/323/	Creaky	/**202**/			-	-
Front	/3<u>2</u>4/	Breathy	/**213**/	Fortis	/405/	-	+
Back	/5<u>23</u>/					+	-
DCT	/4343/					+	+

In table 2 the names of the seven typologically distinct tonotypes are gray-shaded, and their numeral codes are placed between slashes '//'. These tonotypes may have phonetic variants. Central Dipping /323/ in M Register may be phonetically realized as {323, 324, 434, 303, 32<u>3</u>}, etc., and Creaky Dipping /202/ in L Register may be realized as {303,304,204}, etc. Breathy Dipping /213/ has variants of {313, 312}. The DCT has phonetic variants such as {3242, 4232, 5242}, ect. The Back Dipping /5<u>23</u>/ has a variant {4<u>23</u>}. The underline for the tone representations can be removed if no ambiguity is incurred. Back and Front Dipping are differentiated by both [±H_{front}] and [±H_{back}]: Back Dipping has a higher tonal head and a lower tail, and Front Dipping a lower head and a higher head. The feature [±RgM] separates M Register from the other two. By adding [±RgL] the U and L Registers are separated. Besides Creaky and Fortis Dipping, the other five phonologically non-creaky dipping tones also have Stiff variants: creaky

{303, 304, 5̠0̠3̠, 3̠0̠4̠} or Weak Stiff {32̠3̠, 52̠3̠} at the turning point of the pitch contour.

4.4 Contrast of Three Dipping Tones

Three-dipping-tone systems are not as rare as previously expected. While there is only one case found in Chaling Gan (actually two varieties of Changyuan and Buzhuang village, see §2.2, and repeated below), where all three dipping tones are in clear voice and reside in Rg M, three dipping tones are not rare in double- or triple-register systems. Below are three examples. In the first case, all three are produced in clear voice (in figure 14, left panel). In the second case, two are produced in clear voice, and the third in Creaky voice. In the third case, one is in clear voice, the second in Creaky Voice, and the third in Breathy Voice. In these three cases, one is produced in clear voice, the second in Creaky Voice and resides in Rg L, and the third in Discontinuous Fortis, Rg U.

Mandarins usually have mono-register tone systems. Occasionally we find M/L-registers with a pair of dipping tones, one of which is produced in Creaky Voice (Zhu and Yang 2010, 134–147; Zhu 2012a, 1–17). Only in one case or two so far have we found a U/M-register tonal system in Mandarin of northern Jiangsu. As shown in panels b and c, in figure 14, Jianghuai Mandarin variety of Lianyungang (Zhang and Zhu 2012, 193–199) has a Discontinuous Fortis Dipping in U Register and two dipping tones in Rg M, one being Central Dipping and the other Front Dipping.
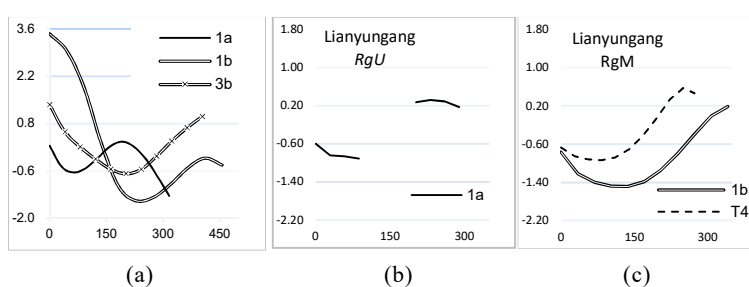

(a)   (b)   (c)

Figure 14 Tripartite dipping contrast. Panel (a) single-register: Gan variety of Changyuan village 长远, Majiang town 马江镇, Chaling County 茶陵, Hunan Province. Panels (b-c) double-register, U and M: Jianghuai 江淮 Mandarin variety used in downtown Lianyungang 连云港 (old variety), Jiangsu Province.

Haimen, a Wu variety not far from Shanghai, has eight tones, four of which are *yang* tones produced with Breathy Voice. Below in figure 15 are three dipping tones in Haimen. One of them is a *yin* tone in M Register, and the other two are *yang* tones with Breathy Voice and reside in L Register. T2a is a Back Dipping {5_23_}, T1b, Breathy Dipping {_32_4}, and T3b Creaky Dipping {202}.
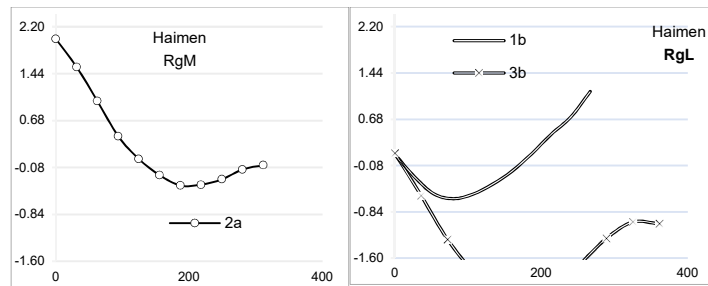
Figure 15 Log z-score normalized mean F0 contours of three Haimen tones: Back Dipping T2a {5_23_} in M Register (left panel), and Breathy Dipping T1b {**324**} and Creaky Dipping T3b {**202**} in L Register (right panel).

It was mentioned in §3.3 there is three-way dipping contrast in Cocuilotlatzala Mixtec. Below is another set of sample contrast of it: a Discontinuous Fortis Dipping /*405*/ in U Register vs. a Creaky Dipping /**202**/ in L Register vs. a normal Central Dipping in M Register.

Figure 16 Contrast among Discontinuous Fortis Dipping {*405*}, Creaky Dipping {**202**}, and Central Dipping {324} in Cocuilotlatzala Mixtec: [ko̧^{405}] 'plate', [ko̧^{202}] 'have a drink', [ko̧^{324}] 'snake'. (Recorded by Dr. Dan Yuan.)

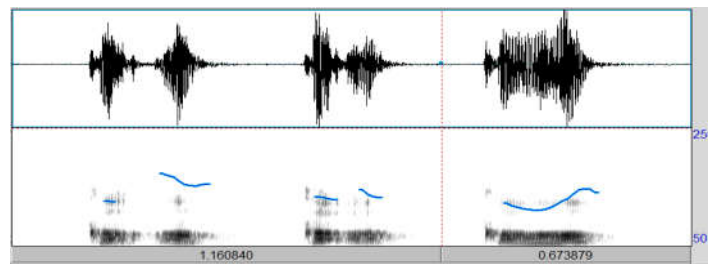Tones of Mixtec seem to consist of a mixed system of Asian contour tones and African register tones, with the former on the monosyllabic words and the latter on polysyllabic words.

4.5 Summary of Contrastive Cases

Table 3 summarizes the contrastive cases discussed above. The default type in the dipping family is Central Dipping /323/ in M Register, which contrasts with all other types except Breathy Dipping. For example, it contrasts with Front Dipping in Xinghua Mandarin, with DCT in Changyuan Gan, with Creaky Dipping in Mixtec, and with Discontinuous Fortis Dipping in Tuofeng Mandarin and Mixtec. The most unusual case is the contrast between Creaky Dipping and Discontinuous Fortis Dipping, which is found in Vietnamese and Mixtec.

Table 3 A matrix presenting examples of contrasting dipping tones

	Ctr /323/	Front /324/	Back /523/	DCT /4343/	Br /213/	Crk /202/	Fortis /405/
Ctr		XH ZP LYG	CY	CY Liyi		M WA	M TF LYG
Front			NLS ZZS			TS	LYG
Back				CY	HM KS	HM	
DCT							
Br						HM	
Crk							M VT
Fortis							

Notes: Ctr=Central, Br=Breathy, Crk=Creaky; CY=Changyuan, DCT=double circumflex tone, HM=Haimen, KS= Kunshan, LYG=Lianyungang, M=Mixtec, NLS=Nanliangshui, TS=Tongshan, TF= Tuofeng, VT= Vietnamese, WA= Wang'an, XH=Xinghua, ZZS= Zhaizishan，ZP= Zhangping

5. SUMMARY

Studies of tone typology were attempted half a century ago, using impressionistic and descriptive data transcribed with FPS. In later years, however, few works followed up in this line. It was until recent one or two years that an abundance of reliable acoustic tonal data has been accumulated and processed, and a tonal model has been developed. These made

tone typology possible. Dipping tones, once represented in RLM, can be readily identified according to their typological status.

This paper has provided a more accurate and adequate phonetic description for a group of dipping tones than previous work on this topic, identified seven types along four phonological parameters (register, length, height and contour), represented them in the RL model, and specified them with four distinctive features, [± RgM, ±RgL, ±H$_{front}$, ±H$_{back}$]. It is hoped that this paper and another two (Zhu 2015; Zhu et al. 2012) would pave the way for a genuine universal tonal typology.

NOTES

1. The affiliations of Xiaonong Zhu also include The Hong Kong University of Science and Technology, Hong Kong; Harbin Institute of Technology, Shenzhen Graduate School, Shenzhen.

2. Below are the abbreviations used in the paper (Ordered alphabetically). DCT: Double Circumflex tone. FPS: Five-Point Scale. Rg L: Lower Register. Rg M: Modal Register. Rg U: Upper Register. RL(M): the Multi-Register and Four-Level (Model). Lo/CULT: Contour Unspecified Low Tone.

3. We do not use the two popular tonal representation schemes, the Five-Point Scale (FPS) and the H/L notation, which are neither adequate nor necessary in transcribing and representing the world's contour tones. Below is a brief review on the deficiencies of the two schemes.

(1) Inadequacy

(1a) Inadequacy in pitch height. The FPS, which defines up to five level tones, is not adequate for representing a six-level-tone system in a Hmong (Miao) variety in Yuliang village, Guizhou Province, China (Zhu et al. 2012, 1–10). The H/L notations with two registers (Yip 2002), defining up to four level tones, is not even enough for the two confirmed five-level-tone systems, Qingjiang Miao (Gwan 1971, 289–305) and Gaoba Dong, a Tai-Kadai language (Shi, Shi and Liao 1986; Zhu 2012b, 1–19).

(1b) Inadequacy in pitch contour. There are less representing symbols in the two schemes than tonal types in real languages that should be distinguished. The form [HLH], for instance, corresponds to three phonological

types of Dipping Tones: Front, Central, and Back Dipping (Zhu et al. 2012, 420–436). As for the "broken" dipping tones with Creaky Voice, none of the schemes has an appropriate form to represent them.

(1c) Inadequacy in length. It is generally acknowledged that contour tones are distinguished between long/unchecked and short/checked with stop consonant coda. Among the long group, however, two sub-groups are identified: High (Long) Falling /52/ vs. Mid-long High Falling /52/ (cf. §3.1), and the Mid-long Falling Tones can be further divided into High and Low (§3.3). These are undistinguishable in the two schemes.

(1d) Inadequacy in phonation. Even if the FPS can represent the five level tones of Qingjiang Miao (Hmong) and Gaoba Dong, it is still not adequate in that the highest level T5 in Gaoba, transcribed as [55], is produced with falsetto and the lowest level tone in Qingjiang, [11], is produced with Breathy voice (Zhu 2012b, 1–19). Therefore, Gaoba T5 is not comparable to, say, the high level T1a [55] in Beijing Mandarin, and the lowest level tone in Qingjiang Miao is not comparable to Cantonese T1b [11]. This kind of incomparability is common between a simple and a complex tone system with non-clear voice: there is a high rising tone in both Beijing Mandarin (T1b) and Yueyang Xiang (T3a), both transcribed as [35] with FPS and converted to [LH]. Again, the high rising in Yueyang is produced with falsetto (Peng and Zhu 2010, 24–32). There is a Dipping tone in both Beijing Mandarin (T2, or the "third one") and Shanghai Wu (T3b), transcribed as [214] with FPS, and analyzed as [L] in Beijing phonology and [LH] or [L] in Shanghai phonology. These two Dipping tones are incomparable typologically, as the one in Shanghai is produced with Breathy voice (Zhu 1995).

In fact, there are hundreds of linguistic varieties in Tai-Kadai, Hmong-Mien, Tibeto-Burman, Austroasiatic, and Central Chinese dialectal groups, such as Wu, Gan and Xiang, which have complex tonal systems with non-clear voice. Current practice in phonology is to convert the impressionistic descriptions, such as [55] and [11], into H/L before conducting theoretical analysis. As shown above, however, both schemes are not adequate descriptively, as well as theoretically. It is always possible to represent falling tones as [HL] with the help of additional notations, such as register symbols or "raised/lowered" symbols; however, that is merely a provisional or, at best, a phonemic solution, a language-specific representation. We do not

know whether [HL] is the same in language A as it is in language B and, thus, cannot conduct cross-language comparisons and further theoretical analysis.

(2) Redundancy

(2a) Redundancy in pitch height. Hyman (1993,75–108) proposes a three-register (which he terms "Tone Root Nodes") and a three-level tonal model which defines up to nine heights. This is unnecessary and not elegant in terms of simplicity. The five levels in FPS are unnecessary because there are only up to four level tones found in normal clear voice.

(2b) Redundancy in pitch contour. One tonotype, e.g., the High Falling /52/, corresponds to many FPS forms, such as [51, 52, 53, 41], etc. (cf. §§3.2, 6.1). In fact, the FPS has too much redundancy in pitch representation. In the case of falling tones, the FPS can define ten types of straight falling tones: [51, 52, 53, 41, 42, 31; 54, 43, 32, 21], thirteen delayed falling tones such as [551, 552, 331, 431…], seventeen depressed falling tones such as [451, 342, 231…], and ten prolonged falling tones such as [511, 512, 411…] –totaling 50. With such redundancies and ambiguities in representation, it is hard to achieve anything meaningful in typological studies.

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分域四度制中的凹调类型

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摘要

本文采用一手材料在分域四度框架中对凹调进行类型学分类，一共辨识出七种凹调。其中四种为常域清冽声凹调： (1) 央凹型，代码为/323/，(2) 后凹型 /5<u>23</u>/，(3) 前凹型 /<u>32</u>4/，(4) 两折型/4343/。另外三种凹调属于非清冽声声质：(5) 下域的气声凹型/213/ ，(6) 下域的嘎裂声凹型 /**202**/，(7) 上域的张裂声凹型 /*405*/。本文使用四对区别特征 [±RgM, ±RgL, ±H$_{front}$, ±H$_{back}$] 来刻画这七种凹调。

关键词
声调　**类**型学　**调**类　**凹**调　**两**折调