Durational Properties of Lexical Stress and Grammatical Stress in Nanchang Chinese and Their Implications for Tonal Contrasts

By
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Abstract

In this thesis, a durational study and a tonal contrast study were conducted to investigate the tonal inventories in syllables with different rhyme durations in Nanchang Chinese, a dialect spoken in southeast China. The findings show that the tonal inventory is reduced in lexically stressless syllables, which have shorter rhyme duration.

Nanchang is a Gan dialect spoken by about 4 million people in the city of Nanchang in Southeast China (Li 1995). There are five lexical tones in Nanchang, transcribed in a five point scale as 42, 24, 45, 213, and 21 (Hou & Wei 1998). Certain syllables in Nanchang are lexically stressless, known as qing sheng. Apart from lexical stress, Nanchang, like Standard Chinese, also has grammatical stress. The grammatical stress is introduced as the result of syntactic structures, for example, In Verb+Noun (VN) phrases, N bears grammatical stress as N is a nonhead in the syntactic structure, and in Noun+Noun (NN) words, the first N carries grammatical stress as it is a nonhead in the syntactic structure. This is known as the 'Nonhead stress' rule (Duanmu 2007).

According to Zhang's (2002) typological survey of contour tone distribution, the rhyme duration is the crucial factor that licenses contour tones (e.g. rising or falling tone). Thus, if the rhyme duration of syllables is affected by phonological parameters such as stress, then we expect the tonal contrast in syllables to be affected as well. This study examines whether different stresses in Nanchang have durational correlates, and if so, what happens to the tonal contrasts in syllables both with and without stress.

The durational study of syllables with different stresses shows that grammatically stressed syllables have significantly longer rhyme duration than grammatically stressless but lexically stressed syllables, which in turn have longer rhyme duration than lexically stressless syllables. However, the size of the difference between grammatically stressed and grammatically stressless syllables is much smaller than that between grammatically stressless and lexically stressless syllables. With this finding, a tonal contrast study was conducted to examine the tonal contrasts in grammatically stressless but lexically stressed and lexically stressless syllables.

Statistically, the five lexical tones in the grammatically stressless group were significantly different from each other in terms of both f0 average and shape whereas in the lexically stressless group, tones 42, 45 and 21 were neutralized and tones 24 and 213 also neutralized. In other words, the underlying tonal contrasts in lexically stressed but grammatically stressless syllables were preserved, whereas in lexically stressless syllables the tonal contrasts were massively reduced.

The correspondence between the durational property of the syllable and its ability to carry tonal contrasts indicates that in order to understand the distribution of phonological contrasts, we must look beyond the pure phonological labels such as "stress" and understand the phonetic properties that the phonological labels entail.

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Durational Properties of Lexical Stress and Grammatical Stress in Nanchang Chinese and Their Implications for Tonal Contrasts

1. Introduction

This thesis investigates the relation between tonal contrasts and the syllables' sonorous rhyme duration that is affected by phonological factors such as stress and syllable structure in Nanchang Chinese, a tone language spoken in Southeast China. There are two types of stress in Nanchang—lexical stress and grammatical stress, and there are two syllable types—syllables with a sonorant ending (either a vowel or a nasal) and syllables that end in a glottal stop. The durational properties of sonorous rhymes in syllables that have different stresses and syllable types are examined. The tonal contrasts the different types of syllables carry are then investigated. This is in order to see whether there exists a relation between the durational properties of syllables and their ability to carry tonal contrasts. By studying the relationship between phonological contrasts (tonal contrasts in this case) and phonetic properties, it is possible to go beyond the typological generalizations about what syllables may carry more phonological contrasts and provide further explanation of *why* syllables with certain phonological features (stress and syllable type in this case) carry more phonological contrasts.

The introduction section starts with the description of stress and syllable types in Nanchang and the tonal contrast distribution in the language. Typological studies on the

relation between sonorous rhyme duration and tonal contrast distribution are then reviewed, followed by a review of phonetic studies that investigate the durational properties of different stress types in Chinese. Finally, research questions are formed.

1.1 Tones, stress and syllable structure in Nanchang Chinese

Nanchang is a variety of the 'Gan' dialectal family spoken in the city of Nanchang in Southeastern China. This dialect is spoken by about four million people. There are five lexical tones in Nanchang. It consists of two types of stress and three syllable types. The following sections describe these phonological features.

1.1.1 Lexical stress in Nanchang

Like in Standard Chinese, the lexical stress in Nanchang is realized on disyllabic words where the first syllable is a full syllable and the second syllable is a light syllable known as 'qing sheng' (Chao 1968). Perceptually, native speakers can tell that the first syllable is more prominent than the second syllable. For Standard Chinese, Duanmu (2007) argued that the first syllable bears lexical stress whereas the second syllable does not as it is a light syllable. Here, Duanmu's argument is used for Nanchang in which a full syllable carries lexical stress while a light syllable does not. In disyllabic words, only the second syllable can be lexically stressless. The presence or absence of lexical stress on the second syllable sometimes may distinguish the meanings of two words:

(1a) toŋ 42 ɕi42[1]

east west

'east west'

(1b) toŋ 42 ɕi

east west

'thing'

In (1a), the syllables are "full-full" and it is not easy for native speakers to tell which has more stress. In (1b), the syllables are "full-light" and the first syllable is judged to be more stressed than the second syllable by native speakers. The stress pattern occurs in both Standard Chinese and Nanchang. The main perceptual difference between a light syllable and a full syllable is that the light syllable is perceived as having a shorter duration compared to the full syllable. Due to such salient perceptual differences, native speakers can easily tell whether the second syllable is a light syllable or not. There is no rule that predicts whether a word will have a full-light structure in Standard Chinese or Nanchang. Therefore the stress pattern of full-light disyllabic words has to be lexically specified. The lexicon with a full-light pattern in Nanchang, however, is not the same as the lexicon of the same stress pattern in Standard Chinese. The notion 'lexical stress' in this thesis is used to distinguish lexically stressed full syllables and lexically stressless light syllables.

1.1.2 Grammatical stress in Nanchang

In contrast to the unpredictable presence of lexical stress, grammatical stress is assigned to syllables following certain rules. The grammatical stress assignment in Nanchang follows the 'Nonhead stress' rule proposed by Duanmu for his analysis of Standard

[1] In this thesis, all tones are transcribed in a 5 point scale where '5' stands for the highest pitch and '1' stands for the lowest pitch (Chao 1968).

Chinese stress. According to Duanmu (2007), the grammatical stress assignment in Standard Chinese relies on the syntactic structure of a phrase or compound.

First, the distinction between a phrase and a compound in Chinese needs to be clarified. A phrase in Chinese has the syntactic structure [X YP], where X refers to the head in X-bar theory (Carnie 2007) and an element at the word level, while YP is the nonhead and is at the phrase level. A compound in Chinese has the syntactic structure [YP X] where YP is the nonhead and X is the head. A typical phrase in Chinese has a [V N] structure ('V' means Verb; 'N' means Noun). Here N is analyzed as NP in X-bar theory and V is the head. A typical compound in Chinese has an [N N] structure (both 'N' means Noun). The first N is analyzed as an NP, which modifies the second N, which is the head (Duanmu 2000). The distinction between phrase and compound in Chinese is still a controversial issue. The distinction used in this thesis is based on Duanmu's analysis.

Following the categorization of phrase and compound in Chinese, a 'Nonhead stress' rule was proposed to predict the existence of grammatical stress on nonhead position (Duanmu 1990, 2000, 2007). The Nonhead stress rule is stated as follows:

(2) Nonhead Stress

In the syntactic structure [X YP] (or [YP X]), where X is the syntactic head and YP the syntactic nonhead, YP should be stressed (Duanmu 2007: pp146).

The main piece of evidence that supports grammatical stress in Standard Chinese on

nonhead positions comes from word length restrictions in words of different syntactic structures. Some Chinese words have two forms, one disyllabic and one monosyllabic with identical meaning. For example, the left two columns in the following example are the monosyllabic and disyllabic forms of a single meaning:

(3)	suan	da-suan	‘garlic’
	zhong	zhong-zhi	‘to plant’
	mei	mei-tan	‘coal’
	dian	shang-dian	‘store’

By using the first two words (‘to plant’ and ‘garlic’), a [V N] phrase can be formed and by using the other two words (‘coal’ and ‘store’) a [N N] compound can be formed. Possible forms are given as follows:

(4)	[Verb	Noun]
	‘plant’	‘garlic’
(a)	zhong-zhi	da-suan
(b)	zhong	da-suan
(c)	zhong	suan
*(d)	zhong-zhi	suan

(5)	[Noun	Noun]
	‘coal’	‘store’
(a)	mei-tan	shang-dian
*(b)	mei	shang-dian
(c)	mei	dian
(d)	mei-tan	dian

In (4), (4d) with a word length [2 1] is not allowed (the digit indicates the number of syllables in each word). In other words, in a [V N] structure, V is not allowed to have more syllables than N. On the other hand, in (5), (5b) with a word length [1 2] is not allowed. In other words, in an [N1 N2] structure, N2 is not allowed to have more syllables than N1. This pattern can be explained by the Nonhead stress rule: N in [V N] should be stressed and N1 in [N1 N2] should be stressed. A stressed phrase cannot have fewer syllables than an unstressed word. The presence of grammatical stress on nonhead

element correctly predicts the word length restriction in Standard Chinese. The word length restriction also occurs in [V N] and [N N] in Nanchang.

Nanchang has word length restrictions due to the existence of grammatical stress. Apart from this, uniquely, some tone sandhi patterns in [N N] and [V N] and some native speaker's judgment of stressed syllable(s) in [V N] phrases and [N N] compounds also indicate that there is grammatical stress in Nanchang.

In Nanchang, shang (213) undergoes tone sandhi and becomes 24 when it is followed by shang (213) and yangqu (21). In other words, 213 and 24 are neutralized when 213 is followed by 213 or 21. The tone sandhi only occurs in [V N] phrases but not in [N N] compounds. For example, for 213+213, a [V N] phrase *ts'ai213+ts'au213* (step on grass') →*ts'ai24-ts'au213* ('a kind of Chinese medicine'). An [N N] compound *ts'ai213+ken213* ('vegetable's root') remains perceptually different from *ts'ai24+ken213* ('handle of a piece of wood'). For 213+21, a [V N] phrase *t'au213+fan21→t'au 24-fan21* ('beg rice') sounds the same as *t'au 24+fan21* ('the wanted'). An [N N] compound *t'au213+fan21* ('a meal set') remains perceptually different from *t'au 24+fan21* ('the wanted'). Such structure sensitive tone sandhi patterns are common in Chinese dialects (Wei 2000). Not only in [N N] and [V N], other lexical items judged by native speakers as having more stressed first syllable do not have tone sandhi whereas lexical items judged by native speakers as having less stressed first syllable do have tone sandhi (Li 1995). Therefore,

we argue that the first tone in [N N] does not undergo tone sandhi because the first syllable is grammatically stressed. The first tone in [V N] does undergo tone sandhi because the first syllable is grammatically stressless.

(Hoa 1983, cited in Duanmu 2007) reported a native speaker of Standard Chinese's stress judgment for several [V N] phrases and [N N] compounds. An example is given as follows:

(6)	Phrase	Compound
	2-1	1-2
	guai4 ren2	guai4 ren2
	blame person	strange person
	'blame others'	'strange person'

In the example above, the phrase and compound are transcribed in Pinyin. They have the same segments and lexical tones. The word 'guai' can either be a verb 'blame' or an adjective 'strange'. '1' is more stressed than '2'. The native speaker's stress judgment for the phrase is 2-1 whereas for the compound is 1-2. This pattern is consistent with the nonhead stress rule. Following Hoa's approach, three native speakers of Nanchang were asked to make stress judgment for the word pair ([V N] phrase: qin42 nin45 'kiss a person' vs. [N N] compound: qin42 nin45 'relatives'). All the three speakers could tell the stress difference between syllables in the word pair, namely, the noun 'nin45' (person) is more stressed than the verb 'qin42' (kiss) in the [V N] (blame person) phrase whereas the

first noun ‘qin42’ (relatives) is more stressed than the second noun ‘nin45’ (person) in the [N N] compound. This suggests that the grammatical stress in Nanchang is quite similar to Standard Chinese in terms of the native speakers’ stress judgment on some phrases and compounds.

In sum, the ‘Nonhead stress’ rule can be used to account for the patterns found by Hoa in Standard Chinese. Similar patterns occur in Nanchang as well. Therefore, together with morphological constraints on word length, native speaker’s stress judgment and the tone sandhi patterns all provide evidence for the existence of grammatical stress in [V N] phrases and [N N] compounds. Based on these arguments, in Nanchang, a [V N] phrase has grammatical stress on N and a [N1 N2] compound has grammatical stress on N1.

1.1.3 Syllable types in Nanchang

There are three types of syllables in Nanchang: CV (C = Consonant; V = Vowel); CVR (R = Sonorant consonant); and CVO (O = Obstruent). There is no vowel length contrast in Nanchang.

1.1.4 Lexical tones and tonal contrast distribution in Nanchang

There are five lexical tones in Nanchang, traditionally transcribed as 42 (yinping), 24 (yangping), 45 (yinqu), 213 (shang), and 21 (yangqu). All five tones can be realized on CV and CVR syllables. On CVO syllables, the tonal inventory is reduced to 5 (yin ru)

and 2 (yang ru) (Li 1995). Therefore, in Nanchang, syllable types restrict tonal contrasts. This is illustrated in Table 1:

Table 1. Number of different tones each syllable type is able to carry.

Syllable type	CV(R)	CVO
Number of tones the syllable can carry	5	2

Hou & Wei (1998) transcribed the tones that surface on light syllables in Nanchang as digits 4 and 2. They reported that if the preceding syllable has tone 45, 24 or 213 then the light syllable becomes 4 regardless of its underlying tone, whereas if the preceding syllable has tone 42 or 21, the light syllable becomes 2 regardless of its underlying tone. The current study investigates the production of the tones that surface in light syllables in order to see whether there are two different tones in light syllables in terms of production.

All documentations about tonal contrast distribution in Nanchang up till now are based on impressionistic transcription. Few acoustic studies have been conducted to examine whether the phonetic properties of syllables with different phonological features (e.g., different syllable types and different lexical stresses). The current study fills this gap by studying the durational properties of those phonological features in order to see whether there is a correlation between the syllables' sonorous rhyme duration and their ability to carry tonal contrasts. In the next section, the literature on why sonorous rhyme duration is

highly correlated with tonal contrast distribution is reviewed and the importance of this study in Nanchang is further motivated.

1.2 The relation between the sonorous rhyme duration and tonal contrast distribution

It is widely known that the main perceptual correlate of tone is the fundamental frequency (f0). Apart from f0, Plomp (1967) and Ritsma (1967) found the spectral region containing the second, third and fourth harmonics is especially important in the perception of f0 as well. Since sonorants consist of richer harmonic structures than obstruents, including the crucial second to fourth harmonics, they are better tone bearers than obstruents. Based on these findings, we argue that the sonorous rhyme in a syllable is the tone bearing unit.

Cross-linguistically, the duration of the sonorous rhymes of syllables has been found to be a crucial factor that determines the syllables' ability to carry contour tones in tone languages (Zhang 2002). In his study, Zhang shows how syllable structure affects the rhyme duration, which in turn becomes the source of tonal contrast differences. I review some of the evidence here.

In standard Thai, CVR syllables have richer tone-bearing possibilities than CV:O. In particular, CV:O in Thai cannot host LH or M tones, whereas CVR can host any of the

five phonemic tones of the language (H, M, L, HL, LH). In contrast, Navajo shows the opposite tonal contrast distribution: CV:O can host any phonemic tone (H, L, HL, LH), but CVR cannot host HL or LH.

To explain this type of language-specific difference, Zhang proposed that what licenses contour tones is a combination of length and sonority: vowels make better contour hosts than consonantal sonorants, but at equal sonority levels, the longer sonorous rhyme is the better carrier. In Zhang's Navajo data, the rhyme in CVR and the V: portion of CV:O are very close in duration. Since the sonority of V is greater than that of R then it implies CV:O is better tone carrier than CVR and the phonology bears this out: CV:O can host more contours. In contrast, in Thai, long vowels are dramatically shorter in closed syllables. As a result, Thai CV:O has considerably less sonorous rhyme duration than CVR, and the difference is enough to compensate for the CVR's inferior sonority status. The comparison of the tonal contrast difference between Thai and Navajo provides crucial evidence that the degree of shortening in closed syllables is the source of their tonal contrast difference.

The contour tone distributions reviewed in Thai and Navajo indicate their close correlation with rhyme duration of different syllable types. But more importantly, it indicates that contour tone distribution cannot simply be predicted by the syllable types (CVR vs. CV:O). To correctly predict contour tone distribution, we must take into

account the phonetic property, namely, the durational property of syllable types. Therefore, language specific phonetics plays an important role in licensing phonological contrasts.

Apart from syllable type, stress status is another phonological parameter that can have durational correlates, which in turn may have effects on the tonal contrasts. For example, in a study of the underlying tonal targets of the neutral tone on light syllables in Standard Chinese, Chen and Xu (2006) found light syllables to be much shorter than full syllables. On average, the sonorous rhyme of the light syllables is only 61% of the length of the sonorous rhyme in full syllables. They found that the neutral tone does have a tonal target. But due to its slow and ineffective implementation, it looks like the neutral tone is influenced by surrounding tones and itself does not have a tonal target. Lin (1980) found that the pitches for the neutral tones are falling to varying degrees if they are after 55, 35 or 51. When the neutral tone is after 213 then it becomes a mid or high-mid level tone. No matter how the tone surfaces on light syllables, we can see clearly that tonal contrasts in light syllables are reduced. In other words, syllables without lexical stress have fewer tonal contrasts than syllables with lexical stress (4 lexical tones can appear in lexically stressed syllables).

Based on the findings in these studies, in Nanchang, tonal contrast distributions in syllables with different syllable structures (e.g., CVR, CVO) and different stress types

(e.g., lexically stressed vs. lexically stressless) are examined. The durational properties of different syllable types and stresses are examined in order to see whether the tonal contrast distributions licensed by certain phonological features, namely, syllable structure and stress, can be explained by the durational property of these phonological features.

1.3 Durational correlates of grammatical stress in Chinese

In the previous section, acoustic studies of durational properties of different syllable types and of lexical stress are reviewed. They showed that the distribution of tonal contrasts differs according to syllable type and lexical stress. Since lexical stress has durational correlates, we may wonder whether grammatical stress has the same durational properties that affect tonal contrasts. An acoustic study of durational properties of grammatical stress is reviewed in this section. But so far, acoustic studies of tones in grammatically stressed and stressless syllables have been absent from the literature.

In a production experiment, Wang (2001) studied the durational correlates of grammatical stress in Standard Chinese. He designed a list of strings that are ambiguous between [V N] phrases and [N N] compounds. An example is given below:

(7a) [V N] phrase
qing55-zheng55 long35-xia55
steam lobster
'to steam lobsters'

(7b) [N N] compound
qing55-zheng55 long35-xia55
steaming(gerund) lobster
'steamed lobsters'

The ambiguity is caused by interpreting *qiang55-zheng55* 'steam' as a verb in (7a) and as a nominal verb in (7b). In the production experiment, the ambiguous strings were located

in two contexts shown as follows:

(8a) ta55 yao51 qu51 chu35-fang35 _____ qu51 le.
he want-to go kitchen go aspect
'he will go to the kitchen to_____'

(8b) ta55 yao51 chi55 _____ qu51 le.
he want-to eat go aspect
'he will go to eat _____'

Only the [N N] interpretation fits into the context in (8a) and only the [V N] interpretation fits into the context in (8b). Four native speakers were asked to produce all [2 2] strings in both contexts ('2' indicates the number of syllables of either V or N in [V N] and [N N]). Wang found that the first syllable in [N N] was significantly longer than the first syllable in [V N] and the fourth syllable in [V N] was significantly longer than the fourth syllable in [N N]. Since the first N in [N N] and N in the [V N] bear grammatical stress, these results support the hypothesis that grammatically stressed syllables are correlated with longer duration.

So far, the acoustic studies of the durational property of lexical and grammatical stresses mainly involve Standard Chinese. Since the syllable type in Standard Chinese is either CVR or CV, it is worthwhile to further examine the durational correlates of lexical and grammatical stress in the CVO syllable type that is present in Nanchang. This would generate a complete picture of the durational property of different stress types in different syllable structures.

1.4 Research questions

The stress types and syllable types introduced in Nanchang are phonological parameters that may affect the duration of the rhymes. Given that sonorous rhyme duration is the crucial factor that licenses contour tones, if a certain stress type or syllable type has durational correlates, then the tonal contrasts on these syllables may be affected by the durational difference.

Another point of investigation in Nanchang is whether the tones that surface on light syllables are determined by the preceding tones regardless of their underlying tones. As mentioned earlier, Hou & Wei (1998) document the tones in light syllables to be either 4 or 2 depending on the preceding tones. The number of different tones that surface on light syllables will be investigated.

To sum up the introduction, in Nanchang disyllabic words there are lexical stress and grammatical stress. The lexical stress distinction is easily perceived. The grammatical stress distinction is based on the nonhead stress rule that assigns the stress either to the first syllable or the second syllable depending on the grammatical structure. Nanchang also has five lexical tones in open or sonorant-closed syllables. In stop-closed syllables the tonal inventory is reduced to two tones. With these properties in Nanchang Chinese, The current study aims to answer the following research questions:

a) Does lexical stress have durational correlates?

b) Does grammatical stress have durational correlates?

c) Is the rhyme duration of CVO syllables significantly shorter than of CV syllables?

d) If there are durational differences among syllables with different stress statuses (lexically stressed vs. lexically stressless and grammatically stressed vs. grammatically stressless), then are there any tonal contrast differences among these types of syllables?

2. Experiment-1: durational correlates of lexical stress and grammatical stress

The first instrumental study examines the durational properties of stress types (lexical stress vs. grammatical stress) in different syllable structures (CV(R) vs. CVO) in Nanchang.

2.1 Methodology

To study the durational correlates of lexical stress and grammatical stress, a wordlist that includes [N N], [V N] and lexically stressless disyllabic words was constructed. Technically, the durational property of different stress types can be examined in the second syllables of [N N], [V N] and lexically stressless disyllabic words. For an [N N] compound, the second syllable bears lexical stress but not grammatical stress (grammatical stress is on the first N). For a [V N] phrase, the second syllable bears both lexical stress and grammatical stress. For a lexically stressless word, the second syllable does not bear lexical stress. The lexically stressless words used in the current study cannot be analyzed as [V N] structures, thus, the second syllable in a lexically stressless word does not bear grammatical stress either. The following table illustrates the stress types the second syllable (either CV or CVO) bears in Nanchang:

Table 2. Stress types on the second syllable in [N N], [V N] and lexically stressless disyllabic words.

Target syllable: σ 2 Syllable structure: CV / CVO	Lexical Stress	Grammatical Stress
Noun + Noun	+	-
Verb + Noun	+	+
Lexically Stressless	-	-

The syllable structures of the second syllables include both CV and CVO structures. Therefore, the durational property of each stress type is examined on both CV and CVO structures. The durational property of lexical stress can be studied by comparing the rhyme duration of lexically stressed second syllables in [N N] and of lexically stressless second syllables in full-light disyllabic words. The durational property of grammatical stress can be studied by comparing the rhyme durations of the grammatically stressed second syllables in [V N] and of the grammatically stressless second syllables in [N N].

CVO syllables can theoretically bear either yin ru (5) or yang ru (2). But in the Nanchang dictionary, most syllables with CVO structure are transcribed as bearing yin ru (5). Thus, the wordlist only contains CVO syllables with yin ru (5). The tones of the first syllables are not controlled since there is almost no tone sandhi in Nanchang except (213+213→24-213 & 213+21→24-21); therefore, tones in the first syllables will not cause the tones in the second syllables to change categorically. The syllable types of the first syllables,

though, are controlled to be CV.

In the wordlist, second syllables with a CV structure bear either yinping (42) or qu (21). This is because cross-linguistically syllables with falling tones have shorter durations than ones with rising and complex contour tones (Zhang 2002). In Nanchang, there are two falling tones, two rising tones and one complex contour tone in CV. As we chose the two falling tones 42 and 21, if CV syllables are significantly longer than CVO syllables, the durational difference is less likely to be caused by the tone length difference.

In both CV and CVO syllables, the vowels are /a/, /i/ or /u/. The vowels in CVO syllables are followed by a glottal stop. For each vowel type, there are 12 words with a CV structure and 12 words with a CVO structure. Together there are 24 words for each vowel. The reason to include 24 words for each vowel is that there are six conditions and there are 4 words in each condition. The six conditions are CV-L-G (CV syllables with both lexical stress and grammatical stress), CV-L (CV syllables with only lexical stress), CV-NoStress (CV syllables without lexical stress or grammatical stress), CVO-L-G (CVO syllables with both lexical stress and grammatical stress), CVO-L (CVO syllables with only lexical stress) and CVO-NoStress (CVO syllables without lexical stress or grammatical stress). The wordlist is illustrated as follows:

Table 3. Wordlist for durational study

Vowel	**CV-L-G**	**CV-L**	**CV -NoStress**	**CVO-L-G**	**CVO-L**	**CVO -NoStress**
a	开花 k’ai42 fa42 ‘to blossom’	鲜花 ɕiɛn42 fa42 ‘fresh flower’	泥巴 ni45 pa0 (42) ‘mud’	理发 li213 faʔ5 ‘cut hair’	铁塔 t’iɛ213 t’aʔ5 ‘iron tower’	菩萨 p’u24 saʔ0 ‘bodhisattva’
	洗车 ɕi213 ts’a42 ‘to wash a car’	货车 fo45 ts’a42 ‘cargo truck’	哑巴 ŋa213 pa0 (42) ‘mute’	修塔 ɕiu42 t’aʔ5 to repair tower’	球拍 tɕ’iu24 p’aʔ5 ‘racket’	糟蹋 tsau42 t’aʔ0 (5) ‘ruin’
	驮 骂 （被 骂） t’o42 ma21 ‘be scolded’	脏话 tso ŋ 42 fa21 ‘obscene language’	芝麻 ʦɿ42 ma0 (45) ‘sesame’	作答 tsu45 taʔ5 ‘to answer’	水塔 sui213 t’aʔ5 ‘water tower’	头发 t’ɛu24 faʔ0 (5) ‘hair’
	卖画 mai21fa21 ‘to sell painting’	公社 koŋ42 sa21 ‘commune’	篱笆 li45 pa0 (42) ‘fense’	买尺 mai213 ts’aʔ5 ‘to buy ruler’	方格 foŋ42 kaʔ5 ‘grid’	勾搭 kou42 taʔ0(5) ‘to gang up’
i	养鸡 yioŋ213 tɕi42 ‘to raise chicken’	土鸡 t’u213 tɕi42 ‘free range chicken’	徒弟 t’u24 t’i0 (42) ‘apprentice’	执笔 tsɨʔ5 piʔ5 ‘to hold a pen’	毛笔 mau45 piʔ5 ‘brush pen’	亲戚 tɕin42 tɕ’iʔ0 (5) ‘relative’

	开机 k’ai42 tɕi42 ‘to turn on a machine’	云梯 yun45 t’I42 ‘cloud ladder’	楼梯 lɛu45 t’i0 (42) ‘stairs’	出力 ts’uʔ5 liʔ5 ‘to exert effort’	蛮力 man45 liʔ5 ‘brute force’	休息 ɕiu42 ɕiʔ0 (5) ‘to have a rest’
	扫地 sau213 t’i21 ‘to sweep the floor’	纸币 tsi213 p’i21 ‘paper notes’	把戏 pa213 ɕi0 (21) ‘tricks’	吹笛 ts’ui42 tiʔ5 ‘to blow flute’	头日 t’ɛu24 ȵiʔ5 ‘the first day’	消息 ɕiɛu42 ɕiʔ0 (5) ‘news’
	拖地 t’o42 t’i21 ‘to mop the floor’	假币 ka213 pi21 ‘false money’	玻璃 po21 li0 (21) ‘glass’	涂漆 t’u24 tɕ’iʔ5 ‘to paint’	顽疾 uan45 tɕ'iʔ5 ‘incurable disease’	今日 tɕin42 niʔ0(5) ‘today’
u	迁都 tɕ’iɛn42 tu42 ‘to move the capital’	草菇 ts’au213 ku42 ‘grass mushroom’	姐夫 tɕia213fu0 (42) ‘brother in law’	放牧 foŋ45 muʔ5 ‘to herd’	红木 fuŋ24 muʔ5 ‘redwood’	舒服 ɕy42 fuʔ0 (5) ‘comfortable’
	收租 ɕiu42 tsu42 ‘to collect rent’	房租 foŋ45 tsu42 ‘house rent’	蘑菇 mo45 ku0(42) ‘mushroom’	享福 ɕioŋ213 fuʔ5 ‘to enjoy happiness’	表叔 piau213 suʔ5 ‘paternal uncle’	排骨 p’ai24 kut5 ‘ribs’
	扫墓 sau213 mu21 ‘to visit the cemetory’	支部 tsʅ42 p’u21 ‘branch unit’	欺负 tɕi42 fu0 (21) ‘to bully’	吃粥 tɕ’aʔ5 tsuʔ5 ‘to eat porridge’	旺族 uoŋ21 ts’uʔ5 ‘prosperous family’	包袱 pau42 fuʔ0 (5) ‘bag’
	修路 ɕiu42 lu21 ‘to repair roads’	继父 ɕi21 fu21 ‘stepfather’	坟墓 fin24 mu0 (21) ‘tomb’	伐木 fa45 muʔ5 ‘to cut lumber’	小鹿 ɕiau213 luʔ5 ‘little deer’	牲畜 sin42ts’uʔ0(5) ‘pasturage’

Together, there are 72 words in total (36 CV syllables and 36 CVO syllables) in the duration study. Among the three types of words, the lexically stressless words were selected from the Nanchang Dialectal Dictionary (Li 1995).

In order to eliminate the final lengthening effect, ten native speakers of Nanchang (6 males and 6 females) were asked to read the words in a carrier sentence, shown in (8). Each sentence was read twice. After the recording, the rhyme durations of the second syllables of each token were measured using Praat (Boersma & Weenink 2003) .

(8) ŋo213 pa213_____cau42 lioŋ213 piɛn42.

I particle_____copy two times

'I copy___twice.'

2.2 Results

In the duration study, there are two independent variables ---- stress status (3 levels) and syllable type (2 levels). Since ten native speakers produced tokens in all six conditions, a two-way repeated measures ANOVA was used for the analysis. The statistics show main effects for both stress status and syllable type. For stress, $F(1.188, 10.695)=26.211$, $p<.001$ (Huynh-Feldt adjusted values are used to correct for sphericity violations). For syllable type, $F(1, 9)=31.755$, $p<.001$.

The main effect of the syllable type on rhyme duration can be seen in the following graph where the mean durations of CVO syllables and CV syllables regardless of different stress are compared:

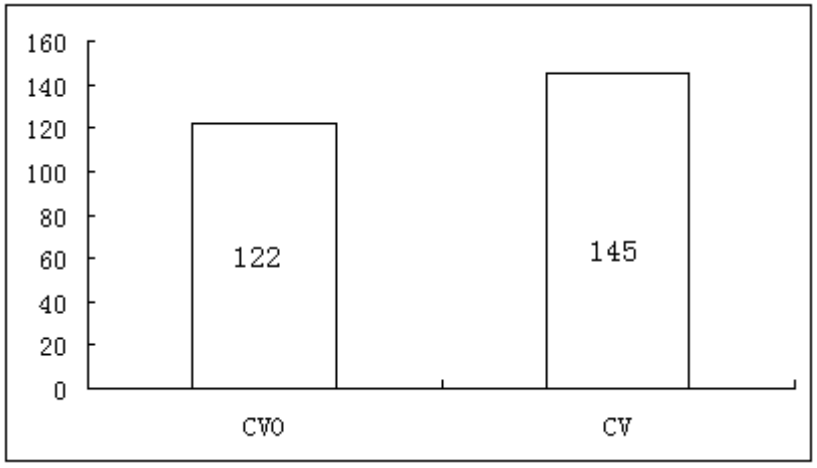

Figure 1. Mean durations of all CVO and CV syllables regardless stress types.

In Figure 1, the mean rhyme duration of CV syllables is 23ms longer than that of CVO syllables, and the difference is highly significant.

The main effect of stress on rhyme duration is examined in two separate one-way repeated measures ANOVAs for CV and CVO syllables. In both CV and CVO, the rhyme durations in different stress conditions (e.g., grammatically stressed, lexically stressless) show a significant difference. The mean rhyme durations of the three types of stresses in

CV and CVO syllables are illustrated in the following graphs:

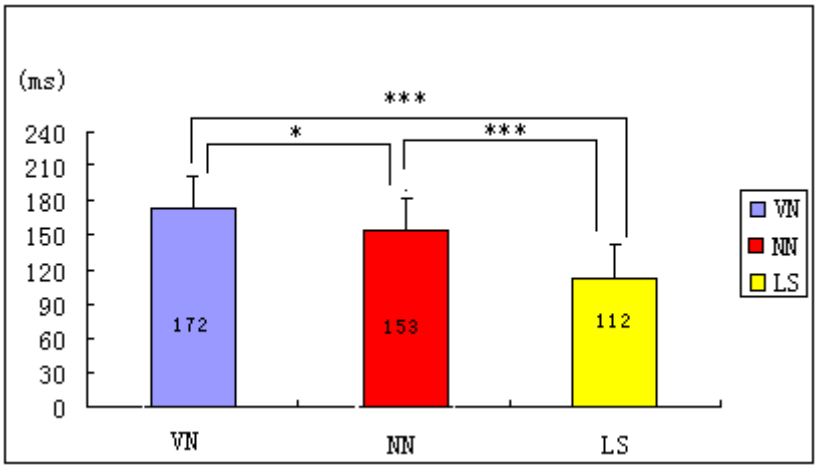

Figure 2. Mean rhyme durations of the **CV** second syllables with three stress statuses (ms). VN (Verb Noun) has both grammatical and lexical stress; NN (Noun Noun) has only lexical stress; LS (Lexically Stressless) has no stress. Three asterisks indicate that the significance level is below .001 whereas one asterisk indicates that the significance level is below .05.

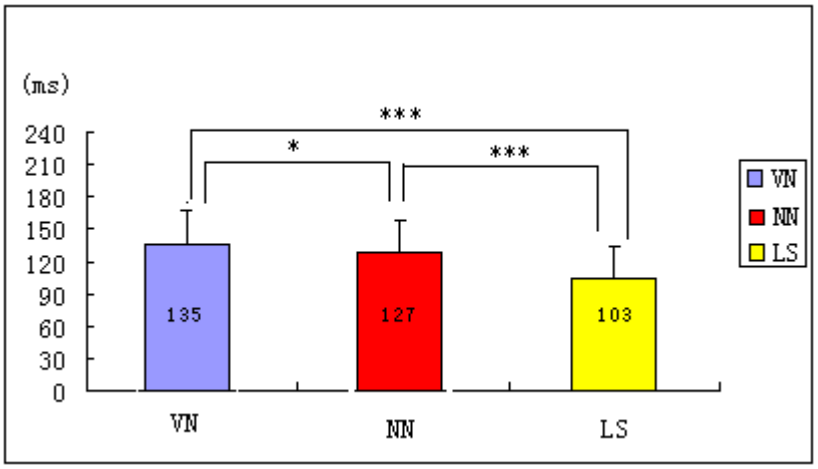

Figure 3. Mean rhyme durations of the **CVO** second syllables with three stress statuses (ms). VN (Verb Noun) has both grammatical and lexical stress; NN (Noun Noun) has

only lexical stress; LS (Lexically Stressless) has no stress. Three asterisks indicate that the significance level is below .001 whereas one asterisk indicates that the significance level is below .05.

As a reminder, the second syllables in VN are grammatically stressed (which have both grammatical and lexical stress); the second syllables in NN are lexically stressed (which have only lexical stress but not grammatical stress); the second syllables in LS (lexically stressless) have no lexical stress or grammatical stress. The asterisks in the above graphs indicate the significance level in pairwise comparisons (e.g., the rhyme duration of the grammatically stressed second syllables vs. lexically stressed second syllables). These significance level results are shown in the following table:

Table 4. Pairwise comparisons in one-way ANOVA for CV and CVO syllables respectively

	Rhyme durational difference between **grammatically stressed** 2nd syllables and **lexically stressed** 2nd syllables	Rhyme durational difference between **grammatically stressed** 2nd syllables and **lexically stressless** 2nd syllables	Rhyme durational difference between **lexically stressed** 2nd syllables and **lexically stressless** 2nd syllables
In CV	p=.043	p<.001	p<.001
In CVO	p=.049	p<.001	p<.001

From Table 4, it can be seen that the significance of the rhyme durational difference

between the grammatically stressed condition and lexically stressed condition is marginal in both CV and CVO syllables. But the durational differences between the grammatically stressed condition and lexically stressless condition, as well as the lexically stressed condition and lexically stressless condition, are highly significant.

Though there is a significant durational difference among the three types of stresses, the effect sizes are different. In CV syllables, the effect size for the difference between the grammatically stressed and lexically stressed condition is 0.47[2]. But the effect size for the difference between the lexically stressed and lexically stressless condition is 0.91. In general, the effect size over 0.5 is considered as a large effect. Thus, we can consider the rhyme durational difference between the grammatically stressed and lexically stressed condition to be moderate whereas the rhyme durational difference between the lexically stressed and lexically stressless condition to be large. In CVO syllables, the effect size for the difference between the grammatically stressed and lexically stressed condition is 0.42. But the effect size for the difference between the lexically stressed and lexically stressless condition is 0.87. Again, in CVO syllables, the rhyme durational difference is large only for the lexically stressed vs. lexically stressless condition but not for the grammatically stressless vs. lexically stressless condition.

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[2] In CV syllables, effect size for the contrast between grammatically stressed 2nd syllables and lexically stressed 2nd syllables: $r_{grammaticallystressed\ vs.\ lexicallystressed} = \sqrt{\frac{F(1, df_R)}{F(1, df_R) + df_R}} = \sqrt{\frac{2.53}{2.53 + 9}} = 0.47$. '1' in the equation indicates df of the model whereas 'df_R' indicates df of error. The effect size r for other contrasts is calculated in the same way according to F(1, dfR) and df_R.

Apart from the main effects, there is also an interaction between stress and syllable type ($F(2, 18)=12.327$, $p<.01$). This interaction is shown in the following graph:

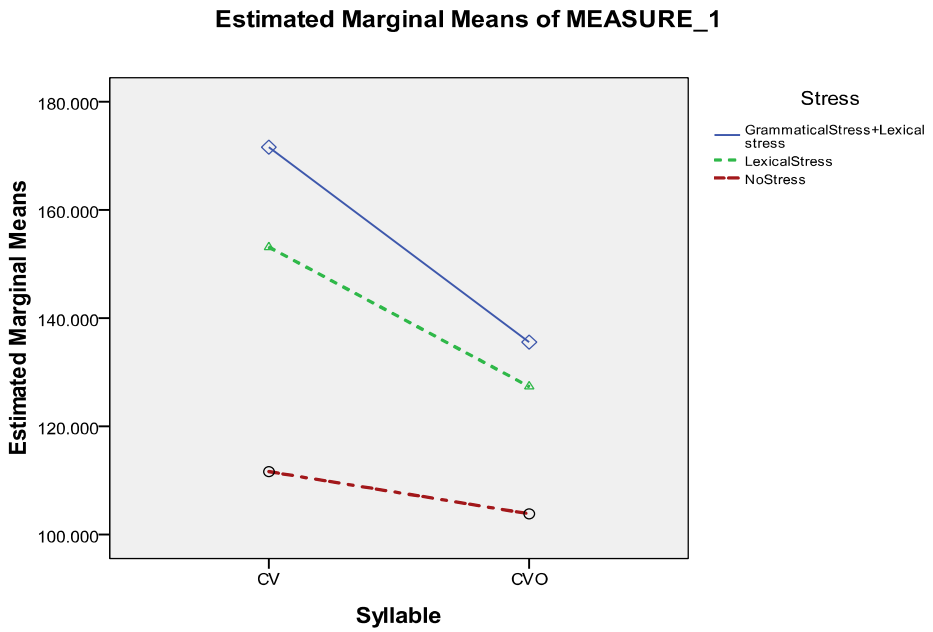

Figure 4. Interactions between stress and syllable in terms of rhyme durations.

From this interaction it can be seen that the rhyme duration reduction in CV is larger than the one in CVO as the stress status goes from grammatically stressed to lexically stressless. In other words, the durational difference among the three types of stress in CV second syllables is larger than the one in CVO second syllables. Particularly, in both CV and CVO second syllables, the rhyme duration in the second syllables without lexical stress becomes much shorter than the rhyme duration in the second syllables with only lexical stress and with both grammatical and lexical stress.

From the duration study, it can be concluded that both grammatical stress and lexical stress have durational correlates. But the rhyme duration difference between syllables with both grammatical and lexical stress and syllables with only lexical stress is considerably smaller than that between syllables with only lexical stress and syllables without any stress. With this finding, a tonal contrast study was conducted.

3 Experiment-2: Study of tonal contrasts

The tonal contrast study investigates the f_0 curves of the five lexical tones in monosyllables and the second syllables of disyllabic words with different stress types.

The tonal contrast study not only investigates the tonal contrasts but also examines whether the surface tones on stressless syllables are determined by the preceding tones. Therefore, ideally, all 25 tonal combinations for the disyllabic words where the second syllable is stressless should be included. If only CV syllables were used, then there would not be enough CV syllables that could cover all 25 tonal combinations. Therefore, the second syllables in the tonal contrast study included both CV and CVR.

Since a large rhyme durational difference between lexically stressed but grammatically stressless syllables and lexically stressless syllables was found, ideally, the tonal contrast situations in syllables with two stress statuses in both CV(R) and CVO syllables should

be examined. However, due to the extremely limited number of CVO syllables with tone 2 (yang ru) since most CVO syllables only carry tone 5 (yang ru), it is not possible to investigate the tonal contrasts in CVO syllables with different stresses.

Before investigating the tonal contrasts in the second syllables of disyllabic words, f_0 curves of the five lexical tones produced in monosyllables were first examined in order to obtain a baseline of f0 curves for the five lexical tones. Thus, two parts were included in Experiment-2. The first part studied the tonal contrasts in monosyllables. The second part studied the tonal contrasts in the lexically stressed but grammatically stressless second syllables and the lexically stressless second syllables in disyllabic words.

3.1 Methodology for the study of tonal contrasts in CV(R) monosyllables

Each lexical tone includes 4 monosyllables. Together, 20 monosyllables were used to establish the baseline of the five lexical tones. Syllables are either CV or CVR. Each monosyllable was pronounced twice in citation form by ten native speakers of Nanchang. These monosyllables are listed in the following table:

Table 5. Monosyllables used in the tonal contrasts study

42	猪 zu 'pig'	边 piɛn 'edge'	开 kai 'to open'	天 tiɛn 'sky'
24	穷 tɕ' ioŋ 'poor'	床 cuaŋ 'bed'	糖 t' oŋ 'suger/candy'	寒 han 'cold'
45	神 sɛn 'god'	变 piɛn 'to change'	云 yun 'cloud'	放 foŋ 'to release'

213	古 ku 'ancient'	草 cau 'grass'	粉 fen 'powder'	老 lau 'old'
21	大 t'ai 'big'	病 p'iaŋ 'illness'	地 t'i 'ground'	饭 fan 'rice'

The f_0 values at every 10% of the rhyme duration (11 points) in the second syllable of each token were extracted using Yi Xu's TimeNormalize script in Praat. The f_0 values were then averaged across the ten speakers.

After establishing the baseline for the five lexical tones, f_0 curves of the five lexical tones on syllables with and without lexical stress were examined. From this, whether the tonal contrasts in syllables with different stress statuses are the same as the tonal contrasts in monosyllables was examined. Since CV(R) syllables with lexical stress and CV(R) syllables without lexical stress have a large rhyme durational difference as shown in Experiment-1, it is expected that the tonal contrasts will be different due to the rhyme durational difference.

3.2 Methodology for the study of tonal contrasts in CV(R) syllables with and without lexical stress

As previously mentioned, for the tonal contrast study of syllables with and without lexical stress a wordlist that includes both CV and CVR syllables needs to be constructed in order to cover all 25 tonal combinations. Even with CVR syllables, there were still not enough lexically stressless disyllabic words in the Nanchang dialectal dictionary to cover

all 25 tonal combinations. Therefore, some lexically stressless disyllabic words were added to the wordlist based on the author's intuition. The following section describes what was included in the wordlist.

3.2.1 Wordlist design

The wordlist included 100 disyllabic words covering 25 tonal combinations. For each tonal combination, there were two words where the second syllables were lexically stressless and two words where the second syllables were lexically stressed but grammatically stressless. The second syllables in both types of words were homophones. For example, the following is a quartet of the tonal combination 42+42:

Table 6. An example of word pairs that include lexically stressless 2nd syllables vs. lexically stressed but grammatically stressless 2nd syllables.

42+42	
Lexically stressless 2nd syllable	Lexically stressed but grammatically stressless 2nd syllable
冤家 yon42 *ka0 (42)* *'enemy'* 亲家 tɕ'in42 *ka0 (42)* *'parents of son/daughter in law'*	私家 sɿ42 *ka42* *'private'* 三家 san42 *ka42* *'three families'*

'0' in the transcription means lexically stressless. '42' in the bracket next to '0' indicates the morpheme's underlying tone. The words in the left column are labeled as 'lexically stressless' second syllable. This is based on the author's judgment. The words in the right column are words with [N N] structure where the second syllables are lexically stressed.

Hence, this forms a word pair where one word is lexically stressless while the other is lexically stressed, but both words have the same underlying tonal combination. For the tonal combination of 42+42, there are two word pairs. For 25 tonal combinations, together, there are 50 word pairs. All word pairs are listed in the appendix.

In the wordlist, 38 lexically stressless disyllabic words that are not in the dictionary were added. Thus, to make sure they really are lexically stressless disyllabic words, a web survey was designed to refine the selection of the lexically stressless words.

3.2.2 Web survey

To do the web survey, the words in the wordlist were first recorded. Each lexically stressless word was recorded by a native speaker of Nanchang (the author) with two different pronunciations. One was pronounced with a stressless second syllable and the other was pronounced with a stressed second syllable. The lexically stressed syllables were also recorded with two different pronunciations, one of which was stressless whereas the other was stressed. All these words were recorded in citation form. The native speaker did the recording in the anechoic chamber of Kansas University phonetics and psycholinguistics laboratory, using an Electro-Voice RE20 microphone and a Marantz PMD671 solid state recorder. Each word was extracted as a separate .wav file for later integration as stimuli into HTML.

With the stimuli in hand, the next step was to post them on a webpage and ask native speakers of Nanchang to judge the naturalness of the pronunciations of each word. The basic structure of the webpage was composed of a one-page of introduction and five pages of naturalness ratings for each stimulus. Considering the length of the web survey, 50 word pairs were split into two blocks. Each block included 50 words each of which had two pronunciations. Thus, each block had 100 stimuli. These stimuli were put into five different pages. The method used in the webpage to play these stimuli was an anchor method by using HTML. Figures 5 and 6 are screenshots of the introduction and naturalness rating in the web survey:

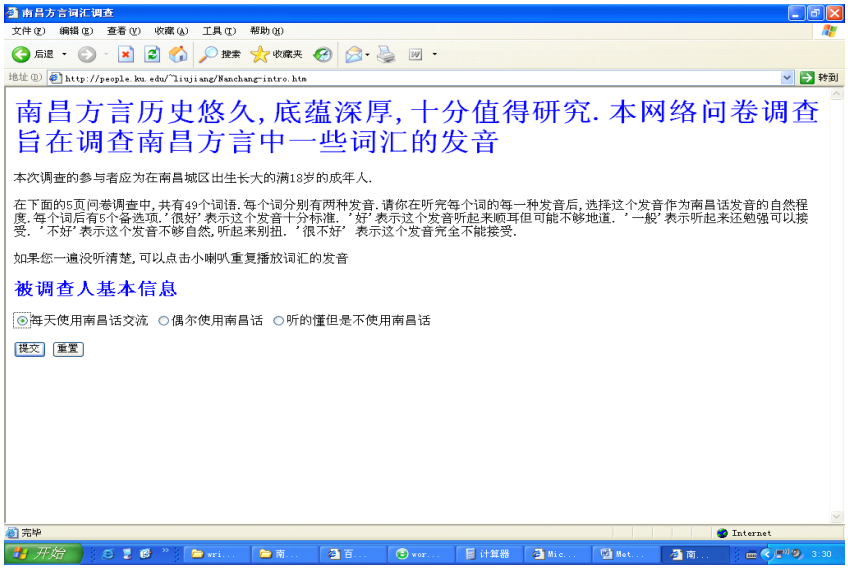

Figure 5. Screenshot of introduction in the online web survey. The introduction page includes the goal of the web survey, explanation of different naturalness ratings such as ‘very good’, ‘good’ and so on, and a survey of the frequency of usage of Nanchang in the subjects’ daily life.

Figure 6. Screenshot of naturalness rating in the online web survey. This page includes the pronunciations of different tokens and the radio buttons of the degrees of naturalness for subjects to choose from.

In the web pages, the naturalness judgment was a rating scale using radio buttons. For each stimulus's naturalness judgment, there were five choices to select from: 'very good', 'good', 'ok', 'bad' and 'very bad' in Chinese characters. The introduction page also used radio type questions to collect the basic information about the participants' use of Nanchang. For example, how frequently they use Nanchang (e.g., on daily basis, occasionally or only listen but do not speak).

To display the web survey, all web pages were located in a public_html folder on a KU server, so were the stimuli. Therefore, any users with an internet connection could obtain access to the web survey anywhere. Perl scripts were used to process the input and to

record the answers to the naturalness judgment made by the users. To record the data, a datafile was used to record the number of responses to each choice for each stimulus. For example, if 10 people selected the first choice, 6 people selected the second, 4 people selected the third and so on, the datafile recorded the exact number of people who made the choice for that particular stimulus. A sketch of the datafile is shown below:

	'verygood',	'good',	'ok',	'bad',	'verybad'
Stimulus1	10,	6,	4,	0,	0

As mentioned above, each stimulus has two pronunciations, one with a lexically stressless second syllable and one with a lexically stressed second syllable. If the native speakers only accepted the stressless pronunciation of a word then they would choose 'very good' or 'good' most of the time for the stressless pronunciation and choose 'bad' or 'very bad' for its stressed pronunciation. Each choice was assigned with a value rating from 5 to 1 (e.g., 'verygood' is 5, 'verybad' is 1, etc.). For a real lexically stressless word, the stressless pronunciations were expected to have a much higher value than the stressed pronunciations. This means the word was widely recognized by the native speakers as lexically stressless.

Eighteen native speakers of Nanchang participated in the web survey. For each stimulus, the value of the stressed pronunciation was subtracted from the value of the stressless pronunciation and then divided by 18 (the number of participants). If the obtained value was equal or above 1 then the word was used as a lexically stressless stimulus. If the

obtained value was less than 1, then the word was dropped from the lexically stressless wordlist.

Twenty one lexically stressless words were selected from the web survey. Together with their corresponding lexically stressed words (the second syllables were homophones of the second syllables in the lexically stressless words), they covered 17 out of 25 tonal combinations (see the complete wordlist in the appendix). Among the 17 tonal combinations, lexical tones that appeared in the second syllables included all five lexical tones in Nanchang.

3.2.3 Recording and measurement of f_0 in the target syllables

All lexically stressed and stressless disyllabic words were put in a carrier sentence:

(8) ŋo213 pa213 _____ cau42 lioŋ213 p'iɛn42.

I particle _____copy two times

I copy ____ twice.

Ten native speakers of Nanchang were asked to record the lexically stressless words and their corresponding lexically stressed words. Each word was read twice. F_0 of the tones carried by syllables with and without lexical stress was measured. F_0 extraction was made by using Yi Xu's TimeNormalize script. In each token, time normalized f_0 values at every 10% of the duration were extracted. Also, the rhyme duration of the lexically stressed and

stressless syllables was measured.

4. Results of tonal contrasts in monosyllables and in the second syllables of disyllabic words

This section presents the f_0 results of five lexical tones in the monosyllables and in the second syllables that are either lexically stressed but grammatically stressless or lexically stressless in the disyllabic words.

4.1 Results of tonal contrasts in monosyllables

The following graph shows the average f_0 curves of five lexical tones:

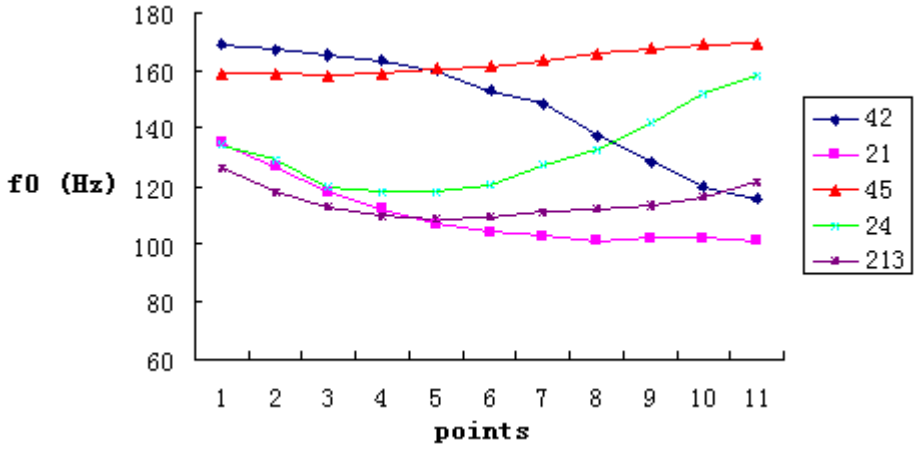

Figure 7. Average f_0 curves of five lexical tones in monosyllables in Nanchang

From Figure 7, it can be seen that the f_0 curves of five lexical tones were different from

each other in terms of tonal shapes. This result was used as baselines for the five lexical tones.

4.2 Results of tonal contrasts in the lexically stressed but grammatically stressless CV(R) syllables and in the lexically stressless syllables.

Ten native speakers' f_0 values for each lexical tone were averaged. The average pitch tracks of different lexical tones in the lexically stressed but grammatically stressless syllables are illustrated in the following figure:

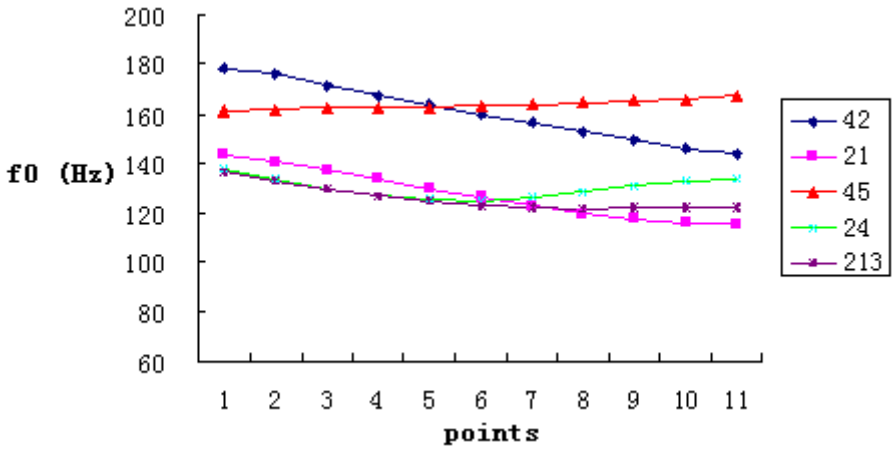

Figure 8. Average f_0 curves of five lexical tones realized in syllables with lexical stress.

As can be seen in Figure 8, the five lexical tones produced by speakers in lexically stressed but grammatically stressless syllables were quite different from each other. In order to describe these differences, a two-way Huynh-Feldt Repeated Measures ANOVA was conducted, with Tone and Point as independent variables. The Tone variable has five

levels—Tone42, Tone21, Tone45, Tone24 and Tone213. A significant main effect of the variable Tone would indicate that the two f_0 curves representing the tones have different average pitches. The Point variable has eleven levels, representing the eleven points where f_0 data were taken. A significant interaction between Tone and Point would indicate that the two curves have different tone shapes. This method of comparing two f_0 curves has been used by Peng (2000) and Zhang & Lai (2010).

The result shows a highly significant main effect of Tone (average f0) and Tone shape (interaction between Tone and Points). The within subject effect comparisons of average f_0 and tone shape between different lexical tones are shown in Table 7:

Table 7. Within subject effect comparisons of average f0 and tone shape between different underlying tones in syllables with lexical stress but without grammatical stress.

	Tone (average f0)	Tone Shape (Tone x Points)
42-45	Non-sig	**
42-21	**	Non-sig
42-24	**	**
42-213	**	**
45-21	**	**
45-24	**	**
45-213	**	**
21-24	**	**
21-213	**	**
24-213	*	**

In Table 7, different lexical tones were significantly different from each other in terms of average f_0 and tone shape. This result indicates that all five lexical tones' contrasts were preserved in the lexically stressed but grammatically stressless syllables.

Turning to tonal contrasts in syllables without lexical stress, the average f_0 curves of each underlying tone in the lexically stressless syllables are illustrated in the following graph:

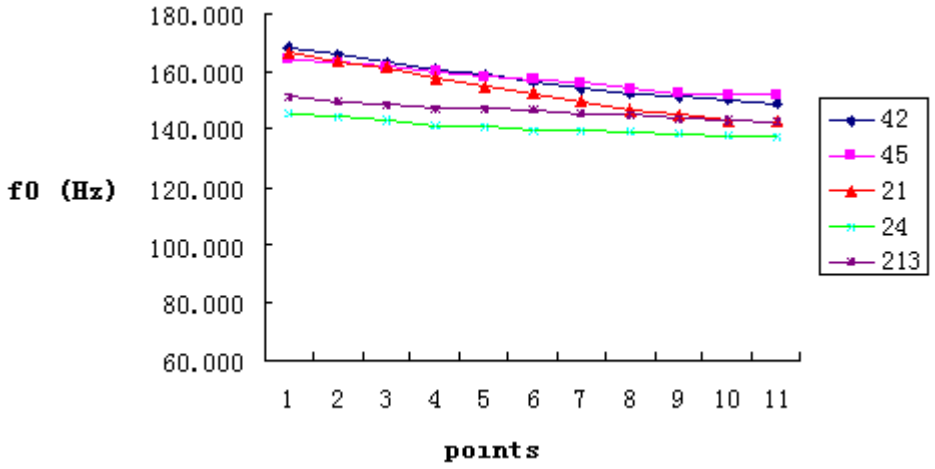

Figure 9. Average f_0 curves of five underlying tones in the lexically stressless syllables.

From Figure 9, it can be seen that all lexical tones become falling tones. Two-way Huynh-Feldt Repeated-Measures ANOVA still shows a significant main effect of Tone and Tone shape. The within subject effect comparisons of average f_0 and f_0 shape between different lexical tones are shown in Table 8:

Table 8. Within subject effect comparisons of average f0 and tone shape between different underlying tones.

	Tone (average f0)	Tone Shape (Tone x Points)
42-45	Non-sig	Non-sig
42-21	Non-sig	Non-sig
42-24	**	**
42-213	**	**
45-21	Non-sig	Non-sig
45-24	*	Non-sig
45-213	Non-sig	Non-sig
21-24	**	**
21-213	*	**
24-213	Non-sig	Non-sig

To make the result of Table 8 more succinct: tones 42, 45 and 21 were the same in terms of average f_0 and tone shape whereas 24 and 213 were the same in terms of average f_0 and tone shape. Clearly, tonal neutralization has occurred. This result indicates that tonal contrasts of five lexical tones were reduced to contrasts between two tones in the lexically stressless syllables.

The tonal contrast patterns in the lexically stressed but grammatically stressless syllables and in the lexically stressless syllables have significant implications for the relation between tonal contrasts and rhyme durations. Five lexical tones were preserved in the lexically stressed but grammatically stressless syllables whereas the tones were neutralized in lexically stressless syllables. Considering the rhyme duration of these syllables with different stresses, there is not a large rhyme durational difference between

the grammatically stressed syllables and the lexically stressed but grammatically stressless syllables. Even with shorter rhyme duration, the rhyme duration of the lexically stressed syllables but grammatically stressless was not as short as the rhyme duration of the lexically stressless syllables. Five lexical tones were preserved in the lexically stressed (grammatically stressless) syllables but not in the lexically stressless syllables. Thus, the claim about the relation between tonal contrasts and rhyme duration of syllables can be that if a drastic rhyme duration reduction occurs in a syllable then the tonal contrasts that appear in the syllable will be reduced as well.

The rhyme durations of lexically stressed but grammatically stressless syllables and of lexically stressless syllables were examined in the tonal contrast study as well. The following graph shows the rhyme duration difference between the lexically stressed but grammatically stressless syllables and the lexically stressless syllables:

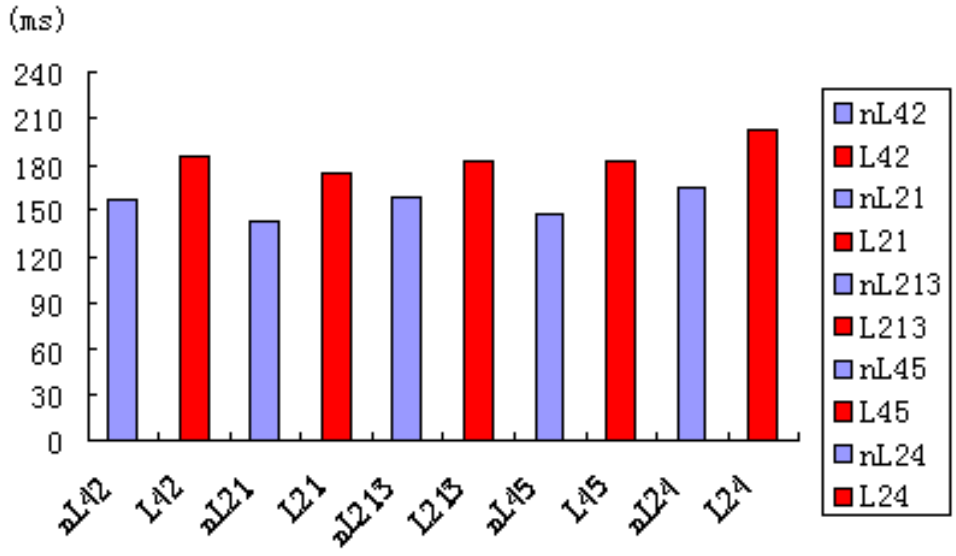

Figure 10. Mean rhyme duration of five lexical tones in syllables with and without lexical stress. 'nL' indicates 'no-Lexical stress'; 'L' indicates 'Lexical stress'.

Two-way Huynh-Feldt Repeated-Measures ANOVA shows significant main effect of Stress ($F(1, 41)=55.997$, $p<.001$) but not Tone. The result indicates the rhyme duration of syllables with lexical stress were significantly longer than that of syllables without lexical stress.

Another issue investigated in the tonal contrast study is whether the tones that surface in lexically stressless syllables are determined by their preceding lexical tones. As Hou & Wei (1998) documented based on impressionistic transcription, the tone in lexically stressless syllables is 4 when it is preceded by the lexical tone 24, 45 or 213 and when it is preceded by the lexical tone 42 or 21 then the tone becomes 2. Thus, they claimed that the preceding lexical tones determine what the tone looks like in the lexically stressless

syllables. In the current study, though not all 25 tonal combinations for lexically stressless syllables were included, the first syllables still included five lexical tones. The underlying tones of the lexically stressless syllables that preceded by five different lexical tones are illustrated as follows:

Table 9. Underlying tones of lexically stressless syllables that follow the lexical tones of the first syllables.

Underlying tones in the 1st sllables	Underlying tones in the 2nd syllable
42	42, 21, 45, 24, 213
21	42, 24, 213
45	42, 21, 24, 213
24	42
213	42, 24, 45, 213

For each lexical tone of the first syllables, the f_0 of its following tones were averaged in the second syllables. The average f_0 curves of second syllables when preceded by different lexical tones are illustrated in the following graph:

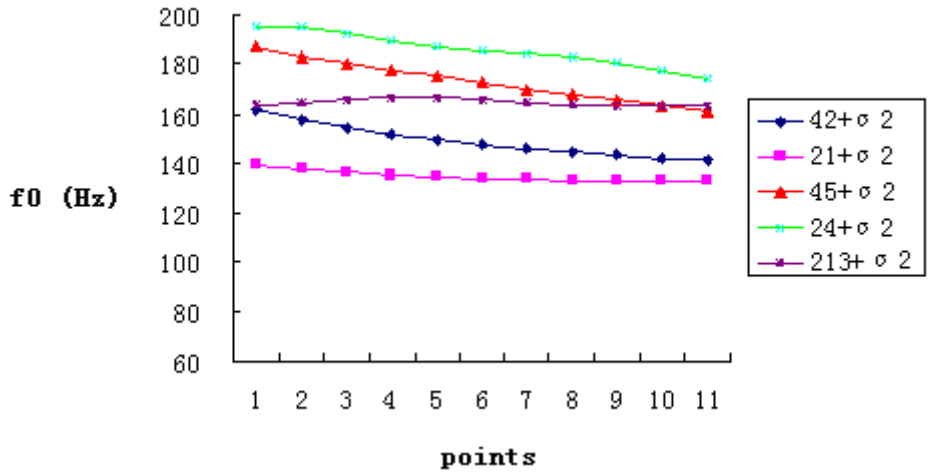

Figure 11. Average f_0 curves of lexical tones in the lexically stressless second syllables (σ2) when preceded by different lexical tones.

Two-way Huynh-Feldt Repeated-Measures ANOVA shows a highly significant effect of Tone and Tone shape. This result indicates that the preceding tones have effects on f_0 curves of the following underlying tones. The within subject effect comparisons of average f_0 and f_0 shape between different underlying tones preceded by certain lexical tones are illustrated in Table 10:

Table 10. Within subject effect comparisons of average f_0 and tone shape between different sets of underlying tones in lexically stressless syllables when preceded by a certain lexical tone.

	Tone (average f0)	Tone Shape (Tone x Points)
42 vs. 45	**	Non-sig
42 vs. 21	**	**

42 vs. 24	**	Non-sig
42 vs. 213	**	**
45 vs. 21	**	**
45 vs. 24	*	Non-sig
45 vs. 213	Non-sig	**
21 vs. 24	**	*
21 vs. 213	**	Non-sig
24 vs. 213	*	**

Note: the digits indicate different underlying tones that follow this certain lexical tone. For example, '21' indicates tones 42, 24 and 213 that follow tone '21'.

Table 10 shows that the surface tones in the lexically stressless syllables were not neutralized to become 4 and 2 according to their preceding tones. Rather, the surface tones in the lexically stressless syllables were different from each other. This result is different from the observation made by Hou and Wei in which they claimed that the tone that surfaces in the lexically stressless syllables is purely determined by its preceding tone, but not affected by its underlying tone. The tonal difference found in the present study was likely caused by tonal coarticulation effect and also by the unequal number of the underlying tones in the second syllables. In terms of tonal coarticulation effect, we examined whether a clear carryover effect exists since we only focus on the tone that surfaces in the lexically stressless second syllables.

Since in the current study tone 42 had five lexical tones both as its preceding tones and following tones then we examined the average f_0 curves of tone 42 when it was preceded

by five different lexical tones and the average f_0 curves of five lexical tones when they followed tone 42. The individual tone's average f_0 situation provides evidence that there exists tonal coarticulation effect and certain lexical tones as a group are neutralized when they are preceded by the same lexical tone.

When the lexical tone of the first syllable was 42, the average f_0 curves of its following underlying tones in the lexically stressless syllables were measured. The same pattern as figure 9 occurred where 42, 45 and 21 were neutralized and 24 and 213 were neutralized:

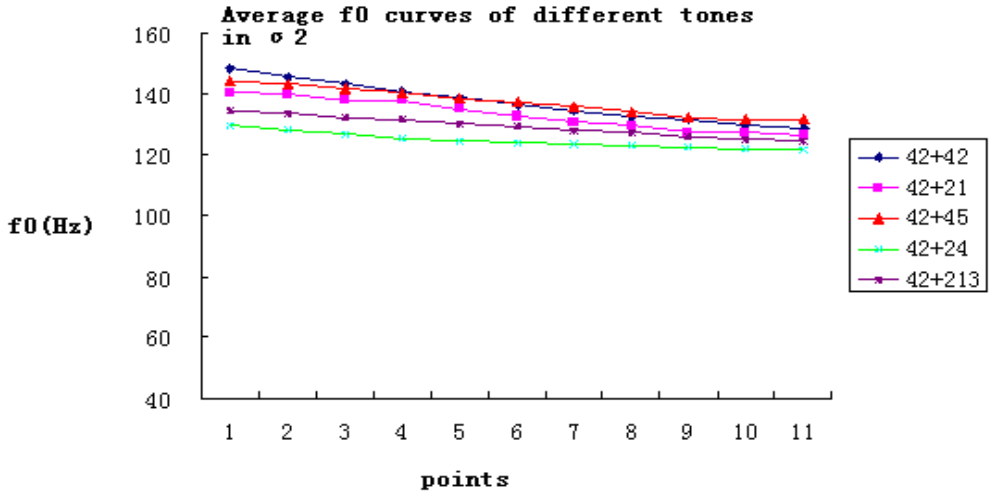

Figure 12. Average f_0 curves of five underlying tones in lexically stressless syllables preceded by the same tone 42.

Two-way Huynh-Feldt Repeated-Measures ANOVA shows a significant effect for both Tone and Tone shape. Within subjects effect showed 42, 45 and 21 were the same and 24 and 213 were the same in terms of average f_0 and f_0 shape. This is exactly the same pattern as the average f_0 of five underlying tones in the lexically stressless second

syllables regardless of the preceding lexical tones. The pitch range of the five underlying tones in Figure 12 was lower than the pitch range of the five underlying tones in Figure 9. This is because of the pitch lowering effect of tone 42 on the following tones. It seems that there is a carryover effect on the pitch range of the tones in lexically stressless second syllables.

When one lexical tone in the lexically stressless syllables was preceded by different lexical tones, a tonal coarticulation occurred. The following figure shows average f_0 curves of the underlying tone 42 in the lexically stressless syllables when it was preceded by different lexical tones:

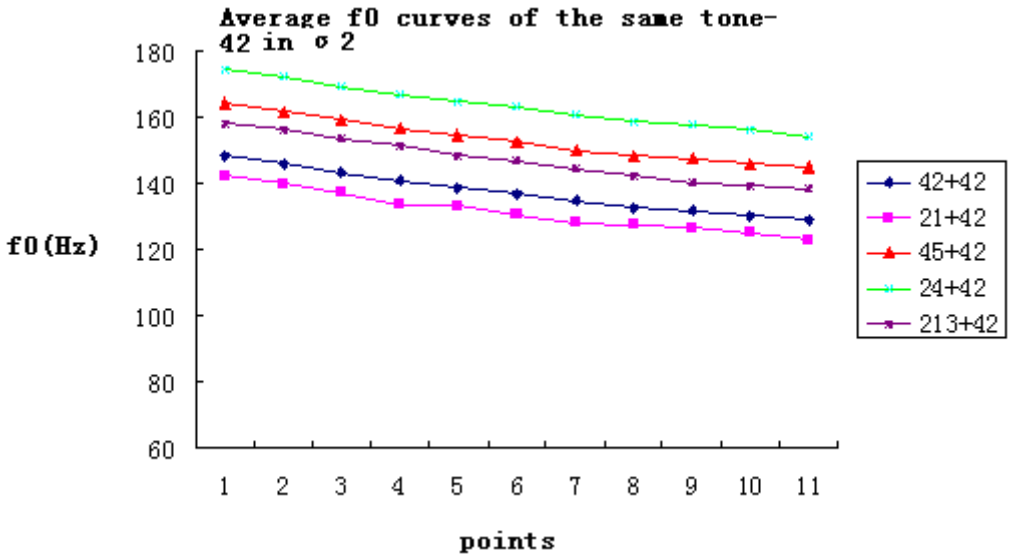

Figure 13. Average f_0 curves of tone 42 in lexically stressless syllables preceded by five different lexical tones.

In Figure 13, the pitch tracks were parallel to each other. A Two-way Huynh-Feldt

Repeated-Measures ANOVA shows a significant main effect of Tone but not Tone shape. The within subject effect comparison shows that the five tones were different from each other in terms of average f_0. As the preceding tone went from tone 21, which has the lowest ending pitch target to tone 213, which has higher ending pitch target than tone 21, the average f_0 of tone 42 became higher. The average f_0 of tone 42 that followed tone 24 was, surprisingly, higher than that followed tone 45; it is likely that there was a pitch peak delay for the preceding tone 24, which had a larger pitch rise than 45. From these results, we claim that an assimilatory carryover effect occurred to the underlying tones in the syllables without lexical stress.

To sum up the results of the instrumental studies, lexical stress had durational correlates in both CV and CVO syllables. The same happened to grammatical stress that had durational correlates in both CV and CVO syllables. The rhyme duration of the syllables with lexical stress was significantly longer than that of syllables without lexical stress. This rhyme durational difference was considerably larger than the rhyme durational difference between the grammatically stressed syllables and the lexically stressed but grammatically stressless syllables. The tonal contrasts for the five lexical tones were preserved in the lexically stressed but grammatically stressless syllables but reduced to contrasts between two tones in the lexically stressless syllables--tone 42, 45 and 21 were neutralized whereas 24 and 213 were neutralized.

5. Analysis

This section aims to sketch a formal analysis for the tonal contrast difference between lexically stressless CV(R) syllables and grammatically stressless but lexically stressed CV(R) syllables. In the formal analysis, the durational basis for the number of tonal contrasts is discussed under the Optimality Theroy framework (Prince & Smolensky 1993). As for why lexical tones become neutralized in certain ways in the lexically stressless syllables, currently, no full fledged analysis is provided. Future perception study is needed to determine whether the two tones that surface in lexically stressless CV(R) are contrastive.

5.1 Tonal contrasts in lexically stressed but grammatically stressless CV(R) and lexically stressless CV(R)

The rhyme duration of the grammatically stressed CV(R) syllables is significantly longer than that of lexically stressed but grammatically stressless CV(R) syllables, which in turn have a longer rhyme duration than the lexically stressless syllables. However, the effect size of the difference between the grammatically stressed CV(R) syllables and the lexically stressed but grammatically stressless ones (r=0.47) is not as large as the effect size of the difference between the lexically stressed but grammatically stressless CV(R) syllables and the lexically stressless ones (r=0.91). The tonal contrast study shows that there are five lexical tones in the lexically stressed but grammatically stressless CV(R) syllables. Only two tones surface in the lexically stressless CV(R) syllables. Though the

rhyme duration of the lexically stressed but grammatically stressless CV(R) syllables is significantly shorter than the grammatically stressed CV(R) syllables, such durational difference may not be large enough to cause significant tonal neutralization. This fact suggests that the rhyme length of lexically stressed but grammatically stressless CV(R) syllables may be the baseline for carrying five lexical tones. Any CV(R) syllables that have shorter rhyme duration than the baseline will have tonal neutralization. Such neutralization causes the reduction of tonal contrasts.

The fact we need to account for is that lexically stressed but grammatically stressless syllables (hereinafter $CVR_{GrammaticallyStressless}$) do not have tonal reduction whereas lexically stressless syllables (hereinafter $CVR_{LexicallyStressless}$) do. The key is the rhyme duration. To formalize the durational constraint on the tonal contrasts, we first classify the durational categories, $CVR_{GrammaticallyStressless}$ and $CVR_{LexicallyStressless}$, on one phonetic scale. The former category has longer rhyme duration than the latter category:

(12) Rhyme duration: $CVR_{GrammaticallyStressless} > CVR_{LexicallyStressless}$

$CVR_{GrammaticallyStressless}$ and $CVR_{LexicallyStressless}$ are two different contexts for bearing tonal contrasts.

Another phonetic scale is the scale of tonal distance between tones. The reason to include a tonal distance scale is that the constraint MINDIST is used for the current analysis. MINDIST is proposed by Flemming (1995, 2006) as a requirement for the minimum

perceptual distance between two contrastive phonemes. Similar to phonemes, contrastive tones also need minimum perceptual distance.

For syllable type σ, the MINDIST constraints are defined in (13a), with an intrinsic ranking as in (13b):

(13) a. MINDIST-σ(tone)=i is defined as:

the distance between any two tones in the tonal inventory on σ must be at least i steps.

b. If i>j, then MINDIST-σ(tone)=j >> MINDIST-σ(tone)=i.

The intrinsic ranking is MINDIST=1>> MINDIST=2>> MINDIST=3>>..... MINDIST=n. In other words, the larger the minimum perceptual difference is the lower it is ranked.

To evaluate the tonal distance, since 4 out of 5 tones in Nanchang are transcribed as having two tonal targets, we can calculate the tonal distance by summing up the tonal difference of the initial tonal targets between different tones and the tonal differences of the final tonal targets between different tones. When we compare 213, which has three tonal targets, with other tones, which only have two tonal targets, we need to interpolate a tonal target between the initial and final tonal targets in tones, which are transcribed as only having two tonal targets, in order to count the tonal distance. The interpolated tonal target has even distance to the initial tonal target and to the final tonal target. To

standardize the calculation, we interpolate a tonal target between the initial and final tonal targets in every tone that are transcribed with only two tonal targets. The calculation of the tonal distance is shown in the following table:

Table 11. Tonal distance between lexical tones in Nanchang.

	42 (4 3 2)	45 (4 4.5 5)	24 (2 3 4)	21 (2 1.5 1)	213
42 (4 3 2)		4.5	4	4.5	5
45 (4 4.5 5)	4.5		4.5	9	7.5
24 (2 3 4)	4	4.5		4.5	3
21 (2 1.5 1)	4.5	9	4.5		2.5
213	5	7.5	3	2.5	

The tonal distance between two tones is the sum of the tonal differences between tonal targets. For example, the tonal distance between 42 and 45 is the sum of the differences between the initial targets (4 vs. 4), the middle tonal targets (3 vs. 4.5) and the final tonal targets (2 vs. 5). The tonal distance is the sum of the absolute values of these differences. Therefore, the tonal distance is 4.5 steps between 42 and 45.

From Table 11 we found the shortest tonal distance (2.5 steps) is between 21 and 213. This suggests that the minimum tonal distance requirement in Nanchang is at least 2.5 steps. Thus, the constraint 'MINDIST=2.5' is highly ranked. Also, we assume that the tonal distances between lexical tones in Table11 are halved in the lexically stressless CV(R) syllables due to the rhyme duration shortening. Therefore, most of lexical tones will have tonal distances less than 2.5 steps. Because of the shorter tonal distance, 'MINDIST=2.5' will be violated severely. Once the tonal distance has been quantified, the violation of

MINDIST can be evaluated.

Apart from MINDIST, we also need MAXMIZECONTRASTS constraint to preserve the number of tonal contrasts maximally in any context. MINDIST constraints interact with MAXMIZECONTRASTS to generate the tonal inventory in syllables with different rhyme duration. The current study shows that $CV(R)_{GrammaticallyStressless}$ has a tonal inventory of 5 whereas $CV(R)_{LexicallyStressless}$ has a tonal inventory of 2. In $CV(R)_{LexicallyStressless,}$ 42, 45 and 21 were neutralized and 24, 213 were neutralized. At this point, it is unclear what tones surface in $CV(R)_{LexicallyStressless}$. It is also unclear why 21 merges with 42 and 45, but not with 24 and 213. However, the crucial result is that the tonal inventory size in $CV(R)_{LexicallyStressless}$ is reduced compared with $CV(R)_{GrammaticallyStressless}$. Let's assume tone 'a' and 'b' surface in $CV(R)_{LexicallyStressless}$. The tonal distance between them must be at least 2.5 steps which is the minimum tonal difference that can be perceived. Also, the markedness constraint *ContourTone/ $CV(R)_{LexicallyStressless}$ is highly ranked that prevents contour tones (simple or complex) from occurring in $CV(R)_{LexicallyStressless}$ because of the shorter rhyme duration. This constraint accounts for why the contrasts between lexical tones such as 45 and 21 that have large tonal distance from each other are not preserved in $CV(R)_{LexicallyStressless}$. Thus, 'a' and 'b' must be level tones. With all these constraints, the tonal inventory of $CV(R)_{GrammaticallyStressless}$ and $CV(R)_{LexicallyStressless}$ are generated from the following tableau:

(16) Tonal inventory in $CV(R)_{GrammaticallyStressless}$.

	MINDIST =1	MINDIST =2	*ContourTone/ $CV(R)_{LexicallyStressless}$	MINDIST= 2.5	MAXMIZE CONTRASTS	MINDIST =3
☞ 42-45-24 -21-213					✓✓✓✓✓	*
42-45-24- 213					✓✓✓✓!	
42-24					✓✓!	

(16) accounts for the tonal inventory in $CV(R)_{GrammaticallyStressless}$. No contrasts between lexical tones are below 2.5 steps. Therefore, MINDIST=2.5, MINDIST=2 and MINDIST=1 are not violated. The highly ranked *ContourTone/ $CV(R)_{LexicallyStressless}$ is not relevant in $CV(R)_{GrammaticallyStressless}$. Thus, it is not violated. MAXMIZECONTRASTS calculates the number of contrastive tones present in $CV(R)_{GrammaticallyStressless}$. The fewer tonal contrasts the more serious violation occurs. Thus, tonal inventory of 5 is more harmonious than tonal inventory of less than 5.

Now we turn to the tonal contrasts in $CV(R)_{LexicallyStressless}$. As mentioned earlier, the tonal distances between lexical tones are halved due to the rhyme duration shortening. The tonal contrast reduction is explained by tableau (17):

(17) Tonal inventory in CV(R)$_{\text{LexicallyStressless}}$.

	MINDIST =1	MINDIST =2	*ContourTone/ CV(R)$_{\text{LexicallyStressless}}$	MINDIST =2.5	MAXMIZE CONTRASTS	MINDIST =3
☞ a-b					✓✓	
24-213-2 1-42-45			*!	*******!	✓✓✓✓✓	*******
42-21-24			*!	***	✓✓✓	*
213-24		*!	*	*	✓✓	
45-21			*!		✓✓	*

The tonal contrast reduction in CV(R)$_{\text{LexicallyStressless}}$ is due to the reduction of tonal distances between lexical tones. Because of the reduced tonal distances, contrasts between most of lexical tones cannot be perceived. In literature, the tones that surface in CV(R)$_{\text{LexicallyStressless}}$ are transcribed as 4 and 2 impressionistically (Hou & Wei 1998; Li 1995). Therefore, the contrast between a and b can be the contrast between 4 and 2. However, this needs future perception experiment to justify.

5.2 Tonal contrasts in CVO

In the current study, we studied the durational properties of CVO syllables and CV syllables with different stresses. As the finding shows, the rhyme duration of CVO

syllables is significantly shorter than CV syllables (122ms vs. 145ms). As mentioned in the introduction, two lexical tones can appear in CVO syllables (2 and 5), whereas five lexical tones can appear in CV syllables. Thus, CVO syllables with shorter rhyme duration have fewer tonal contrasts than CV syllables. This pattern is consistent with the patterns in many other Chinese dialects; some of these dialects are listed in Table 12 to 14.

Table 12. Shanghai (Zee and Maddieson 1979)

Syllable Type	/CV/			/CV?/	
	Tone A	Tone B	Tone C	Tone D	Tone E
Vowel Dur.	262ms	327ms	332ms	102ms	147ms
Tonal Value	/42/	/35/	/24/	/5/	/23/

Table 13. Fuzhou (Zhang 1997a)

Syllable Type	/CV/ or /CVŋ/	/CV?/	
Duration of Sonorous Rime	398ms	192ms	265ms
Possible Tonal Value	/44, 32, 212, 52, 231/	/5/	/23/

Table 14. Pingyao (Hou 1980, Zhang 1997a, b)

Syllable Type	/CV/ or /CVŋ/	/CV?/
Duration of Sonorous Rime	282ms	141ms
Possible Tonal Value	/13, 53, 35/	/23, 54/

Among these dialects, we can see that the sonorous rhymes of CV(R) syllables are considerably longer than CVO syllables. The number of lexical tones that appear in CV(R) syllables is consistently larger than the one that can appear in CVO syllables. The reason that CVO has shorter rhyme duration is that the consonants (e.g., unreleased consonants, glottal stop) after the vowel make the vocal vibration stop abruptly (Duanmu

1994). Therefore, in general, as long as CVO has shorter rhyme duration than CV(R) then the tonal contrasts become reduced in CVO.

Turning to the tonal contrasts in CVO syllables with different stresses, as the duration study shows, the rhyme duration of the grammatically stressed syllables is longer than that of the lexically stressed but grammatically stressless syllables, which in turn have longer rhyme duration than lexically stressless syllables. However, with these durational differences, it is difficult to examine the tonal contrasts in CVO syllables with different stresses. The reason is that there might be only one lexical tone in CVO in Nanchang. Hou & Wei (1998) claimed that there is a trend in Nanchang that yang ru (2) is merging into yin ru (5). This is tested in a pilot study for this thesis. Six Nanchang speakers' pronunciation of four monosyllables with yin ru (5) and four monosyllables with yang ru (2) were recorded (2 speakers are in their 50s; 2 speakers are in their 30s; 2 speakers are in their 20s). Perceptually, yang ru (2) pronounced by five speakers sounded the same as yin ru (5). Only one speaker, who is in his 50s, pronounced two monosyllables with yang ru (2). The dominant pronunciation of yin ru (5) suggests that maybe now only one lexical tone occurs in CVO syllables. In the Nanchang dialectal dictionary (Li 1995), most CVO syllables were transcribed as 5 with only a handful of exceptions. Some syllables transcribed with yang ru (2) were interestingly noted to have a yin ru (5) variant. Due to the extremely limited number of CVO syllables with yang ru (2), it is impossible to examine whether tonal contrasts change if the rhyme durations change due to different

stresses.

Since only level tones appear in CVO (5 and 2), *ContourTone/ CVO is highly ranked. Also, the tonal distance between 5 and 2 is not less than 2.5 steps. The tonal inventory of three tones is not possible in CVO because the only inventory of three tones is /1/, /3/ and /5/ and the tonal distance among them is less than 2.5 steps. As for why the pair /4/ and /1/ are not contrastive tones in CVO in Nanchang, we argue that /1/ is a marked lexical tone cross-linguistically because typologically /1/ is rare in the tonal inventory of both CV and CVO (Bao 1999). Therefore, the constraint '*/1/-LexicalTone/CVO' is highly ranked in Nanchang. The tableau that generates /5/ and /2/ in Nanchang is shown below:

(18) Tonal inventory in CVO

	MINDIST =2	*/1/-LexicalTone/CVO	*ContourTone/ CVO	MINDIST =2.5	MAXMIZE CONTRASTS	MINDIST =3
☞ 5-2					✓✓	
1-3-5		*!		*	✓✓✓	*
4-1		*!			✓✓	
5					✓!	

Up to this point, a formal analysis has been provided to account for the tonal contrast difference between $CV(R)_{GrammaticallyStressless}$ and $CV(R)_{LexicallyStressless.}$ This analysis uses constraints MINDIST, MAXMIZECONTRASTS and *ContourTone/ $CV(R)_{LexicallyStressless}$ to build the constraint ranking so as to generate the correct number of tonal contrasts in the two types of CV(R) syllables ($CV(R)_{LexicallyStressed}$ vs. $CV(R)_{LexicallyStressless}$) with rhyme durational difference. However, the tonal characteristics of tones that surface in $CV(R)_{LexicallyStressless}$ cannot be specified by using this set of constraints because it is not clear whether the two tones in $CV(R)_{LexicallyStressless}$ are contrastive. Future perception study is needed. For CVO, the tonal inventories in CVO syllables with different stresses cannot be examined due to the limited number of lexical items with yang ru (2). The number of tones that are allowed in CVO is explained by using the same set of constraints for the analysis of tonal inventory in $CV(R)_{LexicallyStressless}$. Constraints */1/-LexicalTone/CVO and *ContourTone/ CVO are added into the analysis.

6. Conclusion

Four questions have been addressed in this thesis: (1) Does lexical stress have durational correlates? (2) Does grammatical stress have durational correlates? (3) Is the rhyme duration of CVO syllables significantly shorter than of CV syllables? (4) If there are durational differences among syllables with different stress statuses (lexically stressed vs. lexically stressless and grammatically stressed vs. grammatically stressless), then are there any tonal contrast differences among these types of syllables?

First, the duration study shows that both lexical stress and grammatical stress have durational correlates. The rhyme duration of CVO is shorter than CV regardless of different stresses two types of syllables carry. The effect size of grammatical stress is not as large as the effect size of lexical stress. In other words, the rhyme durational difference between lexically stressed syllables and lexically stressless syllables is larger than the rhyme durational difference between grammatically stressed and grammatically stressless but lexically stressed syllables. The existence of 'grammatical stress' is supported by the durational difference between the first syllable of [N N] and [V N], namely, the first N in [N N] has longer rhyme duration than V in [V N].

Second, the tonal contrast study shows that the five lexical tones are all preserved in grammatically stressless but lexically stressed CV(R) while the tonal inventory of the five lexical tones is reduced into an inventory of two tones in lexically stressless CV(R). This result suggests that the rhyme duration of lexically stressed CV(R) is the baseline for carrying five contrastive tones. Any CV(R) syllables that have shorter rhyme duration than the baseline will have tonal neutralization. The number of tones that surface in grammatically stressless but lexically stressed CV(R) and in lexically stressless CV(R) is determined by the tonal distance between two tones. The minimum perceptual tonal difference between two tones in Nanchang is 2.5 steps. Any tonal contrast that has tonal distance less than 2.5 steps becomes neutralized. When the rhyme duration of lexically

stressless CV(R) becomes shorter the tonal distances between lexical tones become shortened as well. Therefore, the number of lexical tones is reduced due to tonal distance shortening. The markedness constraint *ContourTone/ CV(R)LexicallyStressless and *ContourTone/ CVO eliminate the contour tones that surface in these two types of syllables. Thus, only short level tones are allowed in these contexts. However, further studies are needed to test whether the two tones that surface on $CV(R)_{lexicallyStressless}$ and CVO syllable are indeed contrastive.

Appendix: wordlist used in the tonal contrast study

Note: For each tonal combination, the word on the left has lexically stressless second syllable and the word on the right has lexically stressed but grammatically stressless second syllable. After the web survey, 21 word pairs were used in the recording. The words in boxes are the selected words

42+42			**42+24**	
冤 家 yon42 ka0 (42) 'enemy' 亲 家 tɕ'in42 ka0 (42) 'parents of son/daughter in law'	私 家 sʔ42 ka42 'private' 三家 san42 ka42 'three families'		价 钱 ka42 tɕ'iɛn0 (24) 'price' 招 牌 tsɛu42 p'ai0 (24) 'brand'	脏 钱 tsoŋ 42 tɕ' iɛn24 'dirty money' 金牌 tɕin42 p' ai24 'gold medal'
24+42			**24+24**	
徒弟 t'u24 t'i0 (42) 'apprentice' 棉 花 miɛn24 fa0 (42) 'cotton'	唐 弟 t'oŋ24 t' i42 'cousin' 桃 花 t'au24 fa42 'peach blossom'		葡 萄 p'u24 t'au0 (24) 'grape' 强 强 tɕ'ioŋ24tɕ'ioŋ0(24)(人小名) 'people's nick name'	甜 桃 t'iɛn24 'sweet peach' 城墙 ts'ɨn24tɕ'ioŋ24 'city wall'
45+42			**45+24**	
嫁 妆 ka45 tsɔŋ0(42) 'dowery' 神 经 sɨn45 tɕin0 (42) 'nerve'	浓妆 luŋ 45 tsɔŋ42 'thick make-up' 半 斤 pɵn45tɕin42 'half half kilogram'		来 头 lai45 t'ɛu0 (24) 'background' 名 堂 min45 t'oŋ0 (24) 'matters'	蛇头 sa45 t' ɛu24 'head of a snake' 鱼塘 nie45 t'oŋ24 'fish pond'
213+42			**213+24**	
姐 夫 tɕia213 fu0 (42) 'brother in law' 点 心 tiɛn213 ɕin0 (42) 'snacks'	马 夫 ma213 fu42 'horse man' 菜心 ts'ai213 ɕin42 'heart of pa choi'		本钱 pɨn213 tɕ'iɛn0 (24) 'capital' 枕 头 tsɨn213 t'ɛu0 (24) 'pillow'	假钱 ka213 tɕ'iɛn24 'counterfeit money' 狗头 kiɛu213 t'ɛu24 'head of a dog'
21+42			**21+24**	
地方 t'i21 foŋ0 (42) 'place'	后 方 hɛu21 foŋ42 'the rear line'		后 头 hɛu21 t'ɛu0(24) 'in the back'	大头 t'ai21 t' ɛu24 'big head'
寿 星 siu21 ɕin0 (42) 'people who live long lives'	外 星 uai21 ɕin42 'extra-terrestrial'		外头 uai21 'outside'	树 头 ɕy21 t' ɛu24 'top of a tree'

42+45			**42+213**	
聪 明 tsong mianŋ ‘clever’	刁 民 tiau min ‘cunning citizens’		虾 米 ha42 mi0 (213) ‘dry shrimp’	生 米 saŋ42 mi213 ‘uncooked rice’
功劳 kuŋ42 lau0 (45) ‘contribution’	天牢 t'iɛn42 lau45 ‘prison’		跟斗 kiɛn42 tɛu0 (213) ‘tumble’	三斗 san42 tɛu213 ‘three buckets’
24+45			**24+213**	
猴年 hou24niɛn0(45) ‘year of monkey’	前年 tɕ'iɛn24niɛn0(45) ‘the year before’		寒气 hɒn24 tɕ’i213 ‘cold air’	铜器 t'u ŋ 24 tɕ’i213 ‘copper container’
丰年 feŋ nien ‘harvest year’			潮气 ts'ɛu24 tɕ’i213 ‘humid air’	陶器 tau qi ‘pottery’
45+45			**45+213**	
记性 tɕi45 ɕin0 (45) ‘memory’	人性 nin45 ɕin45 ‘human nature’		神气 sɨn45 tɕ’i0 (213) ‘arrogant’	人气 nin45 tɕ’i213 ‘popularity’
代价 tai45 ka0(45) ‘cost’	油价 iu45 ka45 ‘price of oil’		凉快 lioŋ45 k'uai0(213) ‘coolness’	最快 tsui45 k'uai213 ‘the fastest’
213+45			**213+213**	
仔细 tsʅ213 ɕi0 (45) ‘careful’	好细 hau213 ɕi45 ‘really thin’		手气 sɨu213 tɕ’i0 (213) ‘luck’	老气 lau213 tɕ’i213 ‘old looking’
把戏 pa213 ɕi0 (45) ‘trick’	好戏 hau213 ɕi45 ‘good drama’		韭菜 tɕiu213 ts’ai0 (213) ‘leeks’	好菜 hau213 ts’ai213 ‘good dish’
21+45			**21+213**	
面相 miɛn21ɕioŋ0(45) ‘appearance’	外向 uai21ɕioŋ0(45) ‘extroverted’		义气 ɲi21 tɕ’i0 (213) ‘brotherhood’	大气 t'ai tɕ’i213 ‘grand’

			运气 yn21 tɕ’i0 (213) ‘luck’	利器 li21 tʂ’i213 ‘sharp instrument’

42+21			**24+21**	
机会 tʂi42 fɬi0 (21) ‘chance’	帮会 po ŋ 42 fɬi21 ‘gang organization’		筹划 ts'ɬu24fa0(21) ‘plan’	图画 t'u24fa21 ‘painting’
欺负 tʂi42 fu0 (21) ‘to bully’	生父 saŋ42 fu21 ‘biological father’		闲话 ɕiɛn24fa0(21) ‘gossip’	行话 ho ŋ 24fa21 ‘jargon’
45+21			**213+21**	
毛病 mau45 p’iaŋ0 (21) ‘bad habits’	痨病 lau45 p ’ iaŋ21 ‘phitisis’		水稻 sui213t'au0(21) ‘water rice’	小道 ɕiɛu213t'au0(21) ‘small road’
计划 tʂi45 ‘plan’	年画 niɛn45 fa0(21) ‘new year’s painting’		水分 sui213fɬn0(21) ‘water’	两份 lioŋ213fɬn21 ‘two copies’
21+21				
便饭 p'iɛn21fan0(21) ‘simple meal’	剩饭 sɬn21fan0(21) ‘leftover rice’			
肾病 sɬn21p'iaŋ21 ‘nephropathy’	重病 ts'uŋ21p'iaŋ 21 ‘serious illness’			

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