AN OPTIMALITY ACCOUNT OF TONE-VOWEL INTERACTION IN NORTHERN MIN

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ABSTRACT

This dissertation aims at constructing a fully articulated theory of tone-vowel interaction within the framework of Optimality Theory (OT). It examines the nature of this phenomenon in Northern *Min* languages, as well as various Southeast Asian languages. The questions addressed are (i) what is the nature of tone-vowel interaction? (ii) how do they relate to each other? Two important findings emerge from the investigation. First, tonal types and syllable types are closely related to each other. That is, different groups of tones occur only in a certain kind of syllables. These cooccurrence restrictions are identified as a correlation between tonal contour and syllable weight. Second, tone does not directly affect vowel distributions and alternations. Rather, it is the relative syllable positions in which a vowel occurs and the number of segments present in a syllable that trigger vowel distributions and alternations. These findings lead to the conclusion that tone and vowel do not interact directly and that there is no feature-to-feature correlation between them. Their interaction lies in the prosodic anchor mediating between them. To account for the correlation between tonal contour and syllable weight and the close relationship between syllable structures and vowel features, I propose a prosodic anchor hypothesis which attributes the tone-vowel interaction to the mora and its function as an anchor for both tone and vowel.

The theory proposed in this thesis contains two sets of constraints. The first set governs linking of tones to moras. The examination of moras as tone-bearing units shows that moras differ with respect to how many and what kind of tones they may bear. Thus, Head Binarity (i.e. a nuclear mora must bear two tones) accounts for the quantitative distinction between tonal contours and syllable weight in Fuzhou, whereas the tonal sonority hierarchy (i.e. |+*UPPER*| > |-*RAISED*|) and their harmonic association to the moraic structures (i.e. the constraint ranking *NUC/[-RSD] >> *NUC/[+UPR]) explain the phenomenon of a L tone restricted to the non-nuclear mora in Fuqing. I further show that the interaction of the constraints is capable of deriving the unmarkedness of tonal systems, as well as the cross-linguistic variation of tonal distributions.

The second set of constraints regulates the relation between syllable structures and vowel features. It has been observed that linking of vowel features to prosodic anchor in tight syllables is more restrictive than in loose syllables. This asymmetry is expected under the prosodic anchor hypothesis since the tight syllables are argued to contain one less mora than the loose ones. I further demonstrate that the interaction of the basic syllable structure constraints with the faithfulness constraints can automatically derive the vowel distribution patterns.

Two kinds of stress effects on tone-vowel interaction are identified. First, stressed syllables always preserve their lexical specifications (either tonal or segmental). Second, the vocalic changes in unstressed syllables (i.e. the non-final syllable of a domain) involve reduction of syllable weight. These stress effects can be captured by the constraints Prominence Alignment and Prominence Reduction, respectively. The former assigns a metrical grid to a rightmost syllable, hence preserving its lexical properties, while the latter prohibits a stressed syllable from having two moras. I show that these constraints, interacting with the constraints on syllabification, can successfully derive vowel alternating pairs in disyllabic words.

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I dedicate this thesis to my parents, as well as my brother and sisters.

CHAPTER 1

Introduction

1.1 Overview

The goal of this dissertation is to develop a fully articulated theory of tone-vowel interaction. Contrary to previous theoretical attempts that concentrate on the correlation between tone and vowel quality (Pilszczikowa-Chodak 1972, 1975, Newman 1975 for Hausa; Cheung 1973 for Omei dialect of Mandarin; Wang 1968, Maddieson 1976, Yip 1980, Chan 1985 for Fuzhou), the present study focuses on the prosodic anchor that mediates between tone and vowels and its role in triggering their interactions. The central questions addressed are how tone and vowels relate to each other and the nature of their interaction.

The core of the theory proposed is the prosodic anchor hypothesis. It attributes the phenomenon of tone-vowel interaction to the combination of a prosodic representation in which the mora serves as a prosodic anchor for both tone and vowels, and of a set of universal wellformedness constraints on linking of the mora to tone/vowel. The languages being investigated are mainly <u>Fuzhou</u> and <u>Fuqing</u>, the two Northern *Min* languages spoken on the southern coast of China. Attention is also drawn to the tone-vowel interaction reported in various Southeast Asian languages, such as <u>Sre</u> (a Mon-Khmer language spoken in the South Vietnamese city of Di Linh and the surrounding area), <u>Hu</u> (a Mon-Khmer language spoken in the Xiao Mengyang area in Jinghong county, Sipsong Panna, Yunnan province of China), <u>Siamese</u> (the standard Thai language spoken in Bangkok) and <u>Red Tai</u> (spoken in North Vietnam and the north part of the Sam Nuea province in Lao). In the rest of this section, I will summarize the principal claims of each chapter.

In chapter 2, I address the question of the nature of tone-vowel interaction and argue that tones and vowels do not interact directly (i.e., feature-to-feature); rather, their interaction lies in the prosodic anchor mediating between them. These arguments are based on the findings from a thorough investigation of tone-vowel interaction in Fuzhou and Fuqing. It shows that tonal distributions are closely related to syllable types and that there is a correlation between tonal contour and syllable weight. More complex tones are found in bimoraic syllables than in monomoraic syllables. This type of correlation is further supported by evidence from cooccurrence restrictions between tonal contours and vowel length found in various Southeast Asian languages (i.e., Sre, Hu, Siamese and Red Tai). This finding is compatible with the findings that rime length affects stress and tonal patterns (Duanmu 1990, 1993). Where Duanmu argues that different Chinese languages have different moraic structures, this thesis argues that different syllables within the same language have different moraic structures in Northern Min. Furthermore, an examination of vowel distributions and alternations in both Fuzhou and Fuqing reveals that tone does not directly affect vowel distributions and alternations. It is the relative syllable position in which a vowel occurs and the number of segments present in a syllable that are the direct factors triggering surface realizations of vowels.

The new findings in chapter 2 lead to the prosodic anchor hypothesis proposed in chapter 3. It is stated in (1):

(1) Prosodic anchor hypothesis of tone-vowel interaction

a. Representational Requirement

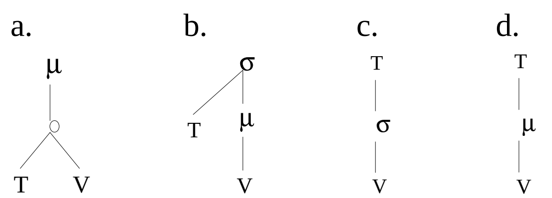
Both tone and vowel must directly link to the lowest prosodic anchor on the prosodic hierarchy, that is, the mora.

b. Constraint Satisfaction

Optimal linking between the prosodic anchor and tone or vowel is determined by a set of universal output constraints.

This hypothesis captures the direct relationship between syllable structure and tone, and the direct relationship between syllable structure and vowels. The condition (1a) states that tone and vowel must link to the mora in order for them to interact directly with the syllable structure. This is encoded in the representation in (2d) but not in (2a), (2b) and (2c), since (2d) is the only representation that satisfies the condition (1a).

(2)



○ = segmental root
T = tone
V = vowe
μ = mora
σ = syllable

Condition (1b) states that the linking of tone or vowel features to the prosodic anchor must be regulated by well-formedness constraints. The basic constraints governing tonal distributions are these known previously as the well-formedness conditions (WFC) (Goldsmith 1976). They can be incorporated into Optimality Theory as a set of faithfulness constraints[1] (McCarthy and Prince 1993a, b, 1994, 1995, hereafter M & P; Prince and Smolensky 1993, hereafter P & S; Pulleyblank 1994, McCarthy 1995, among others).

(3) Faithfulness constraints on tonal distributions

a. PARSETONE: A tone must be incorporated into prosodic structure.
b. FILL-μ: A mora must be filled by a tone.
c. LINEARITY: $String_1$ reflects the precedence structure of $String_2$, and vice versa.
d. UNIFORMITY: No element of $String_2$ has multiple correspondents in $String_1$.
e. LEXTONE: A tone that is present in an output must be present in an input.

The PARSETONE constraint (3a) requires every tone to be parsed onto a prosodic anchor. The FILL-μ constraint (3b) demands all moras to be filled by a tone. The LINEARITY constraint (3c) prevents association lines from crossing. That is, the linear precedence relations of tones of the inputs must be preserved by their outputs. The UNIFORMITY constraint (3d) prohibits a multiple linking between tones and tone-bearing units. To prevent a complex tonal contour (i.e., MLM and MHM) in Fuzhou from giving a trimoraic structure, which is unattested in this language, I appeal to the notion of the nuclear mora, first introduced by Shaw (1992, 1993). The nuclear mora is defined as a syllable head; I propose a constraint that requires a nuclear mora to bear two tones.

(4) Head Binarity (HDBIN)

A mora must bear two tones *x* and *y*, iff it is a syllable head (i.e., a nuclear mora).

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[1] The faithfulness family of constraints has later been incorporated into a generalized theory of correspondence in the works of M & P 1995 and McCarthy 1995.

The interaction of the faithfulness constraint Uniformity and Head Binarity defines two types of tonal systems: ranking HdBin above Uniformity allows contour tones while the reverse ranking gives level tones only. The square brackets without a subscripted "σ" sign indicate a syllable head (i.e., a nuclear mora), while the ones with a subscripted "σ" sign indicate syllable boundaries.

(5) Defining tonal systems by constraint ranking

Input: $[\,[\,\mu\,]\,\mu\,]_\sigma$ T T	Uniformity	HdBin	Remarks
a. $[\,\mu\,]_\sigma$ T T	*	√	contour tone allowed
b. $[\,[\,\mu\,]\,\mu\,]_\sigma$ T T	√	*	level tone only

The tonal system defined in (5a) is found in both Fuzhou and Fuqing since both of these languages allow contour tones. However, the correlation between tonal contour and syllable weight in Fuqing differs from that in Fuzhou in that it is not the tonal quantity but the tonal quality that gives rise to the distinctive syllable weight. Specifically, the tones in the light syllables are non-L while the ones in the heavy syllables always contain a L tone. To account for the asymmetrical behavior of L tone with respect to the syllable weight, I extend the segmental sonority hierarchy (Zec 1988) and propose that tones are also differentiated in terms of their intrinsic sonority. Assuming that a H tone is more sonorous than a L tone, their sonority difference can be encoded into the hierarchy in (6), given that they are represented by the feature [+Upper] and [-Raised] respectively (Yip 1980, Pulleyblank 1986):

(6) Tonal Sonority Hierarchy

|+Upper| > |-Raised|

In Optimality Theory, this tonal sonority hierarchy can be formulated in terms of the constraint ranking in (7), which says that parsing a L tone to a nuclear mora is less favorable than parsing a H tone to a nuclear mora.

(7) Tonal Alignment Constraint (TAC)

*Nucμ/[-Rsd] >> *Nucμ/[+Upr]

Adding the constraint *Nucμ/[-Rsd] to the ranking schema in (5) gives the two types of tonal system in (8a) and (8b). Ranking HdBin above both Uniformity and *Nucμ/[-Rsd], as shown in (8a), forces a L tone to be linked to a head mora, giving rise to a tonal system like <u>Fuzhou</u>. The reverse ranking in (8b) requires a L tone to be linked to a nonhead mora, resulting in a heavy syllable, as attested in <u>Fuqing</u>.

(8) Defining tonal systems containing a L tone

Input: $[[\mu]\ \mu]_\sigma$ T L	Uniformity	*Nucμ/[-Rsd]	HdBin	Remarks
a. $[\mu]_\sigma$ T L	*	*	√	possible in <u>Fuzhou</u>
b. $[[\mu]\ \mu]_\sigma$ T L	√	√	*	possible in <u>Fuqing</u>

It will be shown that the correlation between tonal contour and syllable weight in both <u>Fuzhou</u> and <u>Fuqing</u> can be derived from the reverse rankings of the same set of constraints on tonal distributions.

Chapter 4 deals with the linking between prosodic structures and vowel features. It is shown that vowel distributions in Fuzhou and Fuqing are related to syllable positions in which they occupy. It is also demonstrated that syllabification governed by the interaction of the syllable structure constraints (i.e., NUC, ONS, -CODA) (M & P 1993a, b, P & S 1993) and the harmonic alignment schema *NUC/α, (which encodes the intrinsic sonority of segments suitable for certain syllable positions,) can automatically derive the attested vowel distribution pairs of the monosyllabic words in both of these languages.

Stress effects on tone-vowel interaction are examined in chapter 5. Three findings emerge from this examination. First, a final syllable within a disyllabic domain preserves all of its lexical specifications (tonal and segmental). Neither tone sandhi nor vocalic change takes place in this position. This kind of featural stability in the final syllable is argued to be due to stress. In particular, stress is assigned to the final syllable, so it secures the featural content in that syllable. Second, a non-final syllable within a domain changes either tone (in tight syllables) or both tone and vowels (in loose syllables). In contrast with the feature stability in the final syllable, the change of tone and vowel in non-final syllables is argued to be another stress effect, namely, PROMINENCE REDUCTION which requires a stressed syllable to be monomoraic. The tonal changes observed in this position are of two types. One is contour simplification in loose syllables (i.e., a complex tonal contour gets simplified, hence no complex contour tone appears in a non-final syllable), and the other is the change of tonal features in tight syllables. Although the conditioning factor for the second type of tonal change is not clear so far, the factor that triggers tonal simplification in the loose syllables is argued to be stress, that is, an unstressed syllable cannot have two moras, hence cannot have a complex tonal contour. Third, vowel changes in non-final syllables are the same as the vowel distribution patterns that are found in monosyllabic words. Namely, vowels in loose syllables become the ones in their corresponding light syllables. The similarities between vowel alternations and vowel distributions are not coincidental. Rather, they are argued to follow from the moraic distinction (i.e., monomoraic vs. bimoraic) between the two types of syllables. If a non-final syllable is unstressed it can only be monomoraic, and hence will have an identical moraic structure to the tight syllables. Therefore, both the non-final syllables and the tight syllables in a final position share the same pattern of vowel features. These findings further support the prosodic anchor hypothesis in that the tonal sandhi and vowel changes must be mediated by their prosodic anchor. They interact with each other only when their prosodic anchor gets affected. This is indeed the case as far as stress effects are concerned. Following Wright's (1983) insight, I propose that the stability of the feature content in the final syllable and the changes of tone and vowels in the non-final syllable are subject to different constraints: Prominence Alignment and Prominence Reduction. The former ensures featural stability, while the latter reduces moraic structure. Thus, the tonal contour simplification and the vowel changes parallel to the vowel distributions in tight syllables are accounted for. These two constraints on stress are given in (9) and (10) respectively:

(9) Prominence Alignment (PROMALIGN)

Given a domain *x*, a metrical grid mark must be aligned to the right edge of *x*.

x = a morphological word.

(10) Prominence Reduction (PROMREDUC)

If α is not assigned a metrical grid mark, α cannot be bimoraic.

PROMALIGN ensures the final syllable is stressed, while PROMREDUC requires unstressed syllables to be monomoraic, that is, to make the weak weaker (Prince 1983). The interaction of the constraints governing the stability in the final syllable and the changes in the non-final syllable are shown in (11):

(11) Tonal and vocalic changes triggered by stress

Input	Outputs	PROMREDUC	PARSEμ
(i) T T T T $[[\mu]\ \mu\ ]_\sigma\ [[\mu]\ \mu]_\sigma$ V V V V	a. T T T T $[[\mu]\ \mu\ ]_\sigma[[\mu]\ ]_\sigma$ V V V V	*	*
	b. ☞ T T T T $[[\mu]\ ]_\sigma\ \ [[\mu]\ \mu]_\sigma$ V V V V	√	√
(ii) T T T T $[\ [\mu]\ ]_\sigma\ [\ [\mu]\ ]_\sigma$ V V	a. T T T T $[\ [\mu]\ ]_\sigma\ [\ [\mu]\ ]_\sigma$ V V	*	√
	b. ☞ T T T T $[\ [\mu]\ ]_\sigma\ [\ [\mu]\ ]_\sigma$ V V	√	√

The tableau above shows that when a disyllabic word contains two heavy syllables (i.e., is bimoraic), shown in (11i), only the non-final syllable changes its tone and vowel, since a bimoraic syllable is disallowed in a non-final position. On the other hand, if there is a light syllable (i.e., monomoraic) in the non-final position, shown in (11ii), there is no vowel change since the vocalic change involves reducing a mora. Thus, the different stress effects on tone-vowel interaction can be achieved by the same set of constraints.

1.2 The theoretical framework: Optimality Theory (OT)

The theory of tone-vowel interaction being developed in this dissertation is formulated within the constraint-based grammar of Optimality Theory (P & S 1991, 1993; M & P 1993a, b, 1994, 1995; Pulleyblank 1994, 1995, McCarthy 1995, among others). Contrary to rule-based ordering theory, Optimality Theory assumes that Universal Grammar (UG) contains two functions *Gen* and *Eval*. The former freely generates any amount of output candidates (featural or prosodic) for a given input, while the latter evaluates all members of a candidate set and chooses an optimal output based on a set of ranked constraints. This approach greatly reduces the complexity of determining underlying representations in standard generative phonology, since the grammar focuses its attention on outputs rather than inputs. A lexical entry in OT is assumed to contain both melodic information (i.e., F-elements) and moraic information (i.e., prosody) (M & P 1993a, Pulleyblank 1994, etc.). In the following, I first summarize the basic principles of OT and the linguistic generalizations it captures, then follow up with an outline of basic families of constraints and their empirical coverage of phonological and morphological phenomena.

1.2.1 Basic principles of Optimality Theory

Four basic principles are crucial for Optimality Theory. The first is **violability**. That is, an optimal output may violate some constraints, but the violation is minimal. This amounts to asserting that any surface-true form is only optimal relative to other candidates, and that there is no absolute correctness or incorrectness. The notion "optimal" contrasts sharply with the notion "correctness" in its empirical consequences. An output form may be optimal in context A but not in context B. For instance, in Fuzhou, a syllable without an initial consonant is perfectly possible in word-initial position. However, in non-initial position within a disyllabic word, a vowel-initial syllable gets an onset from the coda in its preceding syllable. In the OT framework, this asymmetrical behavior of an onsetless syllable can be explained by constraint ranking, another basic OT principle we turn to.

The second principle is constraint **ranking**. That is, there is a dominance relation among constraints. Since all constraints are assumed to be universal and present in UG, language-particular behavior is accounted for by different ranking. In other words, whether a particular constraint is active or not depends on its relation to other constraints in a ranking schema. Even within a single language, a particular output may be acceptable in one case but not in another. As an illustration, an onsetless syllable in Fuzhou is acceptable in word-initial position, but not in non-word-initial position when there is a coda consonant preceding it. This is explained in the constraint ranking shown in (12) below. In particular, ranking LEXF (which prohibits insertion of any F-element that is not specified lexically) above ONS (which demands that syllables have an onset) permits an onsetless syllable in word-initial position, but forces an onsetless syllable in non-word-initial position to get an onset from the coda in its preceding syllable if any.

(12) V-initial syllables in different positions within a word

		Ranking: LEXF >> ONS	
Inputs	Candidate set	LEXF	ONS
(i) /V+CV/	a. CV.CV	*!	
	b. ☞ V.CV		*
(ii) /CVC+V/	a. ☞ CV.CV		
	b. CVC.V		*

Given the ranking LEXF >> ONS, when an onsetless syllable is in a word-initial position, the candidate (12-i-b) is better than (12-i-a), since the former satisfies the highly ranked constraint LEXF, even though it violates ONS. On the other hand, when an onsetless syllable is in a non-word-initial position (12-ii-b), it is not acceptable since there is a coda consonant in the preceding syllable. (12-ii-a) satisfies all constraints and therefore is optimal.

The third principle is **inclusiveness**. All candidate analyses must participate in the evaluation process. That is, the function *Eval* must access an entire set of candidates, and there are no special rules or repair strategies for a particular candidate.

The fourth principle is **parallelism**. This amounts to asserting that all constraints and all members of a candidate set are supplied to the function *Eval* in a parallel fashion. In other words, the relation between input and output is parallel and not derivational. This principle sharply contrasts with the Ordering theory in that it eliminates all intermediate stages that are crucial for the rule-ordering theory. The basic properties of OT outlined above are summarized in (13).

(13) Basic principles of Optimality Theory (M & P 1993a:1)

a. Violability: Constraints are violable; but violation is minimal.
b. Ranking: Constraints are ranked on a language particular basis; the notion of minimal violation (or best satisfaction) is defined in terms of this ranking.
c. Inclusiveness: The constraint hierarchy evaluates a set of candidate analyses that are admitted by very general considerations of structural well-formedness. There are no specific rules or repair strategies.
d. Parallelism: Best- satisfaction of the constraint hierarchy is computed over the whole hierarchy and the whole candidate set.

If we assume that a grammar has two constraints A, B, and that A dominates B, then the optimal candidate will be the one that satisfies both constraints or the higher ranked constraint A. This situation is illustrated schematically in the tableau below. The tableau implements Prince and Smolensky's interpretation conventions as follows: (i) A >> B indicates that constraint A dominates constraint B; (ii) constraints are arranged in columns from left to right in order of domination; (iii) a "*" marks constraint violation; (iv) a "*!" signifies a fatal violation (and the subsequent rejection of the candidate); (v) a blank cell indicates constraint satisfaction, and (vi) a pointing finger ☞ or a thumbs up ✌ marks the optimal or winning candidate.

(14)

	Ranking: A >> B		
	Candidate set	A	B
/input/	☞ Cand_1		*
	Cand_2	*!	

Cand_2 in (14) violates A (the higher ranked constraint) and therefore loses out to Cand_1, which satisfies A. It is selected as the optimal candidate, since it obeys the higher ranked constraint A, although it violates the lower ranked constraint B. Where both candidates violate the higher ranked constraint, choice of the optimal candidate depends on the satisfaction of the lower ranked constraint. In this case, as we can see in tableau (15), Cand_2 obeys constraint B, whereas Cand_1 violates it. Cand_2 thus emerges as the winner.

(15)

	Ranking: A >> B		
	Candidate set	A	B
/input/	Cand_1	*	*!
	☞ Cand_2	*	

In situations where both candidates behave identically with respect to violating or obeying constraints, the choice of a winner is dependent on which candidate incurs fewer constraint violations. The following tableaux (16) and (17) demonstrate this scenario:

(16)

		Ranking: A >> B	
/input/	Candidate set	A	B
	Cand$_1$	*	**!
	☞ Cand$_2$	*	*

(17)

		Ranking: A >> B	
/input/	Candidate set	A	B
	Cand$_1$		**!
	☞ Cand$_2$		*

Two constraints which are not crucially ranked in a grammar do not select one over the other. Candidates which satisfy or violate them can be equally selected as optimal, as illustrated in the following tableaux (18):

(18)

		Not Ranking: A, B	
/input/	Candidate set	A	B
	☞ Cand$_1$	*	
	☞ Cand$_2$		*

Optimality Theory with the basic principles outlined above is successful in explaining a number of generalizations that are left unaccountable in generative phonology. First, it explains why an unmarked case can be both present and absent in a particular language.

Certain output forms are allowed generally in a given language but are disallowed in the reduplicative and epenthetic structure of that very language (M & P 1994). This shows that unmarked forms, such as CV syllables, emerge in a given language even though marked forms also show up in that language. Second, OT explains cross-linguistic typology in a principled manner. That is, constraint ranking defines different types of languages. A particular ranking like A >> B is true for a language *x*, the reverse ranking B >> A is also true for a language *y*. This is attested, for example, in tongue root harmony of low vowels in various African languages (Pulleyblank et al. 1995). The universality of UG is ultimately strengthened by this cross-linguistic typology.

1.2.2 The basic types of constraints

Constraints proposed in Optimality Theory are of three types. The first type is the faithfulness family. Since the function *Gen* freely generates any kind of output candidates, restrictions are needed to rule out any candidates that have no relation with a given input. The function of the faithfulness constraints is to demand an identity relation between input and output. Various faithfulness constraints proposed in OT (M & P 1993a, b, P & S 1993, Archangeli and Pulleyblank 1994a, b, thereafter A & P; Pulleyblank 1994, McCarthy 1995) are given below:

(19) PARSE family

PARSE-α: α (feature or node) must be incorporated into prosodic structure.

(20) FILL family

A prosodic constituent must be filled by a F-element.

(21) LEX-α

The addition of feature F or an association to F is prohibited.

(22) LINEARITY

$String_1$ reflects the precedence structure of $String_2$, and vice versa.

(23) UNIFORMITY

No element of $String_2$ has multiple correspondents in $String_1$.

The function of the PARSE family is to ensure that all F-elements are incorporated into a prosodic constituent so they may be phonetically realized. The FILL family requires a prosodic anchor to be filled by a F-element. LEX-α prohibits any insertion of an F-element or a path that is not present in an input. LINEARITY prevents association lines from crossing. UNIFORMITY disallows a multiple linking between F-elements and prosodic anchors.

The second type of constraint is the structural family. The function of this type is to restrict certain prosodic constituents to certain structures. For example, a syllable must have a nucleus, it may have an onset at the leftmost or a coda at the rightmost (M & P 1993a, b, P& S 1993). These are given below:

(24) Syllable structure constraints

a.	NUCLEUS (NUC):	Syllables must have nuclei.
b.	ONSET (ONS):	Syllables must have onsets.
c.	NOCODA (-COD):	Syllables cannot have codas.
d.	*COMPLEX (*COMPX):	No more than one C or V links to one syllable position.

The general function of the structural constraints above is to ensure an unmarked syllable type CV. It is possible for other types of syllables such as CVC or VC to emerge from interaction of the structural constraints with other types of constraints such as the faithfulness family presented above.

The third type of constraint is the alignment family. This type captures harmonic processes such as tongue root harmony in African languages (A & P 1994, b; Akinlabi 1994; Pulleyblank 1994, 1995; Cole & Kisseberth 1995; Kirchner 1993; M & P 1993a, b, 1994; Pulleyblank & Turkel 1995; Pulleyblank et al. 1995; etc.), nasal harmony, stress assignment (Hewitt 1994, 1995), and reduplication (M & P 1993a, b, M & P 1995, McCarthy 1995, Shaw 1995).

(25) Generalized Alignment (M & P 1993b)

ALIGN (Cat1, Edge 1, Cat2, Edge 2) = def

$\forall$ Cat1 $\exists$ Cat2 such that Edge 1 of Cat 1 and Edge 2 of Cat 2 coincide,

Where Cat1, Cat2 $\in$ PCat $\cup$ GCat

Edge1, Edge2 $\in$ {Right, Left}

Notice that the function *ALIGN* in (25) takes four arguments, two of which are categories and the other two of which are edges of the categories. The categories are defined in terms of either prosodic or grammatical constituents, while the edges are either left or right.

The theoretical framework outlined above offers a number of advantages. First, it allows various phonological processes to interact with each other in a parallel fashion. For instance, the languages being investigated here exhibit different kinds of phenomena, such as vowel distributions, vowel alternations, tone sandhi, stress effects, etc.. All of them twist together so that it is hard to make out what's what. The OT framework provides leads for solving these problems by examining possible outputs. Second, it makes it possible to uncover certain unmarked phenomena which otherwise would be obscured. Take the syllable structures in Fuzhou, for example. Onsetless syllables are common in this language. One might mistake this as a counterexample to the unmarked syllable type CV. However, disyllabic compounds in this language show that when two monosyllabic morphemes combine to form a disyllabic word, consonant gemination takes place between the two syllables. This contradiction (i.e., onset is not necessary vs. onset is necessary) can be simply explained by constraint ranking in the current theoretical framework. That is, the unmarked syllable type CV is indeed respected in this language unless something else outranks it. In the Fuzhou case, LEX-F may rank above ONS so that insertion of a consonant in onset position is disallowed. Third, it captures cross-linguistic variation by constraint ranking. The constraint-based grammar of Optimality Theory, therefore, offers an explanatory power for various phonological and morphological phenomena.

CHAPTER 2

The Nature of Tone-Vowel Interaction: Direct or Indirect?

2.0 Introduction

This chapter examines the phonological nature of tone-vowel interaction. It focuses specifically on the problem of whether tonal features and vowel features interact directly (i.e., whether there is a feature-to-feature correlation) or indirectly (i.e., something else plays a role in their interaction). First, I will summarize the results of experimental studies which have found phonetic correlates for tones and vowels. Second, I will review three representative phonological hypotheses that offer accounts of this phenomenon. Third, I will thoroughly investigate tone-vowel interaction in Fuzhou (a Northern *Min* language spoken principally in the Fujian province of China), the best documented case. Data not treated in earlier theoretical studies will be given serious consideration. To explore cross-linguistic variation, I will also investigate tone-vowel interactions in Fuqing, another Northern *Min* language spoken principally in the Fujian province of China, which has not previously been studied in any theoretical framework. Finally, I will examine the nature of the so-called "tight ½ôÒô - loose ËÉÒô" distinction exhibited in both Fuzhou and Fuqing, and show that this distinction is best identified in terms of syllable weight, i.e., between light and heavy syllables. To support this conclusion, the correlation between tonal contour and vowel length exhibited in various Southeast Asian languages, such as Sre (a Mon-Khmer language spoken in the South Vietnamese city of Di Linh and the surrounding area), Hu (a Mon-Khmer language spoken in the Xiao Mengyang area in Jinghong county, Sipsong Panna, Yunnan province of China), Siamese (the standard Thai language spoken in Bangkok), and Red Tai (spoken in North Vietnam and the northern part of the Sam Nuea province in Lao) are also examined. This identification leads to the conclusion that the nature of the tone-vowel interaction is indirect, namely, that tone does not directly affect vowels and vowels do not directly affect tone. Instead, it is the prosodic anchor that has a direct relation with both tone and vowel independently, triggering their interactions.

2.1 Phonetic correlates

A number of experimental studies have been conducted on the nature of the tone-vowel interaction. The studies yield two principal findings. First, there is a correlation between fundamental frequency (F_0) and vowel height, indicated by the first formant (F_1), and second, there is a correlation between vowel duration and pitch height or pitch contour.

Several studies indicate a tendency for higher vowels to be uttered with a higher pitch than lower vowels in similar environments (Peterson and Barney 1952, House and Fairbanks 1953, Lehiste and Peterson 1961, Ladefoged 1964, Mohr 1969, Lea 1972, 1973, Hombert 1976). For instance, the intrinsic fundamental frequency (F_0) of vowels in American English is related to their height (F_1): high vowels ([i] and [u]) have a higher fundamental frequency than low vowels ([a]) (Black 1949, Peterson and Barney 1952, House and Fairbanks 1953, Lehiste and Peterson 1961, Lea 1972, 1973, among others). A similar correlation between vowel height and F_0 is also found in other languages, such as Danish (Petersen 1976), French (Di Cristo and Chafcouloff 1976), Korean (Kim 1968), Serbo-Croatian (Ivic and Lehiste 1963), Mandarin (Chuang and Wang 1976, Tsay and Sawusch 1994) and <u>Fuzhou</u> (Tsay and Sawusch 1994).

Although evidence for the intrinsic correlation between F_0 and vowel height is convincing, there are also other significant findings. For instance, rounded vowels tend to have a higher F_0 than their unrounded counterparts (Sundberg 1969, Ewan 1975, Reinholt Petersen 1978, Iivonen 1987). It is also reported that the intrinsic pitch (F_0) of the short lax vowels [I] and [Y] is equal to that of the long tense vowels [i:] and [u:] in German, even though they are known to have different tongue height (Fischer-JΠrgensen 1990). This suggests that tongue height (F_1) is not the only factor that influences the intrinsic F_0 for vowels, and that other factors such as duration should also be taken into consideration. The correlation between duration and pitch height (F_0) or pitch contour is indeed found in a number of experimental studies. For instance, a high tone is shorter than a mid or a low tone (Benedict 1948:186 for Cantonese; Pike 1974:171 for Chatino; etc.), and a rising tone or a concave tone is longer than a high level tone or a falling tone (Zee 1978 for Taiwanese; Abramson 1962 for Standard Thai; Dreher and Lee 1966, Chuang 1972, Howie 1974 for Mandarin; Langdon 1976 for Yuman languages, etc.). What these findings suggest is that higher F_0 correlates with shorter duration and lower F_0 with longer duration. Therefore, both vowel height (F_1) and duration are possible correlates for either fundamental frequency (F_0) or pitch contour.

2.2 Tone and vowel interaction in phonological theory

Since **tone**, defined as linguistic use of **pitch**, is also primarily identified in terms of fundamental frequency (F_0) (Gandour 1978), it is natural to ask whether the intrinsic correlation between vowel height (F_1) and F_0 manifests itself phonologically in natural languages. In other words, the question is whether there is any empirical evidence suggesting a phonological correlation between tone and vowel height. The evidence from Hausa (an African language principally spoken in Nigeria), for example, is inconclusive. Data is offered both for (Pilszczikowa-Chodak 1972, 1975) and against (Newman 1975) this position. A highly controversial case is Fuzhou (a Northern *Min* language spoken on the southern coast of China). In <u>Fuzhou</u>, a whole series of finals[1] participate in vowel alternations in accordance with their tonal environment. It has been claimed, on the one hand, that in a tone sandhi environment a vowel undergoes raising when the tone it occurs with increases its F_0 (Wang 1968). This is characterized as a tone-induced vowel raising process (Yip 1980). I refer to this claim as the "*height-correlation*" hypothesis. On the other hand, it has been argued that the vowel alternations in <u>Fuzhou</u> involve not only differences in height, but also differences along other dimensions, such as a front/back axis, monophthongs versus diphthongs, etc. (Maddieson 1976, Chan 1985). The height-correlation hypothesis, therefore, is not sufficient to explain all instances of tone-related vowel alternation. The implicit assumption behind this debate is that tonal features and vocalic features may interact directly. This raises a more fundamental question as to the nature of this interaction. In other words, whether the interaction between tone and vowels is <u>direct</u> (i.e., feature-to-feature) or <u>indirect</u> (i.e., mediated by something else). In the following, I will review three different hypotheses on tone-vowel interaction in <u>Fuzhou</u>. Each of them cites a different phonetic correlates as evidence motivating the hypothesis. I will point out the insights and inadequacies of each.

2.2.1 The height correlation hypothesis (Wang 1968, Yip 1980)

The height-correlation hypothesis, proposed by Wang (1968) and supported by Yip (1980), claims that there is a correlation between high tones and high vowels, since both of them give rise to a higher F_0. The evidence for this hypothesis comes from <u>Fuzhou</u>

[1] In traditional Chinese phonology, a syllable is divided into two parts: (i) the initial consonant and (ii) the rest of the syllable, called the final. For instance, the final in a syllable [biáo] 'quick, rapid' is **кб□р**, which contains the on-glide **i**, and a diphthongal nucleus **ao**.

vowel alternations. Wang (1968) extracted data from Yuan (et al. 1960) and presented them in (1):

(1) $\{ \rightarrow \Pi \rightarrow \psi$

$o \rightarrow \upsilon$

$\alpha \rightarrow \varepsilon \rightarrow \iota$

In his view, these alternations operate together with alternations of tone in such a way that "each time a tone with a lower F_0 changes to one with a higher F_0 the vowel also changes to a higher vowel." Based on Wang's observation, Yip (1980) characterizes the conditioning tonal factor for the vowel raising as the [+upper] register, and gives the complete tonal inventory in (2) and the vowel alternating pairs in (3) respectively (column I = "tight" finals ½ôÒô, column II = "loose" finals ËÉÒô).

(2) The complete tonal inventory in Fuzhou given by Yip (1980:341)

I. "tight" finals ½ôÒô		II. "loose" finals ËÉÒô	
[+upper] tones		[-upper] tones	
44	HH	12	LH
52 / 4	HL	13	LL
22	LL	242	LHL
35	LH		

(3) Vowel alternating pairs dealt with by Yip (1980:275)

	I	~	II		I	~	II
a.	ι	~	Eι	d.	Eι	~	αι
b.	ψ	~	{ψ	e.	{ψ	~	©ψ
c.	υ	~	ου	f.	ου	~	Oυ

Yip treats the vowels in the loose finals (in column II) as underlying forms and the ones in the tight finals (in column I) as derived. To derive the correct surface vowels for tight finals, the following vowel-raising rule is proposed (Yip, 1980:277):

(4)
$$\underset{[\alpha\ \text{low}]}{\text{V}} \rightarrow \begin{array}{l}-\text{low}\\-\alpha\ \text{hi}\end{array} \;/\; \underset{[+\text{upper}]}{\text{\_\_}}$$

This rule states that vowel-raising is triggered by the tonal feature [+upper] register. By applying this rule, a [+LO] vowel becomes mid and a [-LO] vowel becomes high in the environment of [+upper] register.

The height-correlation hypothesis, however, faces difficulties concerning the entire system of vowel alternations. The first problem is its inadequacy in accounting for all vowel alternations in this language. As Maddieson (1976) and Chan (1985) point out, other features in addition to vowel height, such as roundness and backness, are also involved in the vowel changes. The alternations, as shown in (5), are the result of (i) modifying the first, or both elements of the diphthong (5.I), or (ii) deleting the non-high part of the diphthong (5. II). (5) is retabulated from Chen and Norman (1965) by Maddieson (1976:194):

(5) I. a) ai → ei

b) au → ou

c) oi → Πy

II. a) ei → i

b) ou → u

c) Πi → y

If only the feature [+upper] triggers the vowel alternations, changes along the parameters of roundness and backness are left unexplained. This indicates that an intrinsic connection between vowel height and tone can only partially account for these observations.

The second problem for this hypothesis is its inadequacy in deriving the surface forms in (3a-c), which involve simplification of the diphthongs (II) in (5). Applying Yip's rule (4) to (3a-c) gives the long forms [ii], [yy] and [uu], respectively, but not the short forms [i], [y], and [u]. To derive these correct forms, a monophthongisation rule is also needed in addition to the vowel-raising rule in (4). Furthermore, the vowel-raising rule must precede the vowel-shortening one since the entire set of non-high vowels in loose finals in (3a-c) are dropped in the corresponding tight finals. The vocalic change that occurs in (3a-c), therefore, may not be best regarded as vowel raising, but as monophthongisation instead (or diphthongisation, depending on whether the tight finals or the loose finals are underlying).

The third problem for the height correlation hypothesis is the implausible vowel inventory that it yields. As Chan (1985) notes, Yip's treatment of the vowel alternations in sandhi forms implies that monophthongal high vowels are not independent phonemes in <u>Fuzhou</u>, but only appear with non-high vowels in diphthongs. If high vowels are only present with a non-high vowel in the surface representations, we need to explain why they cannot occur alone in surface representations, given that the feature [+HI] is an active F-element for lexical entries. This is rare, if not unattested, in vowel system typologies.

The fourth problem for this hypothesis is its inability to capture the cross-linguistic variation in tone-vowel interaction. Some other closely related Northern *Min* languages, such as Fuqing, Fuan and Ningde, also have similar patterns of vowel alternations. Particularly, the tight-loose distinction of finals exists in all of these languages and vowels in the loose finals change into the corresponding forms in the tight finals under different tonal conditions. The tonal inventories of these languages are given in (6). The Fuzhou data is from Liang (1982, 1983, 1988, etc.), Fuqing data is from Feng (1993a), Fuan and Ningde data are from Norman (1977).

(6) Tonal inventories for the four Northeast *Min* dialects

I. tight finals ½ôÒô	**I.** tight finals ½ôÒô				**II.** loose finals ËÉÒô		
	Yin Ping ÒõÆ½	*Yang Ping* ÑôÆ½	*Yang Ru* ÑôÈë	*Shang* ÉÏÉù	*Yin Qu* ÒõÈ¥	*Yin Ru* ÒõÈë	*Yang Qu* ÑôÈ¥
a. Fuzhou ¸£ÖÝ	44 H	53 HM	5	31 ML	213 MLM	23	242 MHM
b. Fuqing ¸£Çå	53 HM	44 H	5	33 M	21 L	22	41 HL
c. Fuan ¸£°²	43 HM	11 L	21	41 HL	35 MH	54	13 LM
d. Ningde ÄþµÂ	33 M	11 L	5	41 HL	35 MH	33	41 HL

Notice that in table (6) above, the tones in the *Yang Ping* category (the shaded cells) vary from language to language. Namely, HM is found in Fuzhou (6a), H in Fuqing (6b), and L in both Fuan and Ningde (6c, d). If vowel changes in Fuzhou were triggered by the [+upper] register (i.e., the tones in the tight finals in I), the same alternations triggered by the tones in the same *Yang Ping* category in Fuan and Ningde (i.e., the cells in (6c, d)) are not expected.

Although the height correlation hypothesis cannot explain all instances of vowel changes related to tonal conditions, it is important to realize that some sort of relationship between tonal environment and vowel changes does exist. It is this observation that has attracted researchers to study the phenomenon of tone-vowel interaction.

The insight of the criticism from Maddieson (1976) and Chan (1985) is that pitch height distinctions cannot be directly responsible for inducing the vowel alternations. An intrinsic association of vowel height and pitch therefore cannot be invoked as an explanation to account for the data in Fuzhou, the most often-cited example in support of this claim. Maddieson also raises the question whether vowel height differences can ever induce linguistically significant pitch variation. He points out that intrinsic variation in the pitch of vowels does not necessarily become phonologically significant.

2.2.2 The "metrical duration" hypothesis (Wright 1983)

Wright's (1983) metrical-duration hypothesis is based on duration differences between vowels in different positions within a disyllabic word. She draws on spectrographic studies which show that the duration of the first syllable of a disyllabic compound is reduced two-thirds from its citation form, while the duration of the second syllable is only reduced less than one-third of its citation form. This evidence does not support the claim that there is a direct cause-and-effect relationship between tonal height and vowel alternations (Wang 1968, Yip 1980). Rather, it suggests that both tone sandhi and vowel quality change are independently related to stress. She attributes both tone sandhi and vowel alternations to an iambic stress pattern which reduces the duration of unstressed syllables. The vowel alternations Wright tries to account for are listed in (7) (I = the tight finals, II = the loose finals).

(7) Vowel alternating pairs dealt with by Wright (1983:28)

	I		**II**		**I**		**II**
a.	ι(N)	~	ει(N)	d.	ειN	~	αιN
b.	ψ(N)	~	Πψ(N)	e.	ΠψN	~	οιN
c.	υ(N)	~	ου(N)	f.	ουN	~	αυN

To account for the vowel alternations in (7), Wright treats the vowels in the loose finals as underlying, and posits the constraint in (8) and the two vowel reduction rules in (9) to derive the vowels in the tight finals.

(8) Constraint against branching nuclei in an unstressed position (Wright 1983:47)

$$
\begin{array}{c}
* \ \sigma_w \\
\vdots \\
N \\
\wedge
\end{array}
$$

The function of (8) is to prevent a syllable having a branching nucleus from occurring in an unstressed position, namely, the first position of a disyllabic domain.

(9) <u>Fuzhou</u> Vowel Reduction Rules (Wright 1983:52)

a. Deletion: If two segments of the branching nucleus agree on all features or all but one, delete the first segment.

b. Quasi-Deletion: If the two segments of the nucleus differ in more than one feature, a short diphthong will be formed, with distribution of [-hi][+hi] in that order, and [+rd] if either segment shows rounding. The other features will be drawn from the second vowel.

Rule (11a) derives i(N), u(N), y(N) from ei(N), ou(N), Πy(N), respectively, while rule (11b) derives Πy(N), ou(N), ei(N) from οι(N), au(N), ai(N), respectively. Here Wright treats Πy(N), ou(N), ei(N) in an unstressed position (i.e., non-final position of a disyllabic domain) as single-segment diphthongs[2], and their corresponding forms οι(N), αυ(N), αι(N) in a stressed position (i.e., final position of a disyllabic domain) as two-segment diphthongs[3]. The question is that if stress conditions vowel alternation, why do the other finals, given in (10) below, retain their citation forms when unstressed?

(10) Other finals (Wright 1983:32)

	jα(N)	ωα(N)
jε(N)	jε(N)	
		ωαι
		ωει

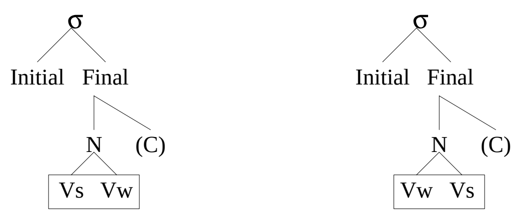
The high vowels [i] and [u] preceding another non-high vowel are written as [j] and [w] in (10). They are defined as 'weak' vowels because of their low intrinsic sonority value. In

[2] What a single-segment diphthong means in terms of moraic structures is that two sets of vocalic features link to a single mora.

[3] Similarly, a two-segment diphthong may be seen as two sets of vowel features linked to two different moras (i.e., each linked to a separate mora).

order to resolve the dilemma, Wright attributes the difference between alternating finals and non-alternating finals to the different structures in (11), in which the subscripts "s" and "w" are defined as "strong" and "weak" based on vowel sonority:

(11) a. Alternating finals b. Non-alternating finals



The structure of the alternating finals in (11a) represents a falling diphthong with a **s-w** nucleus, while the structure of non-alternating finals in (11b) represents a rising diphthong with a w-s nucleus. The constraint in (8) that reduces branching nuclei is claimed not to refer to the "w" left branch of the nucleus. Wright concludes that the vowel alternations in Fuzhou lie in the different prosodic structures of syllables. It has nothing to do with tones. First, in disyllabic words, the finals in an unstressed (i.e., non-final) position reduce in duration from those in stressed or isolation positions. This reduction can be expressed by a constraint forbidding branching nuclei in a weak position as in (8). Second, syllables that have branching nuclei in monosyllabic forms undergo Deletion and Quasi-Deletion.

The insight of Wright's proposal is that first, tone sandhi and vowel alternation in Fuzhou involve different syllable structures. In particular, tonal change and vocalic change are independent of one another; both of them are triggered by stress. Diphthongs in an unstressed position cannot have a branching nucleus, hence reduce some feature content, becoming single-segment diphthongs. Second, tone sandhi involves the loss of a mora since the mora is the tone-bearing unit and unstressed syllables cannot have two moras.

The problem for Wright's (1983) proposal is that the close relationship between tonal groups and vowel distributions in citation forms (i.e., monosyllabic words) is completely ignored. Although the attribution of vowel reduction to stress (in weak position) without considering tonal factors apparently accounts for the vowel quality change in the disyllabic cases, the vowel distributions with the "tight/loose" distinction in a final syllable of disyllabic forms (the "strong" positions) remain unexplained.

2.2.3 The "metrical-tonal contour" hypothesis (Chan 1985)

Chan (1985:424-425) rejects the height-correlation hypothesis, citing evidence from neighboring dialects of Fuan and Ningde where the high tones /5/ and /54/ co-occur with the lower set of vowels. In the context of a correlation between tone and vowel height, such a cooccurrence would be unexpected. For Fuzhou, Chan characterizes a rising tonal contour as one of the conditioning factors for the vowel quality changes. This is based on the phonetic finding that a rising contour is longer in duration than a falling contour or a level tone (Gandour 1977, Zee 1978). However, she observes that there is a rising sandhi tone [35] (MH) which does not trigger vowel quality changes. Therefore, a rising tonal contour alone is not a sufficient condition for vowel quality changes in Fuzhou. The main factor, Chan claims, that differentiates the rising contour in citation tones from the rising tone in sandhi contexts is precisely that of stress. Therefore, the conditions for vowel quality changes in Modern Fuzhou (Chan 1985:468) are stress ('strong' syllables) and a LH (rising) tonal contour, because both of them increase syllable length (only the CVC syllables undergo vowel quality change).

The Fuzhou vowel system proposed by Chan contains three underlying vowels: /i u a/. Their combinations give 7 surface vowels, using the particle type of representations: /i/ = [i], /u/ = [u], /a/ = [a], /iu/ = [y], /ia/ = [e], /ua/ = [o], /uai/ = [ø]. Chan treats all diphthongs as single segments. The tonal representations she assigns are given below:

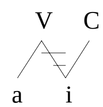
(12) Underlying Tones in Fuzhou (Chan 1985:99-107):

Tones in "tight" finals	Tones in "loose" finals

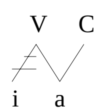
Ying	/44/H	/32/LH	/213/LH	/13/LH
Yang	/51/HL	/5/HL	/131/LHL	

To get the appropriate vowel quality, Chan posits three rules which derive the loose finals from the tight ones, listed below.

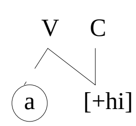
(13) Vowel-lowering rule (Chan 1985:478) [eiN]→ [aiN] and [ΠyN] → [oyN]



(14) i-loss rule (Chan 1985:479) [e] → [a], [eu] → [au], [Π] → [o]



(15) Diphthongisation rule (Chan 1985:481) [iN] → [eiN], [uN] → [ouN], [yN] → [ΠyN]



Chan's proposal differs from Wright's in that it takes tonal contour to be a factor in triggering vowel quality change. Even though Chan claims that both stress and a rising tonal contour are conditions for such changes in that they both increase the syllable length, she does not implement this idea formally. It is therefore never made clear how it actually works. The insightful idea in Chan's proposal is to relate tonal contour to syllable length. This is compatible with the phonetic correlation between pitch contour and duration that is found in a number of experimental studies (see section 2.1 in this chapter for details). What Chan's insight implies is that the intrinsic duration in pitch contour may leave a trace in the phonological behavior of tones.

2.3 Fuzhou tone-vowel interaction

This section investigates tone-vowel interaction in Fuzhou, the most controversial case which has been cited as evidence both for and against the intrinsic height correlation hypothesis. In particular, I will examine vowel distributions and alternations with respect to their tonal environment, and identify the exact factors that trigger the vowel distributions and alternations.

The Fuzhou phonological system has been comprehensively described by a number of scholars, such as Tao (1931), Chao (1943), Chen (1967, 1969), Lan (1953), Wang (1965, 1968, 1969), Liang (1982, 1983, 1984), Zheng (1983, 1988), Chen and Zheng (1990). It contains the 15 consonants in (16), the 10 vowels in (17), and the 7 citation tones in (18):

(16) Consonants:	π	τ	τσ	κ	/
	π⌊	τ⌊	τσ⌊	κ⌊	
		σ			η
	μ	ν		N	
		λ			

In traditional Fuzhou phonology, there is a zero initial consonant, represented by zero. What the zero initial consonant really represents in terms of syllable structure is Onset. Presumably, native speakers access the onset position even though it may be segmentally empty. E. G. Pulleyblank (1986) argues that the zero initial is actually a laryngeal glide.

(17) Vowels:	ι	ψ	υ
	ε	Π	ο
	Ε	{	Ο

α

There is a considerable amount of variation in the phonetic realization of vowels and tones. Take the low vowel [α] in the vowel inventory (17) for example. As can be seen in (19), it has three variant forms: [α], [A] and [ ]. The vowel [ ] only occurs with a following rounded high vowel [υ]. Whether this local assimilation is properly analyzed as phonetic or phonological, it has no bearing on the phonological issues examined in this thesis and will not be transcribed except in the chart in (19). On the other hand, the variation between [α] and [A] is significant since both vowels occur in the same segmental environment. This can be seen in (19) and will be discussed at length below. The Fuzhou phonological system presented here is from Liang (1982, 1984), Chen & Zheng (1990) and Feng (1993b). The tone letters H, M, L are used here to facilitate exposition. In particular, H represents the tonal number 5 or 4 on Chao's (1930) system of tone letters in which 5 indicates the highest pitch, while 1 indicates the lowest pitch. M represents 3 or 2, and L represents 1.

(18) Tones[4]:

	Tones in "tight" finals			**Tones in "loose" finals**	
	Æ½ *Ping*	Èë *Ru*	ÉÏ *Shang*	È¥ *Qu*	Èë *Ru*
Òõ *Yin*	44 H		31ML	213 MLM	23 / MLM
Ñô *Yang*	53 HM	5 / HM		242 MHM	

The chart in (18) only contains citation tones. Sandhi tones are not included here, but will be discussed later (see chapter 5). A citation tone refers to a tone in a monosyllabic morpheme in isolation. Historically, the tones in the *Yin* category are developed from

[4] The tones 5 and 23 only occur in syllables with a glottal stop conda. They are assumed to have the tonal contours HM and MLM since they behave identical to 53 and 213, respectively. The shortening is presumably due to the glottal stop coda whose effect on tonal contour is open for further research.

syllables with initial voiceless obstruents, while those in the *Yang* category are from syllables with initial voiced obstruents.

Fuzhou speakers distinguish between two groups of finals: the "tight" finals and the "loose" finals (the nature of this tight-loose distinction will be identified in section 2.5). The seven citation tones in (18) are divided into two groups corresponding to the groups of finals. In particular, the tight finals contain either a high level tone (H) or a simple falling tone (HM, ML), while the loose ones have either a concave tone (MLM) or a convex tone (MHM), as shown in (18). Segmentally, the tight finals differ from the loose ones in a number of ways, listed in (19) below.

(19) Alternating finals (**I** = "tight" finals; **II** = "loose" finals)

I		**II**	**I**		**II**	**I**		**II**	**I**		**II**
ι	~	ει[5]	ψ	~	Πψ	υ	~	oυ	ιυ	~	ιευ
ι/	~	ει/	ψ/	~	Πψ/	υ/	~	oυ/			
ιN	~	ειN	ψN	~	ΠψN	υN	~	oυN			
			ιε	~	ιE	ψo	~	ψO			
			ιε/	~	ιE/	ψo/	~	ψO/			
			ιεN	~	ιEN	ψoN	~	ψON			
o	~	O	υo	~	υO	Πψ	~	Oψ	υ↔ι	~	υoι
o/	~	O/	υo/	~	υO/	Πψ/	~	Oψ/			
			υoN	~	υON	ΠψN	~	OψN			

[5] The **к ~ ек** corresponding pair occurs in Liang's (1982, 1983) descriptive works as ι ~ Eι. Here and throughout, I write the ι ~ Eι pair as **к ~ ек** to be consistent with the representation of the **ц ~ рц** and **Р ~ Ръ** alternations.

α ~ A α/ ~ A/ α ~ AN N	ια ~ ιA ια/ ~ ιA/ ιαN ~ ιAN αι ~ Aι	υα ~ υA υα/ ~ uA/ υα ~ υAN N αυ ~ Aυ	υαι ~ υA ι
	ει/ ~ Aι/ ειN ~ AιN	ου/ ~ υ/ ου ~ υN N	

First, the table in (19) shows that monophthongal high vowels in the tight finals ([ι], [υ], [ψ]) correspond to diphthongs containing a high vowel component in the loose finals ([ει], [ου], [Πψ]) respectively. Second, tense non-high vowels in the tight finals ([ε], [o], [α]) correspond to their lax counterparts in the loose finals ([E], [O], [A]) respectively. Third, diphthongs formed by a mid vowel and a high vowel in the tight finals correspond to that comprised by a low vowel and a high vowel in the loose finals. Apart from the alternating finals, there are a few non-alternating finals, listed in (20) below:

(20) Non-alternating finals

a. E E/ { {/ Eυ

b. μ ν N

(20a) are found only in tight finals; there are no corresponding loose finals. (20b) are syllabic nasals, which are only found in the morpheme denoting negation.

2.3.1 Tone-vowel interaction in monosyllabic words

In this section, I investigate the vowel distributions in monosyllabic words (the citation forms), and explore the precise factors which trigger the observed distributional effects. Recall that Fuzhou distinguishes two types of finals: the tight finals and the loose finals, whose segmental properties are listed in columns I and II of (19), respectively. Tones in the tight finals are either H level or simple falling (HM, ML), whereas those in the loose finals are either concave or convex. (MHM, MLM). These cooccurrence restrictions are illustrated in all sets of data below.

(21)		**I** "tight"	Gloss		**II** "loose"	Gloss	Distribution
	a.	tsi^{ML}	'only'	d.	tsεi^{MLM}	'will'	i ~ εi
	b.	πιN^{H}	'guest'	e.	πειN^{MLM}	'combine'	
	c.	κι/^{HM}	'reach'	f.	κει/^{MLM}	'lucky'	

(22)		**I** "tight"	Gloss		**II** "loose"	Gloss	Distribution
	a.	ku^{H}	'alone'	d.	kou^{MLM}	'old; reason'	u ~ ou
	b.	τσυN^{ML}	'permit'	e.	τσουN^{MLM}	'handsome'	
	c.	υ/^{HM}	'don't'	f.	ου/^{MLM}	'house'	

(23)		**I** "tight"	Gloss		**II** "loose"	Gloss	Distribution
	a.	sy^{HM}	'must'	d.	sΠy^{MHM}	'sequence'	y ~ Πy
a.							
	b.	sy/^{HM}	'continue'	e.	sΠy/^{MLM}	'save up'	
	c.	τψN^{HM}	'repeat'	f.	τΠψN^{MHM}	'middle'	

The data in (21), (22) and (23) show that a single high vowel in the tight finals ([ι], [u], [y]) corresponds to a diphthong in the loose finals ([ει], [ου], [Πψ]), and that the diphthongs comprise a high vowel preceded by a mid vowel with the same feature value for roundness. However, non-high vowels behave differently from high vowels. The examples in (24), (25) and (26) demonstrate that underlying mid vowels and low vowels surface as tense vowels ([e], [o], [a]) in tight finals and as lax vowels ([E], [O], [A]) in loose finals.

(24)

		I "tight"	Gloss		**II** "loose"	Gloss	Distribution[6]
	a.	tsieN^{H}	'stick'	d.	tsiEN^{MLM}	'fight'	ε ~ E
	b.	tsieN^{HM}	'felt'	e.	tsiEN^{MLM}	'occupy; capture'	
	c.	tsieN^{ML}	'exhibit'	f.	σιEN^{MHM}	'kind; be good at'	

		I "tight"	Gloss		**II** "loose"	Gloss	Distribution
(25)	a.	ko^{H}	'song'	f.	kO^{MLM}	'individual'	o ~ O
a.							
	b.	uoN^{HM}	'forget'	g.	uON^{MHM}	'flourishing'	
	c.	puo/^{HM}	'vigorous'	h.	puO/^{MLM}	'to peel; to shell'	
	d.	kyo^{HM}	'bridge'	i.	κψO/^{MLM}	'decisive'	
	e.	yo/^{HM}	'jump'	j.	yO/^{MHM}	'read (lit.)'	

		I "tight"	Gloss		**II** "loose"	Gloss	Distribution
(26)	a.	kα^{HM}	'false'	f.	kA^{MHM}	'holiday'	a ~ A
	b.	τσια^{H}	'to cover'	g.	τσιA^{MLM}	'sugarcane'	
	c.	kυα^{ML}	'few, scant'	h.	kuA^{MLM}	'hung up'	
	d.	kαυ^{H}	'suburbs'	i.	kAu^{MLM}	'enough'	

---

[6] Notice that the corresponding pair ε ~ ε only occurs with a preceding high vowel [i]. No word is found in the "loose" finals with a mid front unrounded vowel without a preceding [i]. The lack of ε ~ ε distribution without a preceding high vowel is assumed to be an accidental gap.

e.	k⌊αι^{ML}	'change'	j.	k⌊Ai^{MLM}	'approximate'

The patterns of correspondence in (24), (25), and (26) have not been treated in previous theoretical studies. These same patterns are also included in descriptive studies by Liang (1983, 1984, 1990), Zheng (1983; 1988), and Chen and Zheng (1990). Notice that the mid vowels alternating along the tense/lax dimension must not be followed by a high vowel. If a mid back vowel is followed by a high front rounded vowel, it appears as front in the tight finals and as back (Π ~ o) in the loose finals, shown in (27):

(27)		**I** "tight"	Gloss		**II** "loose"	Gloss	Distribution
	a.	ts⌊Πy^{H}	'hurry; urge'	c.	ts⌊oy^{MLM}	'break to pieces'	Πy ~ oy
	b.	ts⌊Πy^{ML}	'marrow'	d.	ts⌊oy^{MLM}	'intensifier adv.'	

Comparing (27) with (25), it can be observed that in (25) the mid vowel surfaces in tense/lax fashion regardless of whether it is preceded by a high vowel. However, when the mid vowel is followed by the high vowel [y], as shown in (27), it appears as a front or back vowel respectively. This different distributional behavior clearly suggests that (i) the presence of another segment, and (ii) the relative syllabic position might also be factors that trigger the particular realization of vowel quality. Further examples of the presence of coda consonant affecting vowel distributions are found in (28) and (29) below:

(28)		**I** "tight"	Gloss		**II** "loose"	Gloss	Distribution
	a.	mei/^{HM}	'strange(lit.)'	c.	mai/^{MLM}	'strange(colloq.)'	ει ~ αι
	b.	teiN^{ML}	'wait'	d.	taiN^{MHM}	'surname'	

(29)	**I** "tight"	Gloss	**II** "loose"	Gloss	Distribution

a.	τσουN^{H}	'stolen goods'	c.	τσαυN^{MLM}	'to bury'	ου ~ αυ
b.	που/^{HM}	'thin (lit.)'	d.	παυ/^{MLM}	'explode'	

The examples in (28) and (29) demonstrate that a low vowel [α] in the loose finals, when followed by a high vowel plus a consonant, corresponds to the mid vowels [ε] and [o] in the tight finals, respectively. Notice that in (26), the low vowel [A] in the loose finals does not raise to mid in the corresponding tight finals. Instead, it changes from lax to tense. The lack of vowel-raising effects cannot be attributed to the tonal environment since the tones in the two types of finals in (26) are the same as those in (28) and (29). What makes the low vowel in (28) and (29) different from that in (26) is the presence of both a post nuclear glide and a coda consonant. This suggests that the number of segments in post nucleus position becomes a conditioning factor for the realization of a low vowel to a mid vowel.

Of more interest is the asymmetrical behavior of high vowels in different syllable positions. High vowels manifest the correspondence between single segments and diphthongs in (21), (22) and (23), but not in (24), (25) and (26). The only difference is the relative syllable positions in which they occur. Particularly, the high vowels in (21), (22) and (23) are the only vowels in the tight finals, hence they can be regarded as in nuclear positions under the nuclear moraic model (Shaw 1992), whereas the ones in (24), (25), and (26) are not necessarily treated as nuclei, since they cooccur with other non-high vowels in the tight finals. The syllable positions, therefore, may also be a factor influencing the realization of vowel quality. This effect of syllable position on vowel distribution is not expected in the height-correlation hypothesis, since the featural specification for a high vowel is the same regardless of its possible syllable positions.

The data in this section clearly suggest that tone is not the only factor affecting vowel realization. Other factors, such as the presence of a coda consonant and the syllable position of vowels, can affect vowel quality change as well. Therefore, tone-vowel interaction in Fuzhou cannot be treated simply as "feature-to-feature correlation" (i.e., certain tonal feature(s) correlate with certain vocalic feature(s)).

2.3.2 Tone-vowel interaction in reduplication

In Fuzhou, adjectives can be reduplicated to denote intensity. The simple case is the reduplication of monosyllabic adjectives in (30), (31), and (32) below. The tone and vowel changes are underlined. Data are from Zheng (1988), Chen and Zheng (1990).

(30)		Adj.	Gloss		Redup. Adj.	Gloss	Alternation
	a.	lεi^{MHM}	'sharp'	→	λι^{HM}λει^{MHM}	'very sharp'	ει → ι
	β.	σου^{MLM}	'colourless'	→	su^{HM}sou^{MLM}	'very colorless'	ου → υ
	c.	τΠψ/^{MLM}	'resentful'	→	ty^{H}τΠψ/^{MLM}	'very resentful'	Πψ → ψ

(31)		Adj.	Gloss		Redup. Adj.	Gloss	Alternation
	a.	NO^{MLM}	'big-headed'	→	No^{HM}NO^{MLM}	'very big-headed'	O → o
	b.	κ⌊A^{MLM}	'quick'	→	κ⌊α^{HM}κ⌊A^{MLM}	'very quick'	A → α

b.

(32)		Adj.	Gloss		Redup. Adj.	Gloss	Alternation
	a.	τOψN^{MHM}	'heavy'	→	τΠψN^{HM}τOψN^{MHM}	'very heavy'	Oψ → Πψ
	b.	πAιN^{MLM}	'stubborn'	→	πειN^{HM}πAιN^{MLM}	'very stubborn'	Aι → ει
	c.	μ υ/^{MLM}	'painful'	→	μου^{H}μ υ/^{MLM}	'very painful'	υ → ου

The data in (30) (31) and (32) show that when a monosyllabic adjective reduplicates into a disyllabic adjective, both vowel and tone in the first syllable of the reduplicated form undergo changes. In particular, four kinds of change take place in the reduplications.

First, a diphthong comprised of a mid vowel and a high vowel loses the mid vowel in (30). Second, a mid or a low lax vowel becomes its tense counterpart in (31). Third, a back mid vowel becomes front in (32a). Finally, a low vowel raises to a mid vowel in (32b-c). The tonal change, on the other hand, involves tonal simplification. A complex contour tone becomes a simple contour tone.

Notice that the vocalic changes involved are the exact same patterns as the patterns of vowel distribution in monosyllabic words. That is, the vowels in the loose finals become the corresponding ones in the tight finals. However, if an original monosyllabic adjective contains a level or a simple contour tone, as the tones in the tight finals in the monosyllabic words, there is no vocalic change to accompany the tonal change in the reduplicated form. The data in (33) below illustrate this pattern.

(33)		Monosyl. Adj.	Gloss		Redup. Adj.	Gloss
	a.	πα^{ML}	'full'	→	πα$^{\underline{MH}}$ πα^{ML}	'very full'
	b.	πυ↔ι^{HM}	'fat'	→	πυ↔ι$^{\underline{ML}}$	'very fat'
					πυ↔ι^{HM}	

(33) shows that once a monosyllabic adjective reduplicates into a disyllabic adjective, the tone in the first syllable of the reduplicated form changes. In (33a), ML in the original monosyllabic form becomes a MH in the first syllable of a reduplicated form, while in (33b), HM in the original morpheme changes into a ML in the reduplicated form. Unlike examples in (30) (31) and (32), the tonal change in these cases is not accompanied by a vocalic change, and these tones are simple falling contour tones.

The same patterns of tone-vowel interaction are also observed in verbal reduplication forms. Data are from Zheng (1983). The little squares in the column of Chinese characters indicate a lack of appropriate Chinese characters to represent these <u>Fuzhou</u> morphemes.

(34)	Verbs	→	Redupl. Vs		Gloss	Alternations
a.	τэει$^{/MLM}$	ìß	τэι^{H} τэει$^{/MLM}$	ìßìß	'just kick something'	ι → ει
b.	πει^{MHM}	±í	πι^{HM} πει^{MHM}	±í±í	'just comb hair'	
c.	σου^{MLM}	Êý	συ^{HM} σου^{MLM}	ÊýÊý	'just count'	υ → ου
d.	ξου$^{/MLM}$	·÷	ξυ^{H} ξου$^{/MLM}$	·÷·÷	'just whisk the dust'	
e.	τσэΠψ^{MLM}	□	τσэψ^{HM} τσэΠψ^{MLM}	□□	'just take a look'	ψ → Πψ
f.	λΠψ^{MHM}	□	λψ^{HM} λΠψ^{MHM}	□□	'just try to wade'	

The examples in (34) show that the diphthongs [Eι], [ου], [Πψ] in the first syllable of a reduplicated verb lose the mid vowel part and become monophthongal high vowels [ι], [υ], [ψ], respectively. The data in (35) and (36) show that the lax non-high vowels become their tense counterparts.

(35)	Verbs	→	Redupl. Vs	Gloss	Gloss	Alternation
a.	κэιE^{MHM}	ÒÐ	κэιε^{HM} κэιE^{MHM}	ÒÐÒÐ	'just stand here and there'	E → ε
b.	σιE$^{/H}$	Ê³	σιε^{H} σιE$^{/H}$	Ê³Ê³	'eat this and that'	
c.	πO^{MHM}	±§	πo^{HM} πO^{MHM}	±§±§	'just hold'	O → o
d.	μυON^{MLM}	îÊ	μυoN^{HM} μυON^{MLM}	îÊîÊ	'just ask'	

(36)	Verbs	→	Redupl. Vs	Gloss	Gloss	Alternation

a.	πэA/^{MLM}	ÅÄ	πэα^{HM} πэA/^{MLM}	ÅÄÅÄ	'just pat something'	A → α
b.	κэιA/^{MLM}	□	κэια^{HM} κэιA/^{MLM}	(ÅÄÕÕ)	'just take a picture'	
c.	σAυ^{MLM}	É¨	σαυ^{HM} σAυ^{MLM}	É¨É¨	'just clear dust'	
d.	κэAN^{MLM}	¿´	κэαN^{HM} κэAN^{MLM}	¿´¿´	'just take a look'	

(37) and (38) demonstrate that a low vowel becomes a mid one and a mid back vowel becomes front when they are followed by both a high vowel and a coda consonant.

(37)	Verbs	→	Redupl. Vs		Gloss	Alternation
a.	ταιN^{MHM}	µæ	τειN^{HM} ταιN^{MHM}	µæµæ	'put sth under sth else'	αιN → ειN
b.	κэαιN^{MLM}	¸Ç	κэειN^{HM} κэαιN^{MLM}	¸Ç¸Ç	'just cover it'	

(38)	Verbs	→	Redupl. Vs		Gloss	Alternation
a.	σOψ^{MHM}	×ø	σΠψ^{HM} σOψ^{MHM}	×ø×ø	'just sit'	OψN → ΠψN
b.	σOψN^{MLM}	ËÍ	σΠψN^{HM} σOψN^{MLM}	ËÍËÍ	'just see somebody off'	

It is important to notice that all the instances of vowel change in reduplications involve the complex contour tones. The verbs with either a level tone or a simple contour tone do not have vocalic changes, as shown in (71), (40), and (41) below.

(39)	Verbs	→	Redupl. Vs	Gloss

a.	λιN^{H}	Áà	λιN^{H} λιN^{H}	ÁàÁà(¶¯)	'carry everywhere'
b.	νψ/^{H}	□	νψ^{ML} λψ/^{H}	□ □(¶¯)	'step on everywhere'
c.	π϶υN^{HM}	Åõ	π϶υN^{ML} π϶υN^{HM}	ÅõÅõ	'hold with hands'
d.	ιυ^{ML}	Ò¨	ιυ^{MH} ιυ^{ML}	Ò¨Ò¨	'keep ladling out'

(40)

	Verbs	→	Redupl. Vs		Gloss
a.	τσ϶ο^{H}	´ê	τσ϶ο^{H}τσ϶ο^{H}	´ê´ê	'keep robbing with hands'
b.	π϶υοN^{HM}	±Ä	π϶υοN^{ML}π϶υοN^{HM}	±Ä±Ä(¶¯)	'jump everywhere'
c.	νιεN^{H}	Äé	νιεN^{H}νιεN^{H}	ÄéÄé	'pick up something'

(41)

	Verbs	→	Redupl. Vs		Gloss
a.	πα^{HM}	ÅÀ	πα^{ML}πα^{HM}	ÅÀÅÀ	'climb everywhere'
b.	σια^{ML}	Ð´	σια^{MH}σια^{ML}	Ð´Ð´	'write everywhere'
c.	τ϶αι^{H}	Ì§	τ϶αι^{H}τ϶αι^{H}	Ì§Ì§	'lift by 2 persons'
d.	λαυ^{HM}	Á÷	λαυ^{ML}λαυ^{HM}	Á÷Á÷	'keep flowing'
e.	ξυαN^{H}	·–	ξυαN^{H}ξυαN^{H}	·–·–	'turn staff over'

The important difference between the ones that have vocalic changes and the ones that do not is their tonal categories. That is, the vowels with a level tone or a simple contour tone do not change, whereas the ones with complex contour tones do change. The patterns of vowel changes are exactly the same as the vowel distribution patterns in monosyllabic words.

2.3.3 Tone-vowel interaction in "cutting foot words"

The "cutting-foot" words (data are from Liang 1982) are disyllabic words formed from monosyllabic words by a process resembling partial reduplication. In particular, the first syllable in the output shares the most sonorous vowel and any segmental material before that vowel with the original word, while the second syllable of the output retains the tone and all segmental material of the original word except the onset, which is replaced by a new onset [l]. This is illustrated in (42), (43) and (44) below.

(42)

	Original	"cutting foot"	Gloss
a.	τσэι^{HM}	τσэι^{ML}.λι^{HM}	'not smooth'
b.	κυ^{HM}	κυ^{ML}.λυ^{HM}	'tie up'
c.	μιN^{H}	μι^{ML}.λιN^{H}	'hide'
d.	κι/^{H}	κι^{ML}.λι/^{H}	'tickle'
e.	συN^{H}	συ^{ML}.λυN^{H}	'move shakily'
f.	πυ/^{H}	πυ^{ML}.λυ/^{H}	'put long thin stuff in a nostril'
g.	νψ/^{H}	νψ^{ML}.λψ/^{H}	'fill in; squeeze'

(43)

	Original	"cutting foot"	Gloss
a.	πιευ^{H}	πιε^{ML}.λιευ^{H}	'spray'
b.	τιεN^{H}	τιε^{ML}.λιεN^{H}	'be given to'
c.	μο^{H}	μο^{ML}.λο^{H}	'rise'
d.	Nο/^{H}	Nο^{ML}.λο/^{H}	'hold one's head high'
e.	τσэυο^{H}	τσэυο^{ML}.λυο^{H}	'tighten up a screw'
f.	κυοN^{ML}	κυο^{ML}.λυοN^{ML}	'roll up'
g.	τσэυο/^{H}	τσэυο^{ML}.λυο/^{H}	'scare'

(44)		Original	"cutting foot"	Gloss
	a.	τα^{ML}	τα^{ML}.λα^{ML}	'twist'
	b.	ηια^{H}	ηια^{ML}.λια^{H}	'split open'
	c.	σαι^{HM}	σα^{ML}.λαι^{HM}	'seat there not move'
	d.	λαυ^{H}	λα^{ML}.λαυ^{H}	'frown'
	e.	σαN^{H}	σα^{ML}.λαN^{H}	'arrest'
	f.	κα/^{H}	κα^{ML}.λα/^{H}	'ward off'
	g.	κэυαN^{HM}	κэυα^{ML}.λυαN^{HM}	'bind'
	h.	ηια/^{H}	ηια^{ML}.λια/^{H}	'hang down; droop'
	i.	NιαN^{H}	Nια^{ML}λιαN^{H}	'upright'

(42) shows that when a syllable contains a single high vowel, the first syllable of the output keeps that vowel without any change. (43) and (44) show that when a monosyllabic word contains more than one vowel, the first syllable of the output always retains the non-high vowel and any segmental material before that vowel. If, for instance, an original word has a sequence like CV_1V_2C, where V_1 is not high and V_2 is high, the first syllable of the output only keeps V_1 but not V_2. This is illustrated in (45) below.

(45)

	original	"cutting foot"	Gloss
a.	τειN^{H}	τε^{ML}.λειN^{H}	'poke (sand in the shoes)'
b.	κει/^{H}	κε^{ML}.λει/^{H}	'press from both sides'
c.	πουN^{H}	πο^{ML}.λουN^{H}	'roll over in sandy material'
d.	Nου/^{H}	Nο^{ML}.λου/^{H}	'look upward'
e.	μΠψN^{H}	μΠ^{ML}.λΠψN^{H}	'puffy'
f.	λΠψN^{H}	λΠ^{ML}.λΠψN^{H}	'ventilate'

Of interest are the cases where the first syllable of the output changes its vowel from the original word. Data in (46), (47) and (48) illustrate these cases.

(46)

	original	"cutting foot"	Gloss	Alternation
a.	τιE^{MLM}	τι$\underline{\varepsilon^{L}}$.λιE^{MLM}	'drip'	E → ε
b.	ηιEυ^{MLM}	ηι$\underline{\varepsilon^{L}}$.λιEυ^{MLM}	'listless'	
c.	ηιEN^{MLM}	ηι$\underline{\varepsilon^{L}}$.λιEN^{MLM}	'throughout'	
d.	πιE/^{MLM}	πι$\underline{\varepsilon^{L}}$.λιE/^{MLM}	'roll up'	

(47)

	original	"cutting foot"	Gloss	Alternation
a.	σO/^{MLM}	σ$\underline{o^{L}}$.λO/^{MLM}	'tie tightly'	O → o
b.	λO/^{MLM}	λ$\underline{o^{L}}$.λO/^{MLM}	'put on'	
c.	τυOι^{MLM}	τυ$\underline{o^{L}}$.λυOι^{MLM}	'hold tightly'	

In (46), (47) and (48) the nuclear vowel in the first syllable of each output changes from lax to tense. The changed vowel and tone are underlined. The question is why do only the examples in (46), (47) and (48) undergo vocalic change but the ones in (42), (43), (44) and (45) do not? The difference between these two sets of data are the tonal categories.

Specifically, the tones in (42), (43), (44) and (45) belong to the tight finals (i.e., H, M, HM), while the ones in (46), (47) and (48) belong to the loose finals (i.e., MHM, MLM).

(48)

	original	"cutting foot"	Gloss	Alternation
a.	ηAυ^{MLM}	η<u>α^{L}</u>.λAυ^{MLM}	'stretch out'	A → α
b.	τA/^{MLM}	τ<u>α^{L}</u>.λA/^{MLM}	'be controlled'	
c.	τAN^{MLM}	τ<u>α^{L}</u>.λAN^{MLM}	'permeate; seep'	
d.	λAιN^{MLM}	λ<u>α^{L}</u>.λAιN^{MLM}	'stand on tiptoe'	
e.	ηιA/^{MLM}	ηι<u>α^{L}</u>.λιA/^{MLM}	'collapse'	

The most interesting cases are those in (49) where the outputs have two alternative forms for the first syllable. This is indicated by the parentheses. In particular, if the input has a sequence CV_1V_2C, where V_1 is mid and V_2 is high, the first syllable of the output can be either V_1 or V_2. Both forms are possible outputs.

(49)

	original	"cutting foot" word	Gloss	Alternation
a.	τσει/^{MLM}	τσι^{L}(τσε^{L}).λει/^{MLM}	'squeeze'	ι ~ ε
b.	τσэει/^{MLM}	τσэι^{L}(τσ—ε^{L}).λει/^{MLM}	'spray'	
c.	ηoυ^{MLM}	ηυ^{L}(ηo^{L}).λoυ^{MLM}	'pour liquid on'	o ~ υ
d.	ηoυ/^{MLM}	ηυ^{L}(ηo^{L}).λoυ/^{MLM}	'sweep past'	
e.	τσэoυN^{MHM}	τσэυ^{L}(τσ—o^{L}).λoυ N^{MHM}	'wring out wet clothes'	
f.	λΠψ/^{MLM}	λψ^{L}(lΠ^{L}).λΠψ/^{MLM}	'subside'	Π ~ ψ
g.	τэΠψ/^{MLM}	τэψ^{L}(τэΠ^{L}).λΠψ/^{MLM}	'draw back'	

Comparing (49) with (45), the sequence of the segmental material is identical. But the alternative outputs observed in (49) do not exist in (45). The question, then, is why do only the examples in (49) have two alternative outputs while those in (45) do not. The only difference between (45) and (49) is again the tonal categories. Specifically, the tones in (49) are complex contour tones (MHM, MLM) while the ones in (45) are level tones (H, M) or simple contours tones (HM). It is the tonal category but not a particular tonal value that determines the output forms.

To sum up, the investigation of Fuzhou tone-vowel interaction reveals that tonal category is only one of the factors that affects vowel distributions and alternations. However, this factor does not affect vowels directly. The tones have a much closer relationship with the types of finals (i.e., the tight/loose distinction) than with vowels. This kind of close relationship will be identified as a correlation between tonal contour and syllable weight (see section 2.5 for details). On the other hand, the syllable position and the number of segments present within a syllable are the factors that directly affect the behavior of vowels (see chapter 3 and 4 for an account of the direct relation between syllable structures and vowels).

2.4 **Fuqing tone-vowel interaction**

Fuqing is another Northern *Min* language spoken principally in Fujian province on the south coast of China. There are over a million speakers in Fujian province alone. Other Fuqing speakers are found in Southeast Asia, Europe, as well as North America.

The Fuqing phonological system contains the 17 consonants (50), 12 vowels (51), and 7 tones (52). The consonants within parentheses occur only in a non-initial position of a domain. Particularly, [B] is a sandhi form for [p] and [p'], while [Z] is for [t] and [t'].

(50) 15 consonants (Feng 1993a:28)

π	τ	τσ	κ	/
πэ	τэ	τσэ	κэ	
(B)	(Z)	σ		η
μ	ν		N	
	λ			

(51) 12 Vowels (Feng 1993a:31)

ι	ψ		υ
ε	Π		ο
Ε	{		Ο
α		A	

(52) Tones (Feng 1993a:35)

I. The "tight" finals				**II. The "loose" finals**		
ÒõÆ½ *Yin Ping*	ÑôÆ½ *Yang Ping*	ÑôÈë *Yang Ru*	ÉÏÉù *Shang*	ÑôÈ¥ *Yang Qu*	ÒõÈ¥ *Yin Qu*	ÒõÈë *Yin Ru*
53 HM	44 H	5/ H	32 M	41 HL	21 ML	22/ ML

As in Fuzhou, there is a tight/loose distinction for finals in Fuqing. The seven citation tones, listed in (52) are divided into two groups. Unlike Fuzhou, however, there are no complex contour tones in Fuqing. The ones in Group I (i.e., in tight finals) are either level tones (H or M) or high falling tone (HM), whereas the ones in Group II (i.e., in loose finals) are either HL or ML. In other words, the tones in the tight finals do not contain a L, while the ones in the loose finals must have a L. Accordingly, vowels are also divided into two groups, as shown in (53).

(53) Fuqing Alternating finals (**I** = "tight" finals; **II** = "loose" finals) (Feng 1993a:31)

Nuclear V	**I**		**II**	**I**		**II**	**I**		**II**	**I**		**II**
High Vs	ι	~	ε	ιN	~	εN	ι/	~	ε/			
	ψ	~	Π	ψN	~	ΠN	ψ/	~	Π/			
	υ	~	ο	υN	~	οN	υ/	~	ο/			
Mid Vs	ε	~	E	εN	~	EN	ε/	~	E/	ευ	~	Eυ
	ιε	~	ιE	ιεN	~	ιEN	ιε/	~	ιE/	ιυ	~	ιευ
	Π	~	{	ΠN	~	{N	Π/	~	{/			
	ο	~	O	οN	~	ON	ο/	~	O/	οι	~	Oι
	υο	~	υO	υοN	~	υON	υο/	~	υO/	υι	~	υοι
	ψο	~	ψO	ψοN	~	ψON	ψο/	~	ψO/			
Low Vs	α	~	A	αN	~	AN	α/	~	A/	αι/αυ	~	Aι/Aυ
	ια	~	ιA	ιαN	~	ιAN	ια/	~	ιA/	ιευ	~	ι υ
	υα	~	υA	υαN	~	υAN	υα/	~	υA/	υοι	~	υ ι

The generalizations that can be abstracted from (53) are the following. First, high vowels [ι], [υ], [ψ] in the tight finals correspond to mid vowels [ε], [ο], [Π] respectively in the loose finals. Second, the tense mid vowels [ε], [ο], [Π] and low vowel [α] in the tight finals correspond to their lax counterparts [E], [O], [{] and [A] in the loose finals, respectively. Third, a low vowel [ ] in Group II (i.e., in loose finals) corresponds to mid vowel [ε] and [ο] in Group I (i.e., in tight finals) depending on its surrounding vowels.

Finally, mid vowels [ε] or [o] in loose finals disappear in the corresponding tight finals when they are both preceded and followed by a high vowel. This kind of vowel correspondence in tight/loose finals is comparable to that in Fuzhou even though the vowel inventory in Fuqing is different from that in Fuzhou. In the following sections, I will examine tone-vowel interaction in Fuqing in detail.

2.4.1 Tone-vowel interactions in monosyllabic words

As in Fuzhou and other Chinese dialects, morphemes are usually monosyllabic, hence, a syllable can be a word. In this section, I investigate vowel distributions with respect to their tonal environment in monosyllabic words and show how tones and vowels interact with each other. The data are from Feng (1993a:33-35).

(54)		**I** "tight"		Gloss		**II**"loose"		Gloss	Distribution
	a.	τσι^{HM}	Ö ®	'a pronoun'	e.	τσε^{HL}	×Ö	'character'	i ~ ε
	b.	πɘι^{M}	·Ë	'robber'	f.	κɘε^{ML}	Æ ø	'air'	
	c.	τιN^{HM}	Õä	'treasure'	g.	τεN^{ML}	Õò	'small town'	
	d.	νι/^{H}	ÈÕ	'day'	h.	κε/^{ML}	¼±	'urgent'	

(55)		**I** "tight"		Gloss		**II**"loose"		Gloss	Distribution
	a.	τσɘυ^{HM}	´Ö	'rough'	e.	τɘο^{ML}	íÃ	'rabbit'	υ ~ ο
	b.	πɘυN^{HM}	·ä	'bee'	f.	μοN^{HL}	Ã Æ	'stifling'	
	c.	συN^{H}	´¬	'boat'	g.	πο^{ML}	¸»	'wealthy'	
	d.	πυ/^{H}	·ü	'lie down'	h.	πο/^{ML}	¸¹	'stomach'	

(56)	I "tight"		Gloss		II"loose"		Gloss	Distribution
a.	τσψ^{M}	Öó	'boil'	e.	τσэΠ^{ML}	´¦	'place'	ψ ~ Π
b.	τσψN^{M}	Ö×	'swell'	f.	τσΠN^{ML}	Ö Ú	'crowd'	
c.	ηψN^{H}	ÐÜ	'bear'	g.	ΠN^{HL}	Ó Ã	'use'	
d.	τψ/^{H}	Öð	'each'	h.	τΠ/^{ML}	Öñ	'bamboo'	

The examples in (54), (55) and (56) above show that high vowels [ι], [υ], [ψ] in the tight finals correspond to mid vowels [ε], [ο], [Π] in the loose finals, respectively. The tones in the loose finals have two characteristics. First, they must be a contour tone. Second, they must involve a L part, hence, be falling (either HL, or ML). On the contrary, the tones in the tight finals do not have these properties. They can be either a level tone (H or M) or a high falling tone (HM). They do not involve any L part. This seems to suggest that vowel height correlates with tonal height. A close examination of the data in (54), (55) and (56), however, reveals that the phonological correlation between tonal height and vowel height cannot be established. First, the tonal height in the two groups of finals cannot be clear-cut. On the one hand, tones in the tight finals are not always H; the M tone also occurs in the tight finals, as shown in (54b) and (56a, b). If the vowel change from the tight group to the loose group were to involve vowel-raising under a tonal condition of H, the same vowel change with a M tone environment in (54b) and (56a, b) would be left unexplained. On the other hand, the tones in the loose group are not always L. The L tone is only a part of the falling contour. The other part of the falling contour is either H or M. If the vowel change from the loose to the tight were to be characterized as vowel-lowering under the condition of L tone, we could not explained why only the L part of the tonal contour conditions the vowel change and the H or M part of the tonal contour in the loose finals cannot be part of the condition. Second, the data in (57), (58), (59) and (60) below reveal that the correspondence between the mid vowels and the high vowels in the two groups of finals only occurs in the nuclear vowel. Non-nuclear high elements in (57c-g), (58d-j) and (60d-k) in the tight finals do not change into mid. This suggests that tone is not a direct factor, or at least not the sole factor affecting vowel features. Rather, the relative possible positions influence vowel distributions directly.

(57)		**I** "tight"		<u>Gloss</u>		**II**"loose"		<u>Gloss</u>	<u>Distribution</u>
	a.	σε^{HM}	Î÷	'west'	h.	σE^{ML}	Ï¸	'small'	ε ~ E
	b.	τεN^{HM}	µÆ	'lamp'	i.	τEN^{HL}	µË	'Deng (surname)'	
	c.	πε/^{H}	°Î	'pull'	j.	πE/^{ML}	°Ë	'eight'	
	d.	κιε^{HM}	¼¦	'chicken'	k.	κιE^{ML}	¼ ¾	'season'	
	e.	νιεN^{M}	È¾	'dye'	l.	NιE^{HL}	Ò Õ	'art'	
	f.	σιε/^{H}	Éà	'tongue'	m.	τσιE/^{ML}	½ Ó	'connect'	
	g.	τευ^{HM}	µñ	'carve'	n.	κэEυ^{ML}	¿Û	'button'	

(58)		**I** "tight"		<u>Gloss</u>		**II**"loose"		<u>Gloss</u>	<u>Distribution</u>
	a.	τэo^{M}	ÌÖ	'ask for'	k.	τO^{ML}	×À	'table'	o ~ O
	b.	κoN^{HM}	□	'oil lamp'	l.	κON^{ML}	¸Ö	'steel'	
	c.	κo/^{H}	»¬	slippery'	m.	κO/^{ML}	¹Ç	'bone'	
	d.	πυo^{HM}	¸¿	'bind'	n.	πυO^{ML}	²¼	'cloth'	
	e.	τυoN^{M}	×ª	'turn'	o.	NυON^{HL}	Ô¸	'willing'	
	f.	Nυo/^{H}	ÔÂ	'month'	p.	κυO/^{ML}	¹ú	'country'	
	g.	ψo^{HM}	Ò ©	'medicine'	q.	ψO^{HL}	Ô Ä	'read'	
	h.	τσэψoN^{H}	Ç½	'wall'	r.	τσэψON^{ML}	³ª	'sing'	
	i.	κэψo/^{H}	¾ç	'play'	s.	κψO/^{ML}	¾ö	'decide'	
	j.	τoι^{HM}	¶Ñ	'pile'	t.	τOι^{ML}	¶Ô	'face'	

(59)

	I "tight"		Gloss		II "loose"		Gloss	Distribution
a.	σΠ^{HM}	Êá	'comb'	e.	σ{^{ML}	Êè	'not familiar with'	Π ~ {
b.	λΠ^{H}	Â¿	'donkey'	f.	τ{^{HL}	Ü Ñ	'limonene'	
c.	τΠΝ^{HM}	¶¬	'winter'	g.	τ{Ν^{HL}	¶¯	'move'	
d.	μΠ/^{H}	Ä¿	'eye'	h.	π{/^{ML}	±±	'north'	

(60)

	I "tight"		Gloss		II "loose"		Gloss	Distribution
a.	πα^{HM}	°×	'white'	l.	πΑ^{ML}	°Ù	'hundred'	α ~ Α
b.	παΝ^{HM}	°à	'class'	m.	πΑΝ^{HL}	²¡	'sick'	
c.	α/^{H}	ºÐ	'box'	n.	Α/^{ML}	Ñ ¼	'duck'	
d.	σια^{M}	Ð´	'write'	o.	σιΑ^{HL}	Ð»	'thank'	
e.	σιαΝ^{HM}	Éù	'sound'	p.	σιΑΝ^{ML}	Ïß	'line'	
f.	τэυα^{HM}	íÏ	'drag'	q.	τυΑ^{HL}	´ó	'big'	
g.	πυαΝ^{H}	ÅÌ	'dish'	r.	πυΑΝ^{ML}	°ë	'half'	
h.	υαΝ^{M}	íë	'bowl'	s.	υΑΝ^{HL}	»»	'change'	
i.	πυα/^{H}	°Ï	'postscript'	t.	πυΑ/^{ML}	²§	'big bowl'	
j.	σαι^{HM}	Ê¨	'lion'	u.	κΑι^{ML}	½ç	'boundary'	
k.	ταυ^{HM}	íµ	'steal'	v.	τΑυ^{ML}	Õ Ö	'cover'	

Third, the vowel distributions in (57), (58), (59) and (60) take place among the nuclear non-high elements. In particular, the tense mid vowels [ε], [o], [Π] and low vowel [α] in the tight finals correspond to their lax counterparts [E], [O], [{] and [A] in the loose finals, respectively. If vowel distributions were purely conditioned by tone height, the distributions with the tense/lax parameter[7] in (57), (58), (59) and (60) would not be expected.

Notice that low vowels behave differently depending on their surrounding segments. Comparing the distributional behavior of low vowels in (60) with that in (61), it becomes clear that a low vowel varies long the tense/lax dimension only when it is not flanked by two high vowels. When it is both preceded and followed by a high vowel, it raises to mid. This kind of asymmetric behavior of the low vowels cannot be entirely attributed to their tonal environment since tones in the tight finals in both (60) and (61) are of the same categories. There must be some other factor(s) involved in triggering these different distributional effects.

(61)		**I** "tight"		<u>Gloss</u>		**II**"loose"		<u>Gloss</u>	<u>Distribution</u>
	a.	σιευ^{HM}	ÉÕ	'burn'	e.	τэι υ^{ML}	Ìø	'jump'	ιευ ~ ι υ
	b.	πιευ^{M}	±í	'watch'	f.	κι υ^{HL}	½Î	'sedan'	
	c.	πυοι^{HM}	±-	'cup'	g.	πυ ι^{ML}	±´	'shell'	υοι ~ υ ι
	d.	πэυοι^{H}	Æ¤	'skin'	h.	πэυ ι^{HL}	±»	'quilt'	

The data in (62) below are interesting because we see another asymmetry in the distributions of mid vowels. Comparing (62) with (57) and (58), we see that mid vowels vary along the tense/lax dimension in (57) and (58), but they do not in (62). Instead, a mid vowel is deleted in (62) when it is flanked by two high vowels. The deletion of a mid vowel in (62) cannot be attributed to its tonal environment since the tones in the tight

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[7] It is possible to interpret the tense/lax distinction as a tongue-height distinction. This interpretation, however, cannot be used to support the correlation hypothesis between tonal height and vowel height, since the tones in the two groups of finals involve a H part in tonal contours, as mentioned above.

finals in both (57), (58) and (62) are of the same categories. Therefore, the direct factor that conditions vowel distributions cannot be tone alone.

(62)		**I** "tight"		<u>Gloss</u>		**II** "loose"		<u>Gloss</u>	<u>Distributions</u>
	a.	$\pi\upsilon\iota^{H}$	·Ê	'fat'	e.	$\pi\upsilon o\iota^{ML}$	□	'rash'	υι ~ υοι
	b.	$\tau\upsilon\iota^{H}$	´·	'thump'	f.	$\tau\upsilon o\iota^{HL}$	¶Ó	'team'	
	c.	τσэιυ^{HM}	Çï	'autumn'	g.	$\kappa\iota\varepsilon\upsilon^{HL}$	¾Ë	'uncle'	ιυ ~ ιευ
	d.	$\kappa\iota\upsilon^{H}$	Çò	'ball'	h.	$\kappa\iota\varepsilon\upsilon^{ML}$	¾¿	'study'	

To sum up, our investigation of tone-vowel interaction in monosyllabic words suggests that, on the one hand, there is a cooccurrence restriction on tone and vowel, and on the other hand, the vowel distributions in monosyllabic words cannot be entirely and directly governed by their tonal environment. Three kinds of asymmetries are observed in this section. First, the high vowels in tight finals behave differently with respect to their relevant syllable positions. They correspond to the mid vowels when they are the only vowel within a syllable. When they occur with another non-high vowel within the same syllable, they do not have such correspondence, and remain as high. Second, the mid lax vowels in the loose finals correspond to their tense counterparts only when they are not flanked by high vowels. If they are surrounded by high vowels, they are deleted in the corresponding tight finals. Third, the low vowels also have two different characteristics. The lax low vowels in the loose finals correspond to their tense counterparts only when they are not surrounded by high vowels. If they do, they raise to mid rather than become lax. These asymmetries in vowel distributions cannot be attributed to their tonal environment since the tonal categories of all tight finals are the same. It seems like the tones relate only to the distinction between tight and loose finals, but do not directly trigger any vowel distribution effect. This suggests that tone does not interact with vowel features directly. Tonal effects on vowels at most can only be associated with the types of finals.

2.4.2 Tone-vowel interaction in disyllabic words

In this section, I investigate tone-vowel interaction in disyllabic words, and explore whether tonal changes relate to vocalic changes. As I mentioned before, morphemes in Fuqing are usually monosyllabic. When a monosyllabic word combines with another monosyllabic word to form a disyllabic word, the tone of the first syllable within a disyllabic word changes. Sometimes, the tonal change is accompanied by vocalic change. This sort of co-variation is illustrated in (63) and (64).

(63)	Morph		Gloss →	Disyl.		Gloss	Alternations
a.	Nε^{HL}	¶ú	'ear'	Nι^{H} πα^{H}	¶ú°Ç	'earpick'	ε → ι
b.	πэε^{ML}	±Ç	'nose'	πэι^{HM} Zψ^{M}	±ÇË®	'nasal mucus'	
c.	πoN^{ML}	·à	'excrement'	πυN^{HM} τэΠN^{M}	·àÍ°	'manure bucket'	o → υ
d.	τσэo/^{ML}	³ö	'to go out'	τσэυ/^{H} κα^{ML}	³ö¼Þ	'(a girl) to marry'	
e.	τσΠ^{ML}	×¢	'pour'	τσψ^{HM} ε^{ML}	×¢Òâ	'pay attention to'	Π → ψ
f.	τΠ/^{ML}	Öñ	'bamboo'	τψ/^{H} τσэψo^{HM}	ÖñÏ¯	'bamboo mat'	

The data in (63) show that the HL or ML tones in the monosyllabic words change into H or HM, respectively, when they occur as the first syllable within a disyllabic word. Meanwhile, the vowel undergoes change as well. In particular, the mid vowels [ε], [o] and [Π] raise and become [ι], [υ] and [ψ], respectively. This kind of co-variation might be viewed as evidence supporting the height correlation hypothesis since the vocalic change in these cases involves vowel raising, while the tonal change can also be characterized as register raising (i.e., from ML to HM), except the example in (63a) where the tonal change is best characterized as tonal simplification (i.e., from HL to H) rather than tonal raising. However, the height correlation hypothesis runs into difficulties as far as the following data in (64) are concerned. The changed syllables are underlined.

(64)	Morph		Gloss →	Disyl. words		Gloss	Alternations
a.	σE^{ML}	Ï¸	'thin'	σε^{H} νE^{HL}	Ï¸Äå	'careful'	E → ε
b.	τιEυ^{ML}	µö	'to fish'	τιευ^{H} Nψ^{H}	µöÓã	'to fish'	
c.	τιEN^{HL}	µç	'electricity'	τιεN^{H} πιευ^{M}	µç±í	'meter'	
d.	νON^{ML}	ÄÛ	'tender'	νoN^{HM} µυOι^{ML}	ÄÛÃÃ	'young sister'	O → o
e.	κAι^{ML}	½æ	'mustard'	και^{HM} ZAι^{HL}	½æ²Ë	'mustard'	A → α
f.	λAυ^{HL}	Àï	'old'	λαυ^{H} νΠN^{H}	ÀïÙ¯	'old man'	
g.	πυAN^{ML}	°ë	'half'	πυαN^{H} νι/^{H}	°ëÈÕ	'half a day'	

The examples in (64) show that the tonal changes involved are the same as those in (63) (i.e., ML becomes HM, and HL becomes H). However, the vocalic changes are different. First, the non-high vowels [E], [O], [A] become [ε], [o], [α], respectively. Second, unlike the high vowels [ι] and [υ] in (63), the high vowels (i.e., [ι] in (64b, c, e) and [υ] in (63) and (64b, f, g)) do not change at all, even though the tonal environment in both (63) and (64) is the same. The only difference between (63) and (64) for the high vowels is their relevant syllable position. In particular, the high vowels in (63) are syllable nuclei while the ones in (64) are not. The effect of syllable position inducing vowel change cannot be explained by the height correlation hypothesis. We therefore need a theory that is capable of encoding both tonal and syllabic factors in affecting vowel change.

(65)		Monosyl		Gloss	Disyl. words		Gloss
	a.	ε^{M}	°«	'short'	$\varepsilon^{\underline{ML}}$ $\kappa\iota\alpha N^{HM}$	°«×Ó	'short guys'
	b.	$\sigma\varepsilon^{M}$	Ï´	'wash'	$\sigma\varepsilon^{\underline{ML}}$ τσэιυ^{HM}	Ï´ÊÖ	'wash hands'
	c.	$\tau o N^{HM}$	µ±	'become'	$\tau o N^{\underline{H}}$ $N\alpha^{HM}$	µ±¼Ò	'decision-maker'
	d.	$\eta o/^{H}$	Ñ§	'to study'	$\eta o/^{\underline{H}}$ $\eta\alpha\upsilon^{HL}$	Ñ§Ð£	'school'
	e.	τэαυ^{H}	Í·	'head'	τэαυ$^{\underline{ML}}$ $\upsilon o/^{M}$	Í·¢	'hair'
	f.	$\eta\alpha/^{H}$	ºÏ	'combine'	$\eta\alpha/^{\underline{ML}}$ $\pi\alpha/^{M}$	ºÏ±Û	'purse'

Notice that the first syllables of disyllabic words in (65) changes their tones. However, unlike the tone change in the previous data, there is no vocalic change occurring with the tonal change. If vowel change were to be attributed to the tonal change, the lack of vocalic change in (65) cannot be explained. Thus, tone is not a direct conditioning factor on vowel changes.

2.4.3 Tone-vowel interaction in reduplications

In this section, I investigate tone-vowel interaction in reduplication and identify the exact factors that trigger their interaction. The data in (66) show that when a monosyllabic adjective reduplicates to form a disyllabic adjective, the first syllable of the disyllabic word undergoes both tonal and vocalic changes.

(66)	monosyl.	→	Redupl. words		Gloss	Alternations
a.	σε^{ML}	Ï¸	σι^{HM}σε^{ML}	Ï¸Ï¸	'very thin and long'	ε → ι
b.	τσεN^{HL}	¾²	τσιN^{H}τσεN^{HL}	¾²¾²	'very quiet'	
c.	μEN^{HL}	Âý	μεN^{H} μEN^{HL}	ÂýÂý	'slowly'	E → ε
d.	κэE^{ML}	¿ì	κэε^{HM} κэE^{ML}	¿ì¿ì	'quickly'	
e.	τOι^{HL}	´ü	τοι^{H}τOι^{HL}	´ü´ü	'little bag'	O → o
f.	ηυON^{HL}	Ô¶	ηυoN^{H} ηυON^{HL}	Ô¶Ô¶	'far away'	
g.	κAυ^{HL}	ºñ	κασ^{H} κAυ^{HL}	ºñºñ	'very thick'	A → α
h.	τσAN^{ML}	Ôõ	τσαN^{H} τσAN^{ML}	ÔõÔõ	'how come'	
i.	τσιA^{ML}	Õ§	τσια^{H} τσιA^{ML}	Õ§Õ§	'just a beginning'	
j.	τσιευ^{ML}	Ð¦	τσэιυ^{HM}τσэιευ^{ML}	Ð¦Ð¦	'just smile'	ιευ → ιυ

There are three kinds of change taking place in (66). First, the tense mid vowel [ε] becomes the high vowel [ι] in (66a-b). Second, the lax non-high vowels [E], [O] and [A] in (66c-i) change into their tense counterparts [ε], [o], and [α], respectively. Third, a mid vowel [ε] is deleted in the output. Meanwhile, the tones in (66) also change. The tonal changes are of two types. First, low falling (i.e., ML) becomes a high falling (i.e., HM), as shown in (66a, d, j). Second, a high falling becomes a high level (i.e., H), as shown in (66b, c, e, f, g,). However, the vocalic changes do not show up in the reduplicated forms in (67), (68) and (69) below.

(67)	monosyl	→	Redupl. words		Gloss
a.	ηι^{HM}	Ï¡	ηι^{H}ηι^{H}τσΠ/^{ML}	Ï¡Ï¡	'watery'
b.	τι/^{H}	Ö±	τι/^{H} τι/^{H}	Ö±Ö±	'very straight'

c.	κιN^{M}	½ô	κιN^{ML}NιN^{HM}	½ô½ô	'closely'
d.	υ^{HM}	ÎÚ	υ^{H} υ^{HM}	ÎÚÎÚ	'very dark'
e.	τσψ^{H}	´É	τσψ^{H}τσψ^{H}λυο/^{ML}	´É´É(ßö)	'calm and confident'

In (67), there are two kinds of tonal changes. First, HM and H of the original words become H in the first syllable of the reduplicated forms, as shown in (67a, b, d, e). Second, a M tone of a original word becomes ML in the first syllable of the reduplicated form, as shown in (67c).

(68)	<u>monosyl.</u>	→	<u>Redupl. words</u>		<u>Gloss</u>
a.	κεN^{H}	Ðü	κεN^{H}NεN^{H}	ÐüÐü	'very high'
b.	τευ^{M}	¶¶	τευ^{ML}τευ^{H}τσιεN^{ML}	¶¶¶¶²ü	'shiver'
c.	πɘιεN^{HM}	Æ«	πɘιεN^{H}μιεN^{HM}	Æ«Æ«	'just in right time'
d.	ηο^{M}	ºÃ	ηο^{ML}ηο^{HM}	ºÃºÃ	'properly'
e.	μοN^{H}	Ã¦	μοN^{H}μοN^{H}	Ã¦Ã¦	'frequently'
f.	ΠN^{H}	ºì	ε/^{ML}ΠN^{H}ΠN^{H}	ºìºì	'very red'
g.	μΠN^{H}	ëü	μΠN^{H}μΠN^{H}	ëüëü	'twilight'

The same kinds of tonal changes are also observed in (68) and (69). However, there is no vocalic change taking place in (67), (68) and (69). The question then, is why is the tonal change accompanied by vocalic change in (66), but not in (67), (68) and (69)? A closer examination shows that the tones in (66) are the ones belonging to the loose finals while tones in (67), (68) and (69) are the ones in the tight finals. It seems that it is the types of finals that determines the cooccurrence of tonal and vocalic changes. Tone itself does not have a direct effect on this choice.

(69)	monosyl.	→	Redupl. words		Gloss
a.	τα^{HM}	½¹	τα^{H}τα^{HM}	½¹¹½¹	'very dry'
b.	λαN^{H}	À¶	λαN^{H}λαN^{H}	À¶À¶	'very blue'
c.	τσια/^{H}	Æà	τσια/^{H}τσια/^{H}	(·ç)ÆàÆà	'windy'
d.	υα/^{H}	»î	υα/^{H} υα/^{H}	»î»î	'lively'

To sum up, the investigation of Fuqing tone-vowel interaction furnishes further support for the findings in Fuzhou. First, there is a cooccurrence restriction on tonal categories and types of finals. Second, tone does not directly affect vowel change. Third, syllable positions and the number of segments present within a syllable are the direct factors inducing vowel change.

2.5 The nature of the tight-loose distinction

Tone-vowel interaction in Fuzhou (section 2.3) and Fuqing (section 2.4) reveals that the tight-loose distinction exists in both Northern *Min* languages. The notion of "final" refers to the subsyllabic constituent "rime", which includes all segmental and tonal features except onset. Since the onset consonant in these languages is not obligatory for forming a syllable (i.e., syllables may lack an onset in Fuzhou and Fuqing, see chapter 4 for details), the final alone may stand as a syllable. The tight-loose distinction of finals can therefore be viewed as a distinction of syllable types. The following table gives a summary of the segmental and tonal distinctions in the two types of syllables.

(70) Segmental and tonal distinctions of different types of syllables in Fuzhou and Fuqing

Lg's	**tight syllables**	**loose syllables**

↓	Segments	Tone	Segments	Tone
(i) Fuzhou	a. monophthongs b. tense vowels c. round harmony required d. low-high vowel sequence disallowed with a coda C	H, ML, HM	a. diphthongs b. lax vowels c. lack of round harmony d. low-high vowel sequence allowed with a coda C	MHM, MLM
(ii) Fuqing	a. two high vowels without a mid vowel in between b. tense vowels c. round harmony required d. low-high vowel sequence disallowed e. high vowels	H, M, HM	a. two high vowels with a mid vowel in between b. lax vowels c. lack of round harmony d. low-high vowel sequence allowed e. mid vowels	HL, ML

The table (70) shows that the tonal and segmental contrasts between the two types of syllables in Fuzhou are similar but not identical to those in Fuqing. In Fuzhou, the tonal contrast is apparently quantity (i.e., simple tonal contour vs. complex tonal contour), while in Fuqing, it is apparently quality (i.e., the L tone occurs only in the loose syllables but not in the tight syllables). Notice that the tones in the tight syllables in both Fuzhou and Fuqing are identical, namely, they are H, M, and HM. The tonal difference of these languages lies in the loose syllables.

The segmental contrasts in the two languages are of three types. The first one is the quantity difference. In particular, the number of vocalic segments present in the tight syllables is one less than in the corresponding loose syllables. In Fuzhou, this contrast appears as monophthongs vs. diphthongs (70i-a). In Fuqing, it is diphthongs vs. triphthongs (70ii-a). The second one is the difference in feature content, namely, the tense-lax[8] distinction in Fuzhou (70i-b) and Fuqing (70ii-b). The third one is the harmonic restrictions in the tight syllables. Both languages require round agreement within a diphthong ((70i-c) and (70ii-c)) and prohibit low-high sequences in a diphthong ((70i-d) and (70ii-d)). The only difference between these two languages regarding the segmental contrast is the correspondence between a high nuclear vowel in the tight syllables and a mid one in the loose syllables. This correspondence exists only in Fuqing (70ii-e) but not in Fuzhou.

The generalizations above raise a number of questions as to the nature of the tight-loose distinction. In particular, why both languages have two types of syllables (i.e., the tight-loose distinction), even though their segmental and tonal properties differ in certain aspects. Why are there only two types of syllables in each of the languages, but not three or four? Two possible answers suggest themselves immediately. One is the quality approach and the other is the quantity approach. Both of them are evidenced in these languages since the tonal and segmental distinctions in these languages involve both quality and quantity differences. In the following sections, I will argue for the second approach, namely, the quantitative distinction between the two types of syllables, as being more promising than the first one.

[8] Alternatively, the tense/lax distinction can be characterized in terms of ATR/RTR distinction. Since the approach taken here assumes that quantity distinction is primary while quality distinction is secondary for the two types of syllables, it is not crucial which pair of features are used to characterize this distinction.

2.5.1 Tone and duration

The intrinsic correlation between fundamental frequency (F_0) and duration has been found in several experimental studies. First, it has been observed that there is a reverse relationship between tonal height and duration. That is, a high tone is shorter than a mid or low tone (Benedict 1948:186 for Cantonese; Pike 1974:171 for Chatino; etc.). Fuqing provides phonological evidence supporting this finding. As shown in table (70), Fuqing tonal distinction in the two types of syllables involves the presence of L tone in the loose syllables and the absence of the L tone in the tight syllables. Given that syllable weight is represented by the number of mora(s), and that the mora is a tone-bearing unit, the presence of a L tone could increase syllable length by requiring another mora, assuming that L tone cannot link to the head tone-bearing unit of a syllable. Thus, the tight-loose distinction of syllable types can be viewed as a contrast between syllable weight, that is, the light vs. heavy syllables. The formal mechanism increasing syllable length by the presence of L tone will be discussed in detail in chapter 3.

Second, it has been reported that pitch contours are related to duration in that a rising tone or a concave tone is longer than a high level tone or a falling tone (Zee 1978 for Taiwanese; Abramson 1962 for Standard Thai; Dreher and Lee 1966, Chuang 1972, Howie 1974 for Mandarin; Langdon 1976 for Yuman languages). The phonological correlation of this type is found in Fuzhou. Two claims have been made in previous studies regarding the tonal distinction in the two types of syllables. The first one is the "pitch height" distinction (Wang 1968, Yip 1980). Yip (1980) claims that the tones in the tight syllables are higher in pitch, whereas the ones in the loose syllables are lower in pitch. This pitch distinction is represented by the feature [±upper]. The [+upper] tones trigger vowel-raising in the tight syllables (assuming that the vowels in the loose syllables are the underlying forms). Hence, a low vowel in a loose syllable (71b) becomes a mid vowel in the corresponding tight syllables (71a).

(71)

		"tight" syllables			"loose" syllables		Distribution
a.	teiN^{ML}	'wait'	b.	taiN^{LHL}	'surname'		εɩN ~ αɩN
c.	k⌊αɩ^{ML}	'change'	d.	k^{h}Aɩ^{HLH}	'approximate'		αɩ ~ Aɩ

However, a low vowel behaves differently in the same tonal environment. The pair 'αɩ~ Aɩ' in (71c-d) shows that a low vowel alternates along the tense/lax dimension only when a high vowel follows it without a coda consonant present. This different behavior of a low vowel with respect to the presence or absence of the coda consonant is unexpected under Yip's proposal since tones in the tight syllables (71a) and (71c) are [+upper] in both pairs, regardless of whether or not a coda consonant is present. If the tonal distinction in question is characterized solely in terms of pitch height, it is not clear why the same tonal feature (i.e., [+upper]) would trigger different vowel alternations for low vowels in (71).

The second claim regarding the nature of the tonal difference in the two types of syllables is the "shape" distinction. Chan (1985) claims that the tones in the loose syllables contain a rising contour (MHM, HMH), while the ones (H, HM, ML) in the tight syllables do not. The rising contour triggers vowel-lowering by increasing syllable length, assuming that the vowels in the tight syllables are the underlying forms. Hence, a mid vowel [e] in the tight final (71c) becomes a low vowel [a] in the corresponding loose final (71d). Chan's proposal is compatible with the phonetic findings. However, Chan claims that the syllable is the tone bearing unit and that vowels link to the CVC skeleton. Since syllable length is represented by the number of moras, it is not clear how the rising contour as a whole unit that links to a syllable node can actually increase syllable length without referring to moraic structure. Chan's insight regarding the possible correlation between syllable length and tonal contour will be formally encoded into my proposal later.

The real tonal distinction between the two types of syllables in Fuzhou, I argue, is quantity rather than quality. In particular, I claim that tones in the tight syllables (H, HM, ML) link to one TBU while those in the loose syllables (MHM, MLM) link to two TBUs, giving rise to the distinctive syllable weight (I will discuss this in detail in chapter 3). It is the distinctive syllable weight that determines the realizations of vocalic segments in the two types of syllables in both Fuzhou and Fuqing (see Chapter 4 for detailed discussion).

2.5.2 Segment and duration

As shown in table (70), the segmental differences between the tight and the loose syllables are of three kinds: (i) the number of vocalic segments differs; (ii) the feature content differs (i.e., tense/lax and high/mid distinctions for the nuclear vowel); (iii) there are harmonic restrictions on the tight syllables. The question that arises is how to encode all of these segmental distinctions in a unified manner. One approach is to characterize the differences in terms of quality, namely, the feature content. This approach, however, can only be partially successful. This is because the featural differences between the two types of syllables in both Fuzhou and Fuqing are only part of the tight-loose distinction. If we characterize this distinction in terms of feature content alone, the majority of generalizations will be left unexplained. The quality approach, therefore, is untenable. The other approach is the quantitative one. Following Wright's insight, we assume that the distinction between the tight and the loose syllables lies in the syllable duration rather than feature content. In particular, I assume that the tight syllables are shorter and the loose ones are longer, hence the tight-loose distinction can be characterized in terms of syllable weight. Given that syllable weight is represented by the number of moras, the observation that there are fewer segments present in the tight syllables than in the loose syllables is explained since short syllables (i.e., the tight ones) contain only one mora, and hence incorporate fewer segments, while longer syllables (i.e., the loose ones) have two moras, hence, incorporate more segments.

One may wonder about the tense/lax distinction, which involves a difference in feature content. Phonetic studies show that tense and lax vowels have intrinsic duration differences. For example, Fischer-JΠrgensen (1990) reports that the fundamental frequency of the long tense vowels [i:] and [u:] is the same as that of their short lax counterparts [I] and [Y] in German. In Cantonese, the tense/lax distinction of vowels represents a length distinction rather than a quality difference (Beijing daxue ±±¾©´óÑ§ 1989). The same can be argued to be true underlyingly for English (Halle and Mohanan 1985). By the same token, it is reasonable to interpret the tense/lax distinction in Fuzhou and Fuqing as a length distinction rather than a quality difference. In general, the tense/lax distinction involves correlation between quantity and quality: either one could be the lexically distinctive property and the other one redundant.

The other featural distinction observed in Fuqing is that a high nuclear vowel in the tight syllables corresponds to a mid vowel in the loose syllables. The question is, can this vowel height difference be interpreted as a length distinction as well? Possibly. The duration difference between vowels of different heights is also found in phonetic studies. For instance, it is reported that a high vowel, other factors being equal, is shorter than a low vowel (Lehiste, 1970:18). This is compatible with the phonological patterning of vowels in Fuqing. In Fuqing, there exists a correspondence between two high vowels in the tight syllables and two high vowels with a mid vowel in between in the loose ones. If the tight-loose distinction is characterized as one of length, this difference in the number of segments, as well as the difference in vowel height, can be interpreted as length difference in terms of the number of moras involved.

Now we turn to the vowel harmony restrictions on the tight syllables. Recall that there are two types of harmony restrictions observed in both Fuzhou and Fuqing. One is that agreement in roundness within a diphthong is required in the tight syllables, but not in the loose ones. The other is that a low-high sequence of vowels is prohibited in the tight syllables but not in the loose ones. All these restrictions involve vowel harmony in terms of a certain feature content. Why then do these harmonic requirements apply only to the tight syllables but not to the loose ones? If we treat the tight-loose distinction as differences in feature content alone, there is no explanation for this phenomenon. On the other hand, if we identify the tight-loose distinction as a length difference, the harmonic restrictions only on the tight syllables are expected. That is, since the tight syllable is light and contains one mora, the cooccurrence of segmental features within a single mora should be more restrictive than that of a long syllable with two moras (see chapter 4 for detailed analysis).

To sum up, by identifying the tight-loose distinction as a distinction in syllable length, all tonal and segmental differences between these two types of syllables are unified in terms of syllable weight, a desirable result.

2.5.3 Further evidence from Southeast Asian languages

If the tight-loose distinction of syllable types exhibited in <u>Fuzhou</u> and <u>Fuqing</u> is identified as a difference in duration, namely, a length distinction, it should be possible to find evidence showing a cooccurrence restriction between tonal contours and vowel length. This kind of evidence is indeed found in various Southeast Asian languages. For example, in <u>Hu</u>, one of two Mon-Khmer languages described by Svantesson (1989), a distinction of vowel length has been replaced by a tonal distinction, i.e., the former short and long vowels have acquired a high tone and a low tone, respectively. In <u>Sre</u>, another Mon-Khmer language, there is co-variation between vowel length and tone, so that long vowels always have a low tone and short vowels a high tone (Manley 1972). Gandour (1977) cites data suggesting a similar phenomenon in <u>Thai</u>. He points out that the loss of a phonological distinction in vowel length historically among certain <u>Thai</u> dialects may be seen as principally conditioned by tone. In Northern Thai and Southern Thai, historically, short vowels tend to become long under the rising tones; long vowels tend to become short under the falling tones (Gandour 1977). In the Chiang Rai dialect short non-low vowels have become long under rising tones, long non-low vowels have become short under non-rising tones (Gandour 1977). In the Phuket dialect long non-low vowels have become short under falling tones, all short vowels have become long under non-falling tones (Gandour 1977). Also, long vowels within a checked syllable occur only with contour tones HL or LM in Siamese and Red Tai respectively, whereas their corresponding short vowels do not have this restriction (Gedney 1965, 1989). All these reported cases furnish further support for the length distinction between the tight and the loose syllables. The following table gives a summary of the correlation between tonal contour and vowel length reported in the Southeast Asian languages.

(72) Correlation between vowel length and tonal contours in Southeast Asian languages

Lg's ↓	**Light syllables**		**Heavy syllables**	
	Segment	Tone	Segment	Tone
Sre	short vowels in checked σ	H	long vowels in checked σ	L, HL
Red Tai	short vowels in a checked σ	M	long vowels in checked σ	LM
Siamese	short vowels in a checked σ	H	long vowels in checked σ	HL
Hu	short vowels	H	long vowels	L
Chiang Rai	long non-low vowels become short	non-rising T	short non-low vowels become long	rising T

Phuket	long non-low vowels become short	falling T	all short vowels become long	non-falling T

2.6 Conclusion

Three findings emerge from our investigation of Fuzhou and Fuqing. First, there is a cooccurrence restriction on tonal categories and vowel distributions/alternations. This cooccurrence restriction is identified with the light-heavy distinction of syllable types. The tonal differences in the two types of syllables are primarily quantitative in Fuzhou, while Fuqing invokes the presence or absence of L. The segmental differences between the two types of syllables involve (i) differences in the number of segments; (ii) differences in feature content (i.e., the tense/lax and the high/mid distinction); (iii) harmonic restrictions on the tight syllables. Second, high vowels behave differently with respect to syllable position. They are active in alternating between monophthongs and diphthongs when they are the only vowel in a syllable, whereas they are inert when they occur with another non-high vowel within a syllable. Third, low vowels behave differently with respect to whether a coda consonant is present or absent. They alternate along the tense/lax dimension when they are followed by either a high vowel or a coda consonant. On the other hand, they raise to mid when they are followed by both a high vowel and a coda consonant. These two types of asymmetries, i.e., the asymmetrical behavior of high vowels with respect to syllable position and the asymmetrical behavior of low vowels with respect to presence/absence of coda, suggest that tone is not the only factor that affects vowel distributions and alternations. The prosodic structure plays an important role in triggering vowel distributions and alternations. Therefore, I conclude that the nature of tone-vowel interaction is indirect. That is, neither tone nor vowel affect each other directly. Their apparent interaction lies in the prosodic anchor that mediates between them. The phonetic correlation between intrinsic fundamental frequency and vowel height cannot furnish any explanation for these asymmetries. These new findings demand an explanation in phonological theory which will be built up in the rest of this dissertation.

CHAPTER 3

Correlation between Tonal Contour and Syllable Weight

3.0 Introduction

In chapter two, I identified two kinds of direct relations. One is the correlation between tonal contour and syllable weight. The other is the influence of syllable structure on vowel features. These new findings raise a number of questions. (i) Why is it possible for tonal contour to correlate with syllable weight? (ii) Why is it the syllable structure (but not tone) that affects vowel features directly? (iii) How are the relation between tonal contour and syllable weight, and the relation between syllable structure and vowel features regulated? The theory developed in this chapter aims to answer these questions. First, I propose a hypothesis which attributes the indirect nature of tone-vowel interaction to a representation in which tone and vowel are mediated by the mora. Second, I examine the dual nature of the mora (i.e. being both a weight unit and tone-bearing unit), and argue that the mora is the only valid prosodic anchor capable of capturing the relations identified in chapter 2. To regulate the linking between tones and TBUs, I make use of the notions "head mora" and "nonhead mora" which are defined in term of the nuclear mora vs. non-nuclear mora distinction first introduced by Shaw (1992, 1993), and explore their asymmetric behavior with respect to their capability of bearing tones. To account for the asymmetric behavior of L tone regarding its restriction to a non-nuclear mora in Fuqing, I propose the tonal sonority hierarchy, which distinguishes L tone from H tone based on their intrinsic sonority, and the harmonic alignment hierarchy, which encodes the tonal intrinsic sonority into syllable positions. Third, I propose a set of constraints, such as Head Binarity (which requires that a nuclear mora bears two tones), and Head

Prominence (which requires a nuclear mora to be filled by the most sonorous tone on the tonal sonority hierarchy). I then demonstrate how their interaction with the faithfulness constraints (previously known as the well-formedness conditions and "automatic association", Goldsmith 1976), can successfully govern tonal distributions, giving rise to the distinctive moraic structures for both Fuzhou and Fuqing. The typological variation between syllable structures and tonal distributions observed by Hyman (1988) can be captured in terms of different rankings of constraints.

Before I proceed to develop the theory, a number of assumptions must be made explicit. First, I assume the version of the prosodic hierarchy (Zec 1988, Hayes 1989, among others) in which the mora is the lowest constituent, shown as in (1):

(1) Prosodic hierarchy

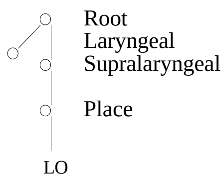
$$\begin{array}{c} \vdots \\ \text{Pw} \\ | \\ \text{Ft} \\ | \\ \sigma \\ | \\ \mu \end{array}$$

Pw = prosodic word
Ft = foot
σ = syllable
μ = mora

The prosodic constituents in (1) that are relevant in the present context are of three types. First, the mora serves as a prosodic anchor for both tonal and non-tonal features to link to. Second, the syllable functions as a morphological domain for association of lexically specified tones and as a prosodic constituent organizing segments (i.e. syllabification). Third, the foot and prosodic word are different domains for stress assignment, which has certain effects on tone-vowel interaction.

Second, I assume the representation of feature geometry (Clements 1985b, Sagey 1986, McCarthy 1988, Odden 1991, Halle and Stevens 1991, Halle 1995, etc.) in that segmental features are organized into classes, such as supra-laryngeal, laryngeal, etc., which in turn are dominated by a segmental root, as shown in (2):

(2) Feature geometry



In the representation above, the root node serves as an organizational device that groups segmental features together.

Third, I assume the tonal features [+upper] and [-raised][1] proposed first by Yip (1980) and later modified by Pulleyblank (1986). However, the use of these features in the present context is different from their use in Yip (1980) and Pulleyblank (1986). First, in Yip's system, both of these features are binary so that a total of four tonal features present in Yip's system (i.e. [+upper], [-upper], [+raised] and [-raised]). In contrast, I assume these features to be monovalent so that only a total of two tonal features is present in the tonal systems being discussed. Second, in Yip's system, there is a dominance relation between [+/-upper] and [+/-raised]. In particular, the feature [upper] divides the entire pitch range into two registers, which in turn are each divided into two by the feature [raised]. The relationship between these tonal features in Yip's system is represented in (3):

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[1] The tonal features originally proposed by Yip (1980) are [+/-upper] and [+/-high]. The feature [+/-high] later is renamed as [+/-raised] by Pulleyblank (1986) in order (i) to avoid confusion between a High tone (H), which could be [+upper, -high] and a Mid tone (M) which could be [-upper, +high], and (ii) to distinguish the tonal feature H from the segmental feature [high].

(3) Tonal features proposed by Yip (1980:45), modified by Pulleyblank (1986:125)

+ upper	+ raised	H
	- raised	HM
- upper	+ raised	M
	- raised	L

As shown in (3), the feature [upper] combined with the feature [raised] gives rise to four level tones. In this chapter, I follow A & P's (1994) combinatorial specification theory and assume that features (either tonal or segmental) are combined to represent tones or segments. The combination of the two features [+UPPER] and [-RAISED] (i.e. the non-default values of Pulleyblank (1986)), therefore, represents four level tones in (4):

(4) Tonal representations for four level tones

a. F-elements: [+UPR], [-RSD]

b.

M_1	H	L	M_2
	+UPR		+UPR
		-RSD	-RSD

(4a) gives two active F-elements [+UPR] and [-RSD]. (4b) shows that the combination of these F-elements gives rise to four level tones. For the languages investigated in this dissertation, three tone levels are sufficient[2]. That is, either M_1 or M_2 could be redundant.

[2] Although languages that have five contrastive level tones are not examined in this thesis, the tonal theory assumed here is capable of representing five level tones by invoking an additional feature, such as the feature [EXTREME] proposed by Maddieson (1971). Thus, combinations of the three features [+UPR] and [-RSD] plus [EXTREME] give rise to five level tones: H, L, M, Extra-H and Extra-L, as in (i).

As for contour tones, I assume that they are sequences of level tones (Woo 1969, Goldsmith 1976, Duanmu 1990, 1994, among others), resulting from interactions of constraints on the linking between tones and tone-bearing units (see detailed discussion later in this chapter). The contour tones are represented as in (5).

(5) Representations of contour tones

(i) Tone feature representations

a. F-elements: +UPPER, -RAISED, EXTREME

b.

M_1	H	L	*	EX-H	EX-L	M_2	*
	+UPR			+UPR		+UPR	+UPR
		-RSD			-RSD	-RSD	-RSD
			EXTR	EXTR	EXTR		EXTR

c. Feature parasitic condition

The presence of [EXTREME] depends on the presence of both [+UPR] and [-RSD].

The five tone representations proposed above differs from the three tone representations assumed in (4) in two regards. First, there is an addition of the feature [EXTREME] in (i), which reflects Maddieson's (1978) insight of "tone-space expansion" idea. That is, when tonal levels in a tone language increase, the entire tone space is expanded. Second, there is an additional condition (i.c). This condition expresses the parasitic relation between the feature [EXTREME] and the features [+UPR] or [-RSD]. That is, the presence of [EXTREME] depends on the presence of both [+UPR] and [-RSD]. The five level tones defined by the combination of these three F-elements can be represented as in (ii), where the M tone could be unspecified for any features as in (iic) (in which the circle stands for a tonal root node) or could be specified for both [+UPR] and [-RSD].

(ii) Representations of five level tones

a. H tone: +UPR
b. L tone: -RSD
c. M tone
e. Extra H: +UPR EXTREME
f. Extra L: -RSD EXTREME

a. HL sequence b. HM sequence c. MH sequence d. LH sequence

Notice that the representations of contour tones in (5) differ from those in Yip (1989) and Jiang-King (1994a, b, 1995a) in that a contour tone, as in Hyman and Pulleyblank (1988), involves two tonal roots in (5) but a single tonal root in Yip (1989) and Jiang-King (1994a, b, 1995a).

3.1 The prosodic anchor hypothesis

The prosodic anchor hypothesis proposed here attempts to answer the questions as to why and how tonal contours correlate with syllable weight, as well as why syllable structures have such a direct influence on vowel features. It is stated in (6):

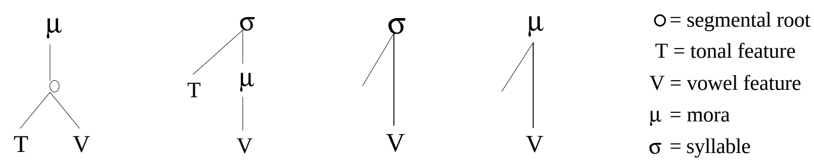
(6) Prosodic anchor hypothesis of tone-vowel interaction

a. Representational Requirement
Both Tonal Root and Vocalic (segmental) Root must directly link to the lowest prosodic anchor on the prosodic hierarchy, that is, the mora.

b. Constraint Satisfaction
Optimal linking between the prosodic anchor and tone or vowel is determined by a set of universal output constraints.

(6) imposes two conditions on tone-vowel interaction. The condition (6a) states that tone and vowel must be represented in a particular configuration in order for them to interact. That is, they must be associated to the same and the lowest prosodic constituent on the prosodic hierarchy: the mora. This amounts to saying that the mora has a direct relationship with tone and vowel independently. This direct relationship between the mora and tone or vowel is represented in (7d) but not in (7a), (7b) and (7c). Thus, (7d) is the only representation that satisfies the condition (6a).

(7) a. b. c. d.



In (7a) both the tone and the vowel link to the same node. However, this node is not a prosodic constituent, it is a segmental root. In this representation, the segmental root node mediates between the mora and tone or vowel, hence it does not satisfy the condition (6a). In (7b) both tone and vowel link to a prosodic anchor, but they each link to a different anchor: the tone links to the syllable node, and the vowel to the mora. Thus, (7b) does not satisfy the condition either. In (7c) both tone and vowel link to the same prosodic anchor, but the anchor is not the lowest constituent on the prosodic hierarchy. That is, the prosodic anchor they link to is the syllable but not the mora. Only (7d) satisfies the condition in (6a) since the prosodic anchor that both tone and vowel associate to is the mora, the lowest prosodic constituent in the prosodic hierarchy. Thus, it is the only representation in which tonal contours may correlate with syllable weight (i.e. the tight/loose distinction between syllable types and tonal groups), in which syllable structure may <u>directly</u> influence vowel features, and in which the <u>indirect</u> relation between tone and vowel may be captured.

The condition in (6b) states that the linking of tone or vowel features to the prosodic anchor must be regulated by well-formedness constraints. In other words, the two kinds of relations (i.e., the correlation between tonal contour and syllable weight and the relation between the syllable structure and vowel features) are subject to certain regulations. The basic constraints governing tonal distributions are those previously known as the well-formedness conditions (WFC) proposed in autosegmental phonology (Goldsmith 1976), re-introduced here in (8) for convenience.

(8) The well-formedness conditions (WFC) (Goldsmith 1976)

a. Each tone must be associated with at least one TBU. (Parse)
b. Each TBU must be associated with at least one tone. (Fill)
c. No association lines may cross. (Linearity)

In the framework of Optimality Theory, the condition in (8a) can be reinterpreted as a PARSE constraint which requires every tone to be parsed onto a prosodic anchor. The condition (8b) can be reinterpreted as a FILL constraint which requires all prosodic anchors to be filled by a tone. The condition (8c) can be captured by LINEARITY (9c) (A & P 1994, McCarthy 1995, M & P 1995), which prevents association lines from crossing. In other words, the functions of WFC can be incorporated into Optimality Theory as a set of faithfulness constraints[3] (M & P 1993a, b, 1994, 1995, P & S 1993, Pulleyblank 1994,

[3] The faithfulness family of constraints have been incorporated into correspondence theory (McCarthy 1995, M & P 1995). The constraints PARSE and FILL are replaced by MAX and DEP, respectively, in correspondence theory. However, the two sets of terminology are not quite identical as far as the treatment of floating tones is concerned. For example, a floating tone satisfies MAX, but not PARSE when it is present in an output, since it is not considered to be associated to any prosodic anchor. Since the effect of floating

McCarthy 1995, among others). In addition, the one-to-one association between tones and TBUs proposed in autosegmental phonology (Clements and Ford 1979, A & P 1994) can be interpreted as a faithfulness constraint UNIFORMITY (McCarthy 1995, M & P, 1995). To prevent the insertion of tones that are not lexically specified for a morpheme, another faithfulness constraint LEXTONE, which is an extension of the LEX-α (Pulleyblank 1994, Pulleyblank & Turkel 1995, Pulleyblank et al. 1995) must be introduced. The basic faithfulness constraints governing tonal distributions are listed in (9), and their effects on tonal distributions are represented in (10) below:

(9) Faithfulness constraints on tonal distributions

a. PARSETONE: A tone must be incorporated into a prosodic structure.
b. FILL-μ: A mora must be filled by a tone.
c. LINEARITY: $String_1$ reflects the precedence structure of $String_2$, and vice versa.
d. UNIFORMITY: No element of $String_2$ has multiple correspondents in $String_1$.
e. LEXTONE: A tone that is present in an output must be present in an input.

The constraint PARSETONE (9a) rules out the representation in (10a), in which the tones are not parsed onto the prosodic anchors (i.e. moras). The FILL constraint (9b) rules out the representation in (10b), since one of the two moras is not filled by a tone. (10c) violates the constraint LINEARITY (9c) because two association lines cross each other. (10d) and (10e) violate the constraint UNIFORMITY since there is a multiple linking between tones or TBUs in each case: two tones link to a single mora in (10d) and two moras are linked

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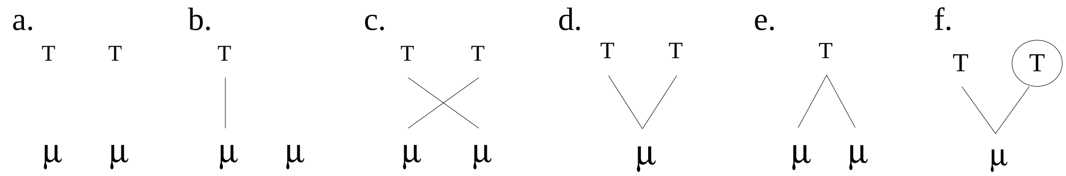
tones are not of concern in this thesis, I leave the question of how the floating tones should be treated in an OT framework open for further research.

by a single tone in (10e)[4]. (10f) violates (9e) since the circled tone is not specified in an input.

(10) The effects of faithfulness on tonal associations



One may assume that the constraints governing the linking of tones to the mora may differ from the ones governing the linking of vowels to the mora, since tone and vowel are represented on different planes. What this implies is that these two kinds of linking are independent of each other. Tones and vowels do not interact directly. They are related to each other only when the prosodic anchor that bridges them is affected. This implication will be borne out once the stress effect on tone-vowel interaction is examined (I will discuss this issue in detail in Chapter 5).

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[4] Both (10d) and (10e) may be surface-true in some languages due to higher ranked constraints, such as PARSETN or FILL$^{\mu}$. In particular, ranking PARSETN above UNIFORMITY would give the representation in (10d), where tones must be parsed onto a mora even though the number of tones exceeds the number of moras, whereas ranking FILL$^{\mu}$ above UNIFORMITY would give the representation in (10e), where all moras must be filled by a tone even though the number of moras exceeds the number of tones.

3.2 Mora: the prosodic anchor for tone-vowel interaction

The prosodic anchor hypothesis in (6) requires that both tone and vowel link directly to the mora. This allows them to interact through the mora. The question that arises is why the mora is the only eligible candidate rather than other prosodic constituents like the syllable, since both the mora and the syllable have been argued (either separately or together) to be possible tone-bearing units in the phonological literature (Hyman 1985, 1988, Hyman and Pulleyblank 1988, A & P 1989, Pulleyblank 1986, Peng 1992, among others)[5]. To test this hypothesis, I examine various possible representations and see how the correlation between tonal contour and syllable weight found in both Fuzhou and Fuqing can be captured.

Three functions of mora have been proposed in the literature (Hyman 1985, Zec 1988, Hayes 1989, among others). First, it serves as a measurement for the number of segments. For example, Hyman (1985) assumes that every segment inherently comes with a weight unit (a mora or an x slot). The weight unit associated with an onset or a coda consonant will be removed by an "onset creation rule" and a "margin creation rule" respectively. Second, mora serves as a core to which segments and autosegments link (Hyman 1985). Third, it serves as a base for syllable structure to build upon (i.e. a sub-syllabic constituent, the lowest prosodic constituent on the prosodic hierarchy) (Zec 1988, Hayes 1989, among others). What is relevant for our purpose here is that the mora serves as a prosodic anchor for both tone and vowel to link to. This requirement, stated in the prosodic hypothesis (6a), is rooted in Hyman's (1985) theory of phonological weight. Hyman takes the strong position of assuming that there is an identity relation between the units that contribute syllable weight (i.e. WUs) and those that bear tones (i.e. TBUs). To

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[5] The condition (6a) does not exclude the possibility that the syllable is a TBU. What this condition really means is that the mora is the sole prosodic anchor for the phenomenon of tone-vowel interaction.

capture this non-arbitrary relation between WUs and TBUs, he proposes a weight tier which consists solely of weight units (i.e., moras or x's). To support Hyman's assumption that WUs are identical to TBUs, one needs to find evidence exhibiting a correlation between tones and syllable weight. Hyman (1985), however, does not provide such evidence. In this chapter, I furnish evidence to show that such a correlation between tonal contours and syllable weight indeed exists in Northern *Min* languages (i.e. Fuzhou and Fuqing), as well as in various Southeast Asian languages, such as in Sre, a Mon-Khmer language (Manley 1972), Hu, another Mon-Khmer language (Svantesson 1989), Thai dialects (Gandour 1977), Siamese and Red Tai (Gedney 1965, 1989). The seven tones in Fuzhou and Fuqing, for instance, are divided into two groups: one group of tones occurs only in light syllables and the other group of tones in heavy syllables, as shown in (11):

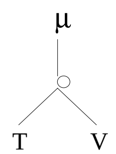
(11) Tones in Fuzhou and Fuqing

	I. Tones in light syllables				**II. Tones in heavy syllables**		
	ÒõÆ½ *Yin Ping*	ÑôÆ½ *Yang Ping*	ÑôÈë *Yang Ru*	ÉÏÉù *Shang*	ÑôÈ¥ *Yang Qu*	ÒõÈ¥ *Yin Qu*	ÒõÈë *Yin Ru*
Fuzhou	44 H	53 HM	5/ H	31 ML	242 MHM	213 MLM	23/ MLM
Fuqing	53 HM	44 H	5/ H	33 M	41 HL	21 ML	22/ ML

To see how these cooccurrence restrictions on tonal contour and syllable weight can be explained by the prosodic anchor hypothesis I examine the representation requirement in (6a) and discuss its consequences in tone-vowel interaction in the two Northern *Min* languages.

First, let's assume that both tone and vowel link to a segmental root node as in (7a), re-introduced here as (12) for convenience:

(12) Segmental root as TBU



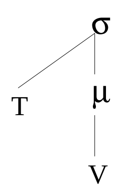
In the representation above, tone and vowel are dominated by the same segmental root node. This implies that every vocalic segment is a potential tone-bearing unit no matter which syllable position it occupies. If this were true, we would expect a high vowel to behave identically with respect to the same tonal environment, no matter whether it appeared as a nucleus of a syllable or as a glide preceding or following a nuclear vowel. This prediction, however, is not borne out. As illustrated in (13), a high vowel behaves differently with respect to its relative syllable positions. It surfaces as a monophthongal high vowel in a tight syllable (which has been identified as a light syllable) and as a diphthong containing that high vowel in a loose syllable (which has been identified as a heavy syllable) (see chapter 2 section 5 for detailed arguments).

(13)		**I** "tight"	<u>Gloss</u>		**II** "loose"	<u>Gloss</u>	<u>Distribution</u>
	a.	τσι^{ML}	'only'	b.	τσεi^{MLM}	'will'	i ~ εi
	c.	τσιεN^{H}	'stick'	d.	τσιEN^{MLM}	'fight'	

In (13a), the high vowel [i] is a nucleus in a syllable with a ML tonal contour. It appears as part of a diphthong in the corresponding loose syllable with a complex tonal contour MLM in (13b). However, the high vowel [i] in (13c-d) does not behave in this manner. Instead, the vocalic difference takes place between a tense mid vowel [ε] and its lax counterpart [E]. What makes the high vowel behave differently in (13a-b) and in (13c-d) is its different syllabic position. In particular, the high vowels are part of the nucleus in (13a-b), whereas they are pre-nuclear glides in (13c-d). If the segmental root were to dominate both tone and vowel features, the asymmetric behavior of the high vowel [ɩ] between the pair of (13a-b) and the pair of (13c-d) is left unexplained. Therefore, tone and vowel cannot be dominated by the same segmental root in the kind of tone-vowel interactions found in Fuzhou and Fuqing, and (12) is not a valid representation for tone and vowel to interact in these languages.

Second, let's examine the representation in (7b), repeated as (14) for convenience. In (14), tone and vowel link to different prosodic anchors: the syllable is the anchor for tone, while the mora serves this function for vowel features.

(14) Mora and syllable serve as different anchors



In this representation, syllable weight should not have any effect on tonal contour since tone links to the syllable node, and syllable weight is represented by the number of moras. Under this representation, any type of syllable (either light or heavy) should occur with any kind of tone (level, simple contour or complex contour). In Northern *Min* languages, however, this is not the case. We see from the data in (11) that the light syllables only have a level or a simple contour tone in both Fuzhou and Fuqing, whereas the heavy syllables only have complex contour tones in Fuzhou and the tones containing a L part in Fuqing. This kind of cooccurrence restriction between tonal contours and syllable types cannot be explained under the representation in (14). Therefore, (14) should be excluded as a possible representation in which tone and vowel interact in the languages investigated.

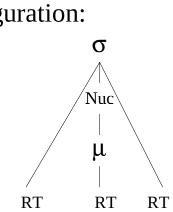
Third, I examine the representation in (7c) where both tone and vowel link to the syllable node, shown as in (15) below for convenience.

(15) Syllable as an anchor for both tone and vowel

$$\begin{array}{c} T \\ | \\ \sigma \\ | \\ V \end{array}$$

Although the syllable is assumed to be a possible tone-bearing unit by some phonologists (Yip 1980, 1989, Hyman 1988, Peng 1992, among others), it is not a possible prosodic anchor for vocalic segments[6]. Treating the syllable as an anchor for vocalic segments amounts to saying that there is no subsyllabic constituent within a syllable as far as features are concerned. Phonologists generally agree that syllables must have some sort of internal structure. One view is that a syllable contains one or more

[6] Doug Pulleyblank (p.c.) points out that the syllable node could be a valid anchor for onsets and non-moraic codas in the following configuration:



The interesting point relevant to the present context is that the leftmost and the rightmost segmental roots in the configuration above could be vocalic segments, such as glides. However, as far as tone-vowel interaction in <u>Fuzhou</u> and <u>Fuqing</u> is concerned, the pre- or post-nucleus high vowels do not show any tonal effect (see chapter 2 and later in this chapter for detailed observations).

moras as its subsyllabic constituents (Hyman 1985, 1988, Zec 1988, among others). Another view is that a syllable has onset, nucleus, and coda as its subsyllabic constituents (Pike & Pike 1947, David 1988). A third view is that a syllable contains onset and rime, which in turn contains nucleus and coda (Levin 1985, Steriade 1988, Bao 1990, among others). To explain the correlation between tonal contours and syllable weight observed in Fuzhou and Fuqing under the representation in (15), one has to stipulate that a level or a simple contour tone can only occur with a syllable having a certain number of vocalic segments. However, even this is not correct, since syllable weight does not necessarily correspond to the number of segments (Hyman 1985). As shown in (13), both the tight and the loose syllables could contain from one to three vocalic segments. If we look at the segmental root alone, there is no way we can distinguish the tight syllables from the loose ones. Also, it cannot explain why the level or simple contour tones occur in light syllables and the complex contour tones in the heavy syllables in Fuzhou. Now, the only choice left is (7d), re-introduced here as (16), in which both tone and vowel link to the mora, the lowest prosodic anchor on the hierarchy.

(16) Mora as the anchor for both tone and vowel

$$\begin{array}{c} \text{T} \\ | \\ \mu \\ | \\ \text{V} \end{array}$$

In this representation, the mora serves as a core for both segment and tone. Since syllable weight is represented by the number of moras, and moras are also tone-bearing units, it is possible in this representation for tonal contours to correlate with syllable weight. This claim is plausible for Fuzhou. Recall that high vowels alternate in the fashion of single segments versus diphthongs only when they occur in nuclear position, as in (17a ~ b). If they are in non-nuclear position, they do not alternate, as in (17c ~ d), where the high vowel is an on-glide, not a nucleus.

(17)		**I** "tight"	Gloss		**II** "loose"	Gloss	Distribution
	a.	tsi^{ML}	'only'	b.	tsɛi^{MLM}	'will'	i ~ ɛi
	c.	tsieN^{H}	'stick'	d.	tsiEN^{MLM}	'fight'	

Since the light-heavy distinction is represented by the number of weight units (i.e. one mora in light syllables and two moras in heavy ones), the occurrence of the simple contour tones in the light syllables and the complex contour tones in the heavy ones is expected, given that the weight unit is identical to the tone-bearing unit. Thus, the seven tones in Fuzhou can be represented as in (18) below[7]. I treat /53/ and /5/[8] as having the same underlying tone HM, because they behave identically with respect to the tone sandhi effect. For the same reason, I treat /213/ and /23/ as a single underlying tone MLM. Thus, the 7 citation tones in Fuzhou are reduced to 5 underlying tones.

(18) Fuzhou tones and syllable weight

[7] Ignore for the moment whether both of the moras in the loose syllables have the same capacity to bear tones.

[8] The tones /5/ and /23/ are called checked tones. They occur only in syllables with a glottal stop coda. No discussion of the checked syllables is planned for this thesis.

a. Tones in the "tight" syllables

a. Tones in the "tight" syllables			b. Tones in the "loose" syllables	
T1: /44/	T2: /53/, /5/	T3: /31/	T4: /213/, /23/	T5: /242/
$[\mu]_\sigma$ H	$[\mu]_\sigma$ H M	$[\mu]_\sigma$ M L	$[\mu \quad \mu]_\sigma$ M L M	$[\mu \quad \mu]_\sigma$ M H M

(18) captures the cooccurrence restrictions that hold between two groups of tones and two types of syllables structurally. All tones in the tight syllables link to one mora, even though they differ in pitch level (i.e. H level in Tone 1, HM in Tone 2 and ML in Tone 3), whereas the tones in the loose syllables link to two moras, even though their shapes are divergent (i.e. concave MLM vs. convex MHM). Assuming for the moment that one prosodic anchor can bear a maximum of two tones, the quantitative distinction for the two groups of tones in <u>Fuzhou</u> will give rise to distinct moraic structures for the two types of syllables in (19):

(19) Distinctive syllable weight in <u>Fuzhou</u>

a. light syllables

$[\mu]_\sigma$

T (T)

b. heavy syllables

$[\mu \quad \mu]_\sigma$

T T T

(19) suggests that the distinctive moraic structures in <u>Fuzhou</u> are determined by the tonal specifications for each morpheme. That is, the specification of a H level or a simple falling tone (either HM or ML) gives rise to a monomoraic structure for the tight syllables, while the specification of a concave tone MLM or a convex tone MHM results

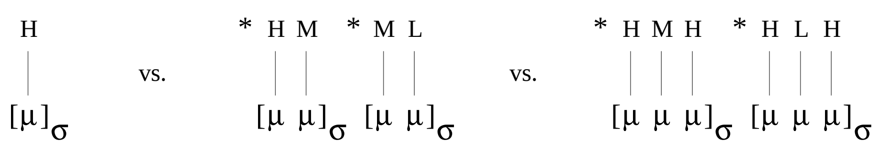
in a bimoraic structure for the loose ones. I will demonstrate in chapters 4 and 5 that it is the different moraic structures that directly trigger the vowel distributions and alternations.

3.3 Head mora vs. nonhead mora

In last section, I argued that the correlation between tonal contour and syllable weight in the Northern *Min* languages can be best explained if the mora is treated as a prosodic anchor for both tone and vowel. This kind of tone-vowel interaction in these languages thus furnishes empirical support for Hyman's hypothesis that the mora is an entity for both weight and tone. This argument raises two questions. First, why don't the complex contour tones (i.e. concave and convex tones) in Fuzhou give rise to three moras in the loose syllables, given the one-to-one association convention between tones and TBUs? In other words, why is the correlation between tone and syllable weight in Fuzhou a two-way contrast but not a three-way contrast as in (20)?

(20) Hypothesized three-way contrast of syllable weight in Fuzhou

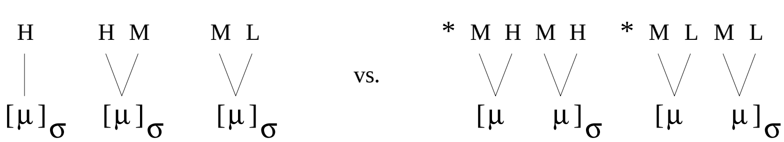
a. monomoraic b. bimoraic c. trimoraic



Second, why are there no extra-complex tonal contours (such as HMHM or LMLM, as shown in (21b)) in Fuzhou (maybe in any language in general), assuming for the moment that a violation of the one-to-one association convention is allowed?

(21) Hypothesized tonal contours in Fuzhou

a. monomoraic syllables b. bimoraic syllables

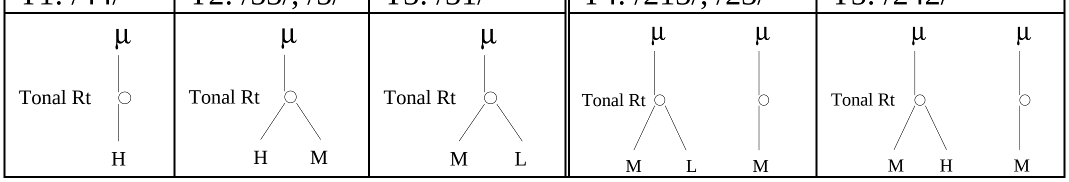


There are two possibilities to rule out the unattested three-way distinctive syllable weight in (20). One possibility is to treat a simple contour tone (i.e. HM, ML) in <u>Fuzhou</u> as involving a single tonal roots and the complex contour tones (i.e. MLM and MHM) as involving two tonal roots, as shown in (22) proposed by Jiang-King (1994a, b, 1995).

(22) <u>Fuzhou</u> correlation between tones and moraic structures (Jiang-King 1994a, b, 1995a)

a. Tones in the "tight" syllabl es

a. Tones in the "tight" syllables			b. Tones in the "loose" syllables	
T1: /44/	T2: /53/, /5/	T3: /31/	T4: /213/, /23/	T5: /242/



However, treating a complex contour tone as involving two tonal roots as in (22b) without distinguishing their two TBUs cannot explain why the extra-complex tonal contours in (21b) are unattested in <u>Fuzhou</u>, or more generally, in any natural language. The other possibility is to impose restrictions on linking between tones and TBUs. That is, regulations are imposed on the relation between tones and moras. This is the approach taken by Hyman (1988). Hyman proposes that there are three possibilities for representing tonal association to moras in a tritonal syllable, as in (23a-c) and (24a-c). Hyman uses

[a]'s as an abbreviation for moras in order to show that these TBUs belong to the same syllable.

(23)

	a.	b.	c.
	[π α∃ α!]$_{\sigma}$	*[π α! α#]$_{\sigma}$	*[π α∃ α#]$_{\sigma}$
	H L H	H L H	H L H

(24) a. [π α∃ α~]$_\sigma$ b. *[π α~ α∃]$_\sigma$ c. *[π α# α∃]$_\sigma$

L H L L H L L H L

However, not all three representations in (23a-c) and (24a-c) are well-formed. Hyman assumes that only (23a) and (24a) are well-formed and (23b-c) and (24b-c) are ill-formed. To capture the difference between the (a)'s and the (b-c)'s in (23) and (24), Hyman (1988) proposes that linking of two tones to an intrasyllabic TBU is permitted only to the first (= head?) mora of a syllable. The insight of Hyman's proposal is that it distinguishes two types of moras: head and nonhead with respect to their tone-bearing behavior. In particular, only head moras are allowed to bear two tones. Hyman also admits certain situations where either the number of tones or the number of TBUs exceeds the other. In such cases, a nonhead mora may bear two tones. What is relevant to the present context is the distinction between a head mora and a nonhead mora. I will pursue Hyman's approach, namely, the approach in which restrictions are imposed on the linking between tones and TBUs, and propose a set of constraints governing the relation between tones and moras in the light of the nuclear/non-nuclear distinction of moras (Shaw 1992a, b, 1993, 1996).

The theory of the nuclear moraic model proposed by Shaw (1992a, b, 1993, 1995) distinguishes two types of moras: nuclear moras and non-nuclear moras. These two types of mora differ in their behavior in templatic reduplications. In certain languages, only nuclear moras but not non-nuclear moras are referred to in reduplication templates. Since moras are argued to be the TBUs in the tone-vowel interactions in Fuzhou and Fuqing, it is natural to ask whether nuclear moras behave differently from non-nuclear moras regarding their tone-bearing capability. The following proposal suggests that tone-bearing moras differ with respect to whether or not they are a syllable head. In particular, a nonhead mora is more restricted than a head mora in what kind of tone and how many tones it may bear. Two possibilities regarding how to define a head mora suggest themselves. One is to define a head mora in terms of "direction". That is, a syllable head can be designated to either the left or the right mora in that syllable. The other possibility is to define a syllable head in terms of "representation". Namely, the mora dominated by the nuclear node is the syllable head, whereas the one not dominated by the nuclear node is nonhead. Since Fuzhou and Fuqing data do not suggest the need of the two sets of notions (i.e., the nuclear vs. non-nuclear and the head vs. nonhead), thus the distinction of head mora vs. nonhead moras can be defined in terms of nuclear vs. non-nuclear mora.

3.3.1 Head Binarity: Fuzhou tonal distributions and prosodic structures

Fuzhou exhibits a cooccurrence restriction on tonal contours and syllable types. In particular, one group of tones (H, HM, and ML) occurs only in the tight syllables, while another group of tones (i.e. MLM or MHM) only with the loose syllables. The tight-loose distinction is identified as the light-heavy distinction in chapter two. The seven contrastive tones in Fuzhou and the syllable types they occur with are given in (25) below:

(25) Fuzhou cooccurrence between tones and syllable types (data are from Liang 1982)

I. Tones in light syllables				**II. Tones in heavy syllables**		
ÒõÆ½ *Yin Ping*	ÑôÆ½ *Yang Ping*	ÑôÈë *Yang Ru*	ÉÏÉù *Shang*	ÑôÈ¥ *Yang Qu*	ÒõÈ¥ *Yin Qu*	ÒõÈë *Yin Ru*
44 H	53 HM	5/ H	31 ML	242 MHM	213 MLM	23/ MLM
τσαN^{H} 'hairpin'	τσαN^{HM} 'incomplete'	τσα/^{H} 'mixed'	τσαN^{ML} 'chop; cut'	τσAN^{MHM} 'stand'	τσAN^{MLM} 'raise'	τσA/^{M} 'tight; bind'

(25) clearly shows a restriction on the cooccurrence between groups of tones and types of syllables. The tones in the light syllables are simpler than the ones in the heavy syllables. To capture this quantitative distinction of tones in the two types of syllables, I propose a constraint that requires a head mora in a syllable to bear two tones.

(26) Head Binarity (HDBIN)

A mora must bear two tones *x* and *y*, iff it is a syllable head (i.e. a nuclear mora).

(26) is a constraint on the relation between tones and moras. It demands that the head mora within a syllable bear two tones. Non-head moras do not have this capability. Consequently, the unattested complex tonal contours (HLHL or LHLH) are excluded. The tableaux in (27) and (28) demonstrate how the interaction of HDBIN with faithfulness in (9) gives rise to the 'tight-loose' distinction of syllable weight (i.e. $[[\mu]]_\sigma$ vs. $[[\mu]\mu]_\sigma$) in Fuzhou. The square brackets without a subscribed "σ" symbol in the output candidates indicate head moras. Shading indicates that constraints are not crucial in determining an optimal output.

The tableau in (27) contains three different tonal specifications in the tight syllables. The input in (27i) is a high level tone (H). Each of the three output candidates violates a constraint. (27i-a) violates HDBIN, (27i-b) violates LEXTN, and (27i-c) violates the PARSETN. Since PARSETN and LEXTN rank above HDBIN and UNIFORMITY, (27i-a) is the optimal output for a H-toned syllable.

The cases in (27ii) and (27iii) are similar in that the input forms are all falling tones. The difference between them is that the former is a high falling tone HM while the latter is a low falling contour ML. There are four output candidates in each of the two cases. Compare the (a)'s and the (b)'s in (27ii) and (27iii): the former violate UNIFORMITY once (i.e. the moras in (27ii-a) and (27iii-a) bear two tones), while the latter violate the same constraint twice (i.e. the head moras in both (27ii-b) and (27iii-b) bear two tones on the one hand and the second tone in each case links to two moras). In Optimality Theory, if competing candidates violate the same constraint, the one incurring fewer violations wins. Therefore, the (a)'s in (27ii) and (27iii) are better than the (b)'s. Now let's compare the (c)'s and the (d)'s in (27ii) and (27iii). The (c)'s in these cases violate HdBin since the head mora in each case bears only one tone, while the (d)'s all violate ParseTn because one tone in each of these cases fails to be parsed onto the prosodic anchor. Since ParseTn and LexTn dominate HdBin, which in turn dominates Uniformity, the ranking ParseTn, LexTn >> HdBin >> Uniformity determines (a)'s over (b)'s, (c)'s and (d)'s for (27ii) and (27iii).

(27) <u>Fuzhou</u> tone distributions in the "tight" syllables

Input	Outputs	ParseTn	LexTn	HdBin	Uniformity
(i) /44/ H	a. ☞ H [μ]			*	
	b. H L [μ]		*!		*
	c. H [μ]	*!		*	
(ii) /53/ HM	a. ☞ H M [μ]				*
	b. H M [μ] μ				* !*
	c. H M [μ] μ			*!	
	d. H M [μ]	*!		*	
(iii) /31/ ML	a. ☞ M L [μ]				*
	b. M L [μ] μ				* !*
	c. M L [μ] μ			*!	

	d. M L / [μ]	*!		*	

Notice that this ranking ensures that all optimal outputs in (27) have a single mora, hence, the light syllable. Now let's turn to the tones in the loose syllables in (28).

(28) <u>Fuzhou</u> tone distributions in the "loose" syllables

Input	Outputs	ParseTn	LexTn	HdBin	Uniformity
(i) /213 / MLM	a. ☞ M L M / [μ] μ				*
	b. M L M / [μ] μ			*	*
	c. M L M / [μ] μ μ			*	
	d. M L M / [μ]			*	* *
	e. M L M / [μ] μ			*	* * !*
	f. M L M L / [μ] μ		*!	*	* *
	g. M L M / [μ] μ	*!		*	
(ii) /242/ MHM	a. ☞ M H M / [μ] μ				*
	b. M H M / [μ] μ			*	*
	c. M H M / [μ] μ μ			*	
	d. M H M / [μ]			*	* *
	e. M H M / [μ] μ			*	* * !*
	f. M H M H / [μ] μ		*!	*	* *

	g. M H M / [μ] μ	*!		*	

The two cases in (28) are of the same type: they both involve three tones in their lexical specifications. The difference between them is the tonal shape. In particular, the tonal contour in (28i) is a concave tone (MLM) while the one in (28ii) is a convex one (MHM). Again, both (a) candidates in these cases violate Uniformity, both (b), (c), (d) and (e) violate HdBin, both (f) violate LexTn, and all (g) violate ParseTn. Since Uniformity ranks below HdBin which in turn is below LexTn and ParseTn, the (a) are the best outputs for each case.

Notice that the ranking that chooses (a) over the rest in (28) is identical to the ranking in (27). However, the syllable structures in (27) and (28) are different. The former is monomoraic since the tones are lexically specified as simple contours, while the latter is bimoraic since their tones are complex contour tones[9]. The constraint Head Binarity and its interaction with the faithfulness constraints (i.e., ParseTn, LexTn and Uniformity) plays a crucial role in deriving the distinctive moraic structures, giving rise to contrastive syllable weight. Fuzhou tonal distribution, governed by the constraint interaction (i.e. the ranking ParseTn, LexTn >> HdBin >> Uniformity), determines the syllable weight in this language.

[9] A question raised by Doug Pulleyblank (p.c.) is how to ensure the tonal composition of attested Fuzhou melodies, or in general, how to constrain the basic composition of various attested tonal sequences in different languages. A tentative answer is to impose constraints on tonal combinations, such as *[+upper]/[-raised], which would rule out a HL sequence or a LH sequence, resulting in a HM or a MH sequence with L being underparsed. Even though the details need to be worked out, the general approach seems promising (see the Fuqing case in this chapter).

3.3.2 Head prominence: Fuqing tonal distributions and prosodic structures

Another case of correlation between tonal contour and syllable weight is Fuqing. The tonal system in Fuqing differs from that in Fuzhou in that the tones in the loose syllable are not complex contour tones. Instead, the tonal distinction between the tight and the loose syllables involves a quality difference, namely, the L tone. Fuqing tonal distributions with respect to the syllable weight are exemplified in (29) below.

(29) Fuqing Tones

I. Tones in light syllables				**II. Tones in heavy syllables**		
ÒõÆ½ *Yin Ping*	ÑôÆ½ *Yang Ping*	ÑôÈë *Yang Ru*	ÉÏÉù *Shang*	ÑôÈ¥ *Yang Qu*	ÒõÈ¥ *Yin Qu*	ÒõÈë *Yin Ru*
53 HM	44 H	5/ H	33 M	41 HL	21 ML	22/ ML
$\sigma\iota N^{HM}$ ÐÄ 'hart'	$\sigma\iota N^{H}$ Éñ 'spirit'	$\sigma\iota N^{H}$ Êµ 'solid'	$\sigma\iota N^{M}$ Éô 'ante'	$\sigma\varepsilon N^{HL}$ Éö 'kidney'	$\sigma\varepsilon N^{ML}$ ÐÅ 'letter'	$\sigma\varepsilon N^{ML}$ ÊÒ 'room'

(29) shows that tones in the tight syllables are either level (H or M) or high falling (HM), whereas the ones in the heavy syllables are either low falling (ML) or high falling (HL). Crucially, the tones in the light syllables do not have L, whereas the ones in the heavy syllables all contain a L. The questions, then, are why L tones occur only in the heavy syllables and why there is no L level tone? What is the difference between L tone and non-L tones? To answer these questions, I argue that the difference between L tones and non-L tones lies in the intrinsic sonority of pitch.

As with segments, tones have their intrinsic sonority. High tone has higher pitch (i.e. higher fundamental frequency) than low tones. Parallel to the segmental sonority hierarchy, this intrinsic difference of pitch can be stated as a tonal sonority hierarchy in

(30), assuming that tones are represented by the features [+UPPER] and [-RAISED], as well as their combinations.

(30) Tonal Sonority Hierarchy

|+*Upper*| > |-*Raised*|

If tones differ in their intrinsic sonority, this property of tones must manifest itself in tonal phonology. One possibility for tones to behave differently with respect to their sonority difference is that the higher a tone is on the sonority hierarchy, the more prominent it is. This assumption can be stated in terms of the tonal harmonic alignment in (31), in light of the segmental harmonic hierarchy proposed by P & S (1993).

(31) Tonal Harmonic Hierarchy

Nuc$^{\mu}$/[+Upper] > Nuc$^{\mu}$/[-Raised]

What (31) says is that linking a H tone to a nuclear mora is more harmonic than linking a L tone to a nuclear mora. This harmonic alignment effect of tones can be encoded into a constraint ranking (32) similar to that on segmental alignment in P & S (1993).

(32) Tonal Alignment Hierarchy

*Nuc$^{\mu}$/[-Rsd] >> *Nuc$^{\mu}$/[+Upr]

The ranking schema in (32) means that linking a L tone to a nuclear mora within a syllable is less optimal than linking a H tone to a nuclear mora. To see how these tonal sonority alignment constraints interact with the faithfulness constraints ParseTn, LexTn and Uniformity, giving the syllable weight distinction in <u>Fuqing</u>, look at the tableaux (33) and (34) below. The features [+Upr] and [-Rsd] represent H tone and L tone respectively.

The input in (33i) is a falling contour (HM). The output set contains four candidates. The violations of ParseTn (33i-c), *Nuc$^{\mu}$/[-Rsd] and LexTn (33i-d) are fatal, since these are the most highly ranked constraints in this set. Compare the first two candidates (33i-a) and (33i-b): the former violates UNIFORMITY while the latter violates HDBIN. Since HDBIN ranks above the UNIFORMITY, (33i-a) wins. The particular ranking that chooses (33i-a) over (33i-b) is HDBIN >> UNIFORMITY.

(33) <u>Fuqing</u> tone distributions in light syllables

Input	Outputs	*NUC$^{\mu}$/[-RSD]	PARSETN	LEXTN	HDBIN	UNIFORMITY
(i) /53/ HM	a. ☞ H M [μ]					*
	b. H M [μ] μ				*	
	c. H M [μ]		*!			
	d. H L M [μ] μ	*!		*!		*
(ii) /44/ H	a. ☞ H [μ]				*	
	b. H M [μ]			*!		*
	c. H [μ]		*!		*	
	d. H L [μ]	*!		*!		*
(iii) /33/ M	a. ☞ M [μ]				*	
	b. M H [μ]			*!		*
	c. M [μ]		*!		*	
	d. M L [μ]	*!		*!		*

The cases in both (33ii) and (33iii) differ from that in (33i) in that the lexically specified tones are level tones but not a HM falling contour. The difference between

(33ii) and (33iii) is that (33ii) contains a H level, while (33iii) contains a M level. The (a) in (33ii) and (33iii) is more optimal than the (b), (c) and (d), since it satisfies the highly ranked constraints *Nucμ/[-Rsd], ParseTn and LexTn, even though it violates HdBin, the lowly ranked constraint. The crucial ranking established in (33) is *Nucμ/[-Rsd], ParseTn, LexTn >> HdBin >> Uniformity.

(34) differs from (33) in that all inputs in (34) contain a L tone and the constraint *Nucμ/[-Rsd] plays an important role in choosing an optimal candidate. Parsing a L tone to the nuclear mora in the (d) of (34i) and (34ii) results in violation of *Nucμ/[-Rsd]. The (b) and (c) violate LexTn and ParseTn respectively. The only candidate left is the (a). It satisfies all *Nucμ/[-Rsd], LexTn and ParseTn, even though it violates HdBin.

(34) Fuqing tone distributions in the "loose" syllables

Input	Outputs	*Nucμ/[-Rsd]	ParseTn	LexTn	HdBin	Uniformity
(i) /41/ HL	a. ☞ H L [μ] μ				*	
	b. H M L [μ] μ			*!		*
	c. H L [μ]		*!		*	
	d. H L [μ]	*!				*
(i) /21/ ML	a. ☞ M L [μ] μ				*	
	b. M H L [μ] μ			*!		*
	c. M L [μ]		*!		*	
	d. M L [μ]	*!				*

(34) shows that ranking *Nuc$^{\mu}$/[-Rsd], ParseTn and LexTn above HdBin is crucial in deriving the bimoraic structures for the loose syllables in Fuqing. The entire ranking for Fuqing is *Nuc$^{\mu}$/[-Rsd], ParseTn, LexTn >> HdBin >> Uniformity. This constraint interaction gives rise to the tight/loose distinction of the syllable weight in Fuqing (35):

(35) Fuqing tones and syllable weight

a. Tones in the "tight" syllables

a. Tones in the "tight" syllables			b. Tones in the "loose" syllables	
T1: /53/ [μ]$_\sigma$ H M	T2: /44/, /5/ [μ]$_\sigma$ H	T3: /33/ [μ]$_\sigma$ M	T4: /21/, /22/ [μ μ]$_\sigma$ M L	T5: /41/ [μ μ]$_\sigma$ H L

3.3.3 A summary

I have shown that moras behave differently with respect to how many tones they can bear and what kind of tones they can bear. These differences can be captured by the nuclear moraic model proposed by Shaw (1992, 1993). First, nuclear (head) moras can bear two tones while non-nuclear moras only bear one tone, as shown in the Fuzhou case. Second, nuclear (head) moras are restricted not to bear L tone, while non-nuclear moras do not have this restriction, as shown in the Fuqing case. By defining the nuclear mora as a syllable head, I propose a set of constraints (i.e. HdBin and *Nuc$^{\mu}$/[-Rsd]) that regulates the linking between tones and prosodic anchors. I show that the interaction of these constraints with the faithfulness constraints (i.e. ParseTn, LexTn and Uniformity) successfully derives the correlation between tonal contours and syllable weight in Fuzhou and Fuqing. I also demonstrate that the reverse ranking of these constraints accounts for the different patterns of the tone-syllable structure correlation that are observed in Fuzhou and Fuqing. The rankings are given in (36) below:

(36) Typological variations on tonal distributions in Fuzhou and Fuqing

Types	Ranking	Languages
a.	ParseTn, LexTn >> HdBin >> Uniformity, *Nucμ/[-Rsd]	Fuzhou
b.	*Nucμ/[-Rsd], ParseTn, LexTn >> HdBin >> Uniformity	Fuqing

3.4 Hyman's typology of tonal distributions

A number of theoretical attempts to impose restrictions on tonal distributions are proposed in the phonological literature (Goldsmith 1976, Hyman 1988, Bickmore 1993, among others). Among these studies, Hyman's (1988) draws attention to typological variations of tonal distributions with respect to syllable structure. He observes that tonal languages may differ in two aspects. The first is the prosodic constituents serving as tone-bearing units. Some languages choose syllable head (which is defined as the nuclear mora) as TBU, while others may choose mora as TBU. The second aspect of cross-linguistic variation lies in whether a language imposes a one-to-one constraint on linking between tones and TBUs. Thus, these two parameters define four different tone systems in (37):

(37) Hyman's typology (1988:49-50)

a. b.

c. d.

Languages like (37a) and (37b) choose the head mora as TBU. The difference between these two types of languages is that (37a) allows a tone-bearing unit to bear two tones but (37b) does not. Languages like (37c) and (37d) allow all moras (either head or nonhead) to serve as TBU. However, (37c) permits contour tones while (37d) does not. Furthermore, a clear generalization that can be abstracted from (37) is that whereas some languages may prohibit contour tones, no language disallows level tones. If we replace Hyman's parameters (i.e. TBU = either σ or μ and whether contour tones are allowed or disallowed) with the two constraints PARSETONENUC$^{\mu}$ (which requires tones to be parsed onto a head mora in a syllable) and UNIFORMITY (which disallows multiple linking between tones and TBUs) respectively, Hyman's typological variations can be redefined in terms of whether the two constraints are enforced or optional, shown as in (38):

(38) Recast of Hyman's typology

		PARSETNNUC$^{\mu}$	
		Enforced	Optional
UNIFORMITY	Enforced	[μ] T * [μ] H L	μ T * μ H L
	Optional	[μ] T [μ] H L	μ T μ L

Notice that in the four types of tonal systems defined above, none rejects level tones. This unmarked tonal pattern is nicely captured. The cross-linguistic variation discussed in Hyman (1988) lie in whether a grammar of a particular language imposes either one or two of these constraints. In the framework of Optimality Theory, both the universal unmarkedness and the cross-linguistic variation can be achieved by constraint ranking, shown as in (39) below:

(39) Constraint ranking in deriving Hyman's typology

		ParseTnNucμ	
		ParseTnNucμ >>ParseTn	ParseTn >>ParseTnNucμ
Uniformity	Uniformity >> HdBin	Type A [μ] * [μ] T H L	Type B μ * μ T H L
	HdBin >> Uniformity	Type C [μ] [μ] T H L	Type D μ μ T L

(39) shows that ranking the faithfulness constraint Uniformity above the structural constraint HdBin defines the language types A and B (i.e. contour tones are prohibited), whereas the reverse ranking gives rise to the language types C and D (i.e. contour tones are allowed). On the other hand, if ParseTnNucμ dominates ParseTn, the language types A and C (i.e. only nuclear moras are allowed to bear tones) are achieved, whereas the reverse ranking of these two constraints derives the language types B and D (i.e. all moras

are allowed to bear tones). Thus, the universal unmarkedness and language typology are achieved by different rankings of the same set of the constraints, a desirable result.

3.5 Conclusion

The prosodic anchor hypothesis proposed in this chapter to account for the correlation between tonal contours and syllable weight and the direct relation between syllable structure and vowels contains two conditions. The first condition requires tone and vowel to link to the same mora. It is this particular representation that captures the important role the mora plays in the kind of tone-vowel interaction found in Fuzhou and Fuqing. The second condition, namely, constraint satisfaction, requires that linking of the prosodic anchor (i.e. the mora) to either tone or vowel must be well-formed. That is, constraints are imposed on the relation between the mora to both tones and vowels rather than directly imposed on the relation between tonal features and segmental features.

The examination of the mora with respect to its function as both a weight unit and a tone-bearing unit reveals that moras are distinguished in terms of their tone-bearing behavior. Some moras are allowed to bear certain kinds of tones and some are not. Furthermore, some moras are allowed to bear more than one tone and some are not. This asymmetric behavior of moras can be best characterized as the distinction of head mora (which is defined as nuclear mora) vs. nonhead mora (which is defined as non-nuclear mora). I further propose a set of constraints governing the linking between the mora and tones and demonstrate how their interaction with the faithfulness constraints is sufficient to derive distinctive syllable weight in both Fuzhou and Fuqing. Moreover, I show how the different ranking of the same set of constraints can successfully capture the unmarked tonal type (i.e. the level tones) and the cross-linguistic variation observed by Hyman (1988).

The correlation between tonal contours and syllable weight accounted for in this chapter is compatible with Duanmu's (1990, 1993) finding that rime length affects stress and tonal patterns within a polysyllabic domain. Based on his comparative study of Mandarin and Shanghai tone sandhi, Duanmu draws attention to the relation between rime length and tonal change, and observes that Mandarin differs from Shanghai in two respects. First, the rime length in Mandarin is more complex than in Shanghai. That is, Mandarin has more diphthongs and coda consonants. Second, in Shanghai, non-initial syllables within certain domains lose their lexical tones, whereas in Mandarin non-final syllables keep their lexical tones. These findings lead Duanmu to conclude that the tonal difference between the two types of languages lies in their different rime structures. In particular, all M-languages (i.e., Mandarin related languages) have complex rimes which carry inherent stress, therefore retain their lexical tones. On the other hand, all S-languages (i.e., Shanghai-related languages) have simple rimes which do not carry inherent stress, and therefore, do not retain their lexical tones. Whatever the precise status of Duanmu's claim that Chinese languages fall into two classes, M-languages and S-languages, this thesis supports the claim that moraic distinctions are important. It shows that different moraic structures affecting both tonal and segmental patterning play a crucial role language-internally in Northern *Min* languages.

CHAPTER 4

Linking between Prosodic Structure and Vowel Features

4.0 Introduction

Two direct relations emerged from the investigation of Fuzhou and Fuqing in chapter 2. One is the correlation between tonal contour and syllable weight, and the other is the direct influence of syllable positions (i.e. nucleus vs. non-nucleus) on vowel features. These relations are captured in the prosodic anchor hypothesis proposed in chapter 3, repeated here for convenience in (1):

(1) Prosodic anchor hypothesis of tone-vowel interaction

a. Representational Requirement

Both tone and vowel must directly link to the lowest prosodic anchor on the prosodic hierarchy, that is, the mora.

b. Constraint Satisfaction

Optimal linking between the prosodic anchor and tone or vowel is determined by a set of universal output constraints.

The condition (1a) requires tone and vowel to link to the same mora in order for them to interact. The condition (1b) requires the linking between the mora and tone or vowel to be governed by a set of well-formedness constraints. In chapter 3, I motivated the constraints governing tonal distributions and demonstrated how their interaction gives rise to distinctive prosodic structures for both Fuzhou and Fuqing. The first direct relation, namely, the correlation between tonal contours and syllable weight, has thus been accounted for. The task of this chapter is to deal with the second direct relation, namely, the direct influence of syllable positions on vowel distributions. I will first review current syllable theory within the optimality framework. I then propose a set of constraints on linking between the prosodic structures and vowel features in Fuzhou and Fuqing, showing that their interaction with the basic syllable structural constraints proposed by M & P (1993a, b, 1994) and P & S (1993), as well as segmental sonority constraints (P & S 1991, 1993), can successfully derive attested vowel distributional pairs.

4.1 Syllable theory in OT framework

A syllable (σ) is defined as a prosodic constituent, the second lowest on the prosodic hierarchy proposed by Zec (1988), and has its own internal structure. Different theories assume different subsyllabic constituents for the syllable. The syllable theory proposed by M & P (1993a, b) and P & S (1991, 1993:6 & 8) assumes that a syllable must have a peak, presumably, Nucleus[1]. It may also have margins: Onset as leftmost and Coda as rightmost. The syllable theory of P & S assumes that the relation between inputs and outputs follows from general Optimality Theory. That is, the function *Gen* freely builds up any number of output syllabic structures for each given input. These output candidates must be evaluated by the function *Eval* with respect to a set of ranked constraints. The optimal output is the one that best satisfies highly ranked constraints.

There are two types of constraints proposed in the syllable theory of P & S. One type is the structural constraints, such as NUC (syllables must have a nucleus), ONS (syllables

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[1] The term "Nucleus" is used frequently to formulate the constraints even though it is not explicitly proposed to be a formal subsyllabic constraint in M & P (1993a, b) and P & S (1991, 3).

must have an onset), -COD (syllables must not have a coda), etc.. The other type is the constraints, such as *M/α (α cannot be a margin of a syllable) and *P/α (α cannot be a syllable peak). The former governs the basic syllable structures and the latter restricts association of segments to syllable positions based on universal segmental sonority. The top-down (i.e. looking for segmental material to fill certain syllable positions) and bottom-up (i.e. looking for a syllable position for a segment to be parsed onto) syllabification often brings constraints into conflict. The resolution lies in constraint ranking.

4.1.1 Basic syllable structures

A number of empirical generalizations are captured by the syllable theory. The first generalization regards the universal unmarked syllable structure. It has been observed that CV syllables are invariably allowed in all languages. The structural constraints listed below in (2) ensure this unmarked syllable type:

(2) Basic syllable structure constraints (P & S 1993)

a. NUC: syllables must have nuclei.
b. ONS: syllables must have onsets.
c. -COD: syllables must not have codas.
d. *COMPLEX: no more than one C or V may associate to any syllable position node.

The terms "nuclei", "onset" and "coda" in the constraints above are used as cover terms for different syllable positions in P & S's theory, but do not refer to any formal subsyllabic constituents. According to the constraints above, a string of CVCV should always be syllabified as .CV.CV. (the dots indicate a syllable break). Any syllabification other than .CV.CV. would violate one or more of the structural constraints. For instance, to parse a string CVCV into three syllables like .C.VC.V. would violate Nuc (in the first syllable), Ons (in the second and third syllables), and -Cod (in the second syllable). The unmarked syllable structure thus is defined by satisfying all the structural constraints listed in (2).

The second generalization captured by the syllable theory in the OT framework is referred to as "Jakobson's typology" of syllable structures. It has been observed that the three elements of a syllable, namely, the onset, nucleus and coda, do not have equal status in terms of obligation. The nucleus is the only required element in all types of syllables, whereas the onset and coda may be optional in some languages. Furthermore, although not all languages require the onset in every syllable, no language requires the coda in every syllable. Syllable structure, therefore, varies from language to language depending on whether the onset is required or the coda is forbidden. A chart (3) showing "Jakobsonian typology" (1962) is presented below.

(3) Jakobsonian typology of syllable structures (from P & S 1993:85)

		Onsets	
		Required	Optional
Codas	Forbidden	Σ^{CV}	$\Sigma^{(C)V}$
	Optional	$\Sigma^{CV(C)}$	$\Sigma^{(C)V(C)}$

This cross-linguistic variation can be captured quite nicely in the syllable theory in the OT framework by the possible rankings of the structural constraints with respect to faithfulness. In particular, if Ons dominates Parse, the onset is required; otherwise, it is optional. Similarly, if -Cod ranks above Parse, the coda is forbidden; otherwise, it is optional. The typological variation derived by the interaction of the structural constraints with faithfulness is given in the following chart. The capital letter *F* denotes the faithfulness set, while the capital letter *F* with a subscribed "i" stands for a member in this set, namely, either Parse or Fill.

(4) Jakobson's typology derived by constraint ranking (P & S 1993:86)

		Onsets	
		Ons >> F_j	F >> Ons
Codas	-Cod >> F_j	Σ^{CV}	$\Sigma^{(C)V}$
	F >> -Cod	$\Sigma^{CV(C)}$	$\Sigma^{(C)V(C)}$

Chart (4) shows that four types of syllable structure can be derived by the four pairs of constraint-ranking. The ranking of both Ons and -Cod above faithfulness (i.e. Ons, -Cod >> *F*) gives only the most unmarked syllable structure (i.e. Σ^{CV}), which has onset but no coda. Conversely, the ranking of faithfulness constraints above both Ons and -Cod (i.e. *F* >> Ons , -Cod) allows the most marked syllable structure (i.e. $\Sigma^{(C)V(C)}$), optionally allowing both onset and coda. In between there are two types of syllable structures, namely, $\Sigma^{(C)V}$ and $\Sigma^{CV(C)}$, which result from the ranking of Ons and -Cod between the two faithfulness constraints. Notice that the difference between *F* and F_i is not trivial. *F* denoting the entire set of faithfulness constraints must be respected, whereas F_i standing for a member of the faithfulness set needs not be. In terms of ranking, F_i can be ranked below other constraints, while *F* cannot. Ranking F_i at the bottom amounts to saying that there are cases where lexical properties are not respected at all. However, such cases have not been found in any language so far. Moreover, what this chart demonstrates is that ranking of constraints plays a crucial role in determining different types of syllable structure.

4.1.2 Segmental sonority constraints

Another generalization encoded in the syllable theory within OT is universal segmental sonority. It has been observed that the suitability of each segment to syllable positions is largely determined by the intrinsic prominence of segments, which is represented by the sonority hierarchy in (5):

(5) Segmental sonority hierarchy[2] (Zec 1988)

a, i, ... d, t

greater sonority ←

(5) indicates that low vowels are more sonorous than high vowels, which in turn are more sonorous than voiced stops, and so on. Universally, the more sonorous a segment, the better it serves as a syllable peak. Conversely, the less sonorous a segment, the better it serves as a syllable margin[3]. These generalizations can be captured by the two sets of

[2] Segmental sonority could also be based on features like the tonal sonority hierarchy proposed in chapter three (see section 3 in chapter 3 for detailed arguments).

[3] The term "margin" in P & S's (1993) theory refers to both onset and coda which are not distinguished. This problem is noted but not addressed seriously in P & S (1993:162). Also, it is observed that more sonorous codas are better than less sonorous ones (Prince 1983, Zec in prep., Clements 1990). This is also

association constraints: the peak hierarchy and the margin hierarchy[4], as shown in (6) and (7) respectively:

(6) Peak Hierarchy (P & S 1993:129)

*P/t >> *P/d ... *P/i >> *P/a

(7) Margin Hierarchy (P & S 1993:129)

*M/a >> *M/i ... *M/d >> *M/t

(6) and (7) require that more sonorous segments make more harmonic peaks and less harmonic margins. Within the OT framework, it is possible for other constraints to be interspersed into the two hierarchies, giving rise to various syllable structures. For example, problematic inputs like /CCVV/ bring the segmental association constraints and the structural constraints into conflict. An input C ideally parsed as a margin may actually be parsed as a peak, or vice versa, in response to top-down constraints on syllable shape. These two conflicting sources of constraints must be harmonized in syllabification by constraint-ranking. This will be demonstrated in the following two Northern *Min* languages, namely Fuzhou and Fuqing.

The syllable structure assumed in this chapter is as follows. A syllable node (σ) may contain one or two moras (μ). A syllable head is a nuclear mora which is indicated by a Nuc node. Segments directly linking to the syllable node are referred to by the term Onset

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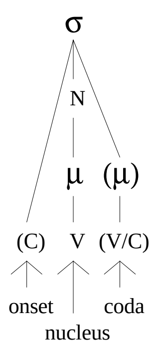
true for Fuzhou. Since this study focuses on tone-vowel interaction, I leave the question of how onset and coda should be distinguished open for future research.

[4] The peak-margin dichotomy is argued to be insufficient to account for pre-nucleus glides in Fuzhou "cutting foot words" (i.e. disyllabic words formed by the principle of Fanqie, see the section 5.4 to follow) (Jiang-King 1994a, b, 1995a, b).

(leftmost of a Nuc). The term Coda refers to a segment rightmost of a Nuc, which may link to the syllable node directly or indirectly (i.e. via a mora). (8) illustrates the syllable structure I assume.

(8) Syllable structure assumed in general



The general syllable structure assumed in (8) may vary in a particular language along the lines of whether a coda is moraic, or whether a language has contrastive syllable weight.

4.2 Fuzhou syllabification

Fuzhou distinguishes between two types of syllables: the light syllable (i.e. monomoraic) and the heavy one (i.e. bimoraic). The different number of moras in different types of syllables is determined by tonal properties. That is, a level tone or a simple contour tone (i.e. H, HM or ML) gives a single mora to the tight syllables, whereas a complex contour tone (i.e. MLM or MHM) gives two moras to the loose syllables (see detailed arguments in chapter 3). What is relevant to the present context is that these distinctive syllable structures have a direct influence on vowel features. In other words, the vowel distributions and alternations observed in chapter 2 are highly restricted by the established syllable structures. This direct relationship between the syllable structures and vowel features is captured by the proposed theory since it allows the distinctive syllable structures to play an important role in linking segments to different syllable positions.

Before I discuss Fuzhou syllabification, I will first lay out the basic syllable structures in Fuzhou and the relevant constraints assumed.

4.2.1 Fuzhou syllable structure

Most of Fuzhou syllable structure falls comfortably within the purview of the basic theory of syllable structures (M & P 1993a, P & S 1993). Fuzhou admits a wide range of segmental sequences within a syllable: V, CV, VV, CVV, VC, CVC, VVV, CVVV, VVC, CVVC (Liang 1982). Onsets and codas are optional, underparsing of segmental root nodes is disallowed. Nuclei are the only elements required. Fuzhou thus exemplifies the typological family $\Sigma^{(C)V(C)}$, in the terminology of the basic CV syllable structure theory (P & S 1993, chapter 6). This means that the faithfulness constraints dominate both Ons and -Cod, allowing the V syllable when there is no segmental material for an onset and a coda. Various syllables without a consonant are exemplified in (9). Data are from Liang (1982).

(9)		monosyl.	Gloss		monosyl.	Gloss
	a.	ɩ^{H}	'cloth'	e.	uai^{H}	'aslant'
	b.	u^{H}	'black'	f.	uo^{H}	'put together'
	c.	o^{H}	'stick'	g.	yo^{ML}	'shrivel up'
	d.	a^{ML}	'Asian'	h.	au^{H}	'sunken'

The syllables in (9a-d) contain a single vowel, hence, the nucleus only. There is no margin at all. The ones in (9e-h) show that a syllable in Fuzhou may have more than one vowel without any consonant. This seems to suggest that Ons and -Cod do not play any role in Fuzhou syllabification. However, the following data in (10) show that Ons is respected where possible in disyllabic words.

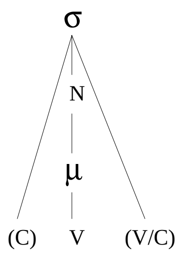
(10)	monosyl.	Gloss	+	monosyl.	Gloss	→	disyl. words	Gloss
a.	τσэυON^{MHM}	'similar'		ψON^{MHM}	'shape'		τσэυoNNψON	'presentable'
b.	ξυoN^{ML}	'powder'		ΠψN^{HL}	'red'		ξυoNNΠψN	'pink'

The examples in (10) show that when a coda consonant is followed by an onsetless syllable, gemination (which is indicated by an underscore in the above examples) occurs. The occurrence of consonant gemination can be attributed to the effect of the constraint Ons. Since Ons is active, it puts pressure on the syllabification so that the second onsetless syllable gets an onset from its preceding coda. The contrast between (9) and (10) lies in the interaction between the structural constraint Ons (M & P 1993a, b, P & S 1993) and the faithfulness constraint Lex-α (Pulleyblank 1994, P & T 1995, Pulleyblank et al. 1995): the former requires a syllable to have an onset, while the latter prohibits insertion of any F-element which is not present in the input. By ranking Lex-α above Ons, the lack of onset in (9) is accounted for since there is no consonant present in the input. On the other hand, the inputs in (10) contain a consonant in an appropriate position for gemination (i.e., from the previous morpheme). The occurrence of consonant gemination is expected since the output with the onset satisfies both Lex-α and Ons, while the one without an onset would violate Ons. This shows that the structural constraint Ons does play a role even though it ranks below the faithfulness Lex-α.

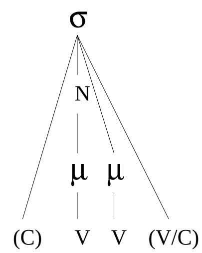
Fuzhou has two types of syllables: the light (i.e. monomoraic) syllables and the heavy (i.e. bimoraic) ones, given in (11a) and (11b) respectively:

(11) Fuzhou syllable structures

a. The light syllable in tight finals



b. The heavy syllable in loose finals



The contrastive syllable structures above are motivated by the constraints on tonal distributions. In particular, the monomoraic structure in (11a) results from the simple tonal contours (i.e. H, HM, M) while the bimoraic one in (11b) from the complex tonal contours (i.e. MHM and MLM) (see chapter 3 for detailed discussions). Before I proceed to demonstrate Fuzhou syllabification, a number of assumptions must be made explicit.

First, following A & P (1994), I assume the theory of Combinatorial Specification in that featural elements combine to represent segments. The seven vowels in Fuzhou ι, ψ, υ, E (ε/E), Π, O (o/O), A (α/A), thus can be represented as in (12):

(12) Fuzhou vowel representation

a. F-elements: +Lo, +Hi, +Rd, +Front

b.

E_1	A	$ι_1$	O	E_2	υ	$ι_2$	Π	*	*	*	ψ	*	*	*	*
	+LO							+LO	+LO	+LO		+LO	+LO	+LO	+LO
		+HI			+HI	+HI		+HI			+HI	+HI	+HI		+HI
			+RD		+RD		+RD		+RD		+RD	+RD		+RD	+RD
				+FRT		+FRT	+FRT			+FRT	+FRT		+FRT	+FRT	+FRT

c. Conditions: Hi/Lo: if +Hi, then not +Lo.

Lo/Rd: if +Lo, then not +Rd.

Lo/Frt: if +Lo, then not +Frt.

I propose four active vowel features in (12a), whose combinations are represented in (12b). Columns headed by an * indicate the absence of featural combinations ruled out by the three grounding conditions in (12c) which are undominated in Fuzhou.

Second, I assume the faithfulness families[5] of constraints (M & P 1993a, b, P & S 1993, Pulleyblank 1994, P & T 1995, Pulleyblank et al. 1995, among others) in (13):

(13) Faithfulness constraints

a. PARSE-α: an F-element (feature or node) α must be parsed onto an appropriate prosodic constituent.

b. FILL: A prosodic constituent must be filled by an F-element.

c. LEX-α: an F-element (feature or node) α that is present in an output form is also present in the input: $[\ldots\ \alpha\ \ldots]_{output} \rightarrow [\ldots\ \alpha\ \ldots]_{input}$

Third, I assume the basic structural constraints in (14) (M & P 1993a, P & S 1993), in which the constraint *COMPLEX proposed by M & P (1993a) is decomposed into three constraints: *COMPLEX-COD, *COMPLEX-ONS and *COMPLEX-NUC:

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[5] The faithfulness set of constraints are later incorporated into the correspondence theory developed by McCarthy (1995) and M & P (1995). The terminology has been changed such that PARSE and FILL correspond in large measure to MAX and DEP, respectively. For the purposes of this thesis, either approach to faithfulness would be sufficient for the present context.

(14) The basic structural constraints

a. NUC: syllables must have nuclei.

b. ONS: syllables must have onsets.

c. -COD: syllables must not have codas.

d. *COMPLEX-COD: No more than one post-nucleus segment may link to σ directly.

e. *COMPLEX-ONS: No more than one pre-nucleus segment may link to σ directly.

f. *COMPLEX-NUC: No more than one segment may link to nuclear mora directly.

Fourth, I reformulate the harmonic nucleus constraint *P/α (P & S 1993) as *NUC/α, since Nucleus is proposed to be a syllable head, hence, a formal constituent within a syllable (Shaw 1992, 1993). *NUC/α is a set of constraints restricting certain segments to a nuclear position. It contains a number of members with the ranking given in (15).

(15) The set of harmonic nucleus constraints (HARMNUC)

*NUC/C >> *NUC/[+HI] >> *NUC/[+LO]

With the assumptions above made clear, I now demonstrate how the interaction of these constraints can automatically derive the attested vowel distribution pairs in Fuzhou.

4.2.2 The contrast between monophthongs and diphthongs

As observed in chapter 2, the vowel distributions in Fuzhou exhibit a correspondence between monophthongs in the tight syllables and diphthongs in the loose ones. The distinctive syllable types are argued to reflect a difference in syllable weight (i.e. monomoraic vs. bimoraic), resulting from their tonal properties (i.e. H, HM, ML vs. MLM, MHM) (see chapter 3 in detail). Given these contrastive syllable structures, linking an underlying high vowel to different syllable structures would give a single high vowel in the tight syllables on the one hand and a **possible** long high vowel in the loose syllables on the other hand. However, the expected vowel length distinction does not show up. There is no surface long high vowel in Fuzhou phonology. Instead, the segmental contrast shows up as a difference between a monophthongal high vowel and a diphthong containing that high vowel. The corresponding vowel pairs are illustrated in (16) below.

(16)	**I** "tight"	Gloss		**II** "loose"	Gloss	Distribution
a.	tsi^{H}	'f. word'	g.	tsεi^{MLM}	'will'	/ι/ → i ~ εi
b.	πιN^{H}	'guest'	h.	πειN^{MLM}	'combine'	
c.	kυ^{ML}	'ancient'	i.	koυ^{MLM}	'old; reason'	/υ/ → u ~ ou
d.	τσυN^{ML}	'permit'	j.	τσουN^{MLM}	'handsome'	
e.	sy^{H}	'beard'	k.	sΠy^{MLM}	'(cotton)wadding'	/ψ/ → y ~ Πy
f.	tyN^{HL}	'repeat'	l.	tΠyN^{MHM}	'middle'	

Moreover, the examples in (16) show that the component vowels of a diphthong share all vocalic features except [+Hi]. The lack of the length contrast for high vowels can be captured by ranking ParseHi above *Nuc/Hi[6]. As a result, a high vowel links to a nuclear mora only when there is no other vowel present. On the other hand, if there is another non-high vowel occurring with a high vowel, the high vowel can not link to a nuclear mora. It can only be parsed onto a non-nuclear mora, giving rise to a diphthong in the loose syllables. To ensure (i) that the outputs in the loose syllables consist of a non-high vowel followed by a high vowel and (ii) that the two component vowels within a diphthong share all vocalic features but [+Hi], as exemplified in (16g-l), the faithfulness

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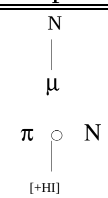
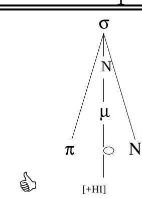
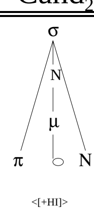
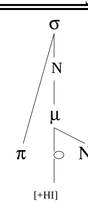
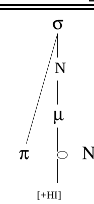
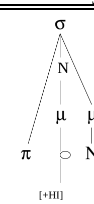
[6] I owe this insight to Doug Pulleyblank (p.c.).

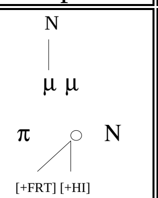
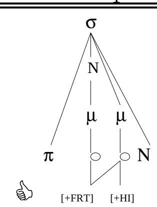
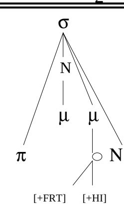
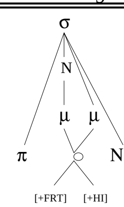
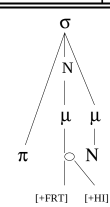
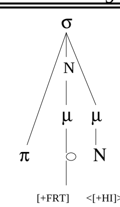
constraint FILL-μ in (13b) and its interaction with *NUC/HI play an important role in deriving the alternating pairs. Mapping a high vowel /ɩ/ to the monomoraic structure is relatively straightforward, and is demonstrated in the tableau (17) below. Following standard notational conventions, an exclamation mark ("!") signals a fatal violation; an asterisk ("*") represents a single violation; and shading indicates that constraints are not crucial in determining an optimal output. Technically, the mora need not be in the input, but it is required by tonal distributions (see discussions in chapter 3). This will be generally true and will not be repeated for every tableau.

(17) Output candidates [πɩN^H] 'guest'

Input	$Cand_1$	$Cand_2$	$Cand_3$	$Cand_4$	$Cand_5$
	 [πɩN^H] 'guest'	 [πoN]	 [πɩN]	 [πɩ]	 [piN]
LEX-μ					*!
PARSERT				*!	
*NUC/C			*!		
PARSEHI		*!			
*NUC/HI	*		*	*	*

The last two candidates in (17) show that violation of LEX-μ (which disallows adding moras that are not present in an input) or PARSERT (which demands a segmental root to be parsed onto a prosodic structure) is fatal, so they are out. Compare the first three candidates: $Cand_3$ violates *NUC/C because the nuclear mora is filled by both the high vowel [ι] and the velar consonant [N]. $Cand_2$ violates PARSEHI, while $Cand_1$ violates *NUC/HI. Since PARSEHI ranks above *NUC/HI, $Cand_1$ wins. The two faithfulness constraints LEX-μ and PARSERT are highly ranked in all cases. Any output candidates violating them will be out, thus will not be included in the following tableaux. Notice that the crucial ranking in this case is PARSEHI >> *NUC/HI.

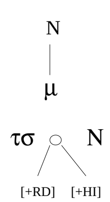
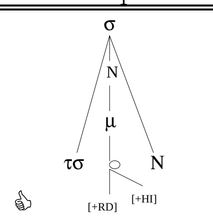
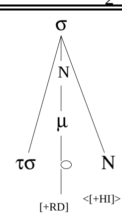
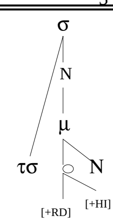
(18) Output candidates for [πειN^{MLM}] 'combine'

Input	$Cand_1$	$Cand_2$	$Cand_3$	$Cand_4$	$Cand_5$
	 [πειN^{MLM}] 'combine'	 [πιN]	 [πι:N]	 [πιoN]	 [πoN]
PARSEHI					*!
*NUC/HI			*!	*!	
FILL-μ		*!			*

The ranking PARSEHI >> *NUC/HI established in (17) rules out the last candidate in (18), since it violates PARSEHI (i.e. the feature +HI in $Cand_5$ is left unparsed). Both $Cand_3$ and $Cand_4$ in (18) violate *NUC/HI in different ways. $Cand_4$ does so by parsing a high vowel to the nuclear mora only, while $Cand_3$ violates it by linking the high vowel to both the nuclear and non-nuclear moras. Compare $Cand_2$ and $Cand_1$: the former violates FILL-μ because the left mora is unfilled, while the latter satisfies it by linking the feature +FRONT to the nuclear mora. Thus, $Cand_1$ is the best one. Since the optimal output satisfies all constraints, there is no crucial ranking in this case.

The alternating pair **ц** ~ **рц** can be derived in the same way as the pair **к** ~ **ек**. The difference is that the F-element [+RD] is involved in the **ц** ~ **рц** pair, but not in the **к** ~ **ек** pair. The sharing of all features other than [+HI] within a diphthong can be captured by the interaction between *NUC/HI and FILL-μ: the former prevents the nuclear mora in a syllable from being filled by [+HI], while the latter demands that all moras must be filled. This conflict between the two constraints triggers parsing any feature other than [+HI] to the nuclear mora. Consequently, the roundness or frontness harmony exhibited in (16g-l) has been ensured. The evaluation for the **ц** ~ **рц** pair is illustrated in (22) and (23) respectively.

(19) Output candidates for [τσυN^{ML}] 'permit'

Input	$Cand_1$	$Cand_2$	$Cand_3$
	 [τσυN^{ML}] 'permit'	 [τσoN]	 [τσυN]
*NUC/C			*!
PARSEHI		*!	
*NUC/HI	*		*

In (22), linking the velar consonant [N] to a nuclear mora, as shown in $Cand_3$, results in a violation of *NUC/C. Given the ranking PARSEHI >> *NUC/HI established in (17) , the first candidate wins since it violates *NUC/HI, while the second candidate violates PARSEHI. Again, we see that the ranking *NUC/C, PARSEHI >> *NUC/HI plays a crucial role in choosing $Cand_1$ over $Cand_2$.

Tableau (23) shows the [+RD] spreading that is triggered by the interaction between *NUC/HI and FILL-μ in deriving the correct output form [ou]. Cand$_5$ violates PARSE-HI since the feature [+HI] is left unparsed. Cand$_3$ and Cand$_4$ are ruled out by *NUC/HI since the high vowel [u] links to a nuclear mora in both cases. The difference between them is that the high vowel links to both moras in Cand$_3$ but only the nuclear mora in Cand$_4$. Cand$_2$ violates FILL-μ (i.e. the nuclear mora is left unfilled), while Cand$_1$ violates nothing. Therefore, Cand$_1$ wins. Comparing Cand$_1$ with Cand$_2$, FILL-μ crucially chooses Cand$_1$ over Cand$_2$ since the nuclear mora in the first candidate is filled by [+RD], whereas the nuclear mora in the second one is left empty.

(20) Output candidates for [τσουN^{MLM}] 'handsome'

Input	Cand$_1$	Cand$_2$	Cand$_3$	Cand$_4$	Cand$_5$
N μ μ τσ N [+RD] [+HI]	☞ σ N μ μ τσ N [+RD] [+HI] [τσουN^{MLM}] 'handsome'	σ N μ μ τσ N [+RD] [+HI] [tsεuN]	σ N μ μ τσ N [+RD] [+HI] [τσυ:N]	σ N μ μ τσ N [+RD] [+HI] [τσυN]	σ N μ μ τσ N [+RD] <[+HI]> [τσoN]
PARSEHI					*!
*NUC/HI			*!	*!	*!
FILL-μ		*!			

The corresponding pair **ъ ~ Ръ** exemplified in (16e, f, k, l) is similar to the pair **ц ~ рц**. The difference is that the **ъ ~ Ръ** pair involves feature agreement in both roundness and frontness: [y] occurs with [Π], not *ey, *oy. This featural agreement for roundness and frontness within a diphthong can be seen as an instance of the parasitic harmony proposed by Cole and Kisseberth (1994). The essential idea of Cole and Kisseberth's proposal is that the harmonic domain of a feature *x* co-exists with the harmonic domain of a feature *y*. This captures the empirical observation that prosodic anchors within a certain domain tend to share more features if they already share a certain feature. To derive an output where the two component vowels within a diphthong share all vocalic features but [+HI], I postulate a parasitic constraint in (21), along the lines of Cole and Kisseberth (1994:10).

(21) Parasitic Constraint (PARAS(RD, FRNT))

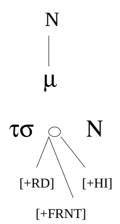
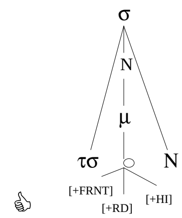
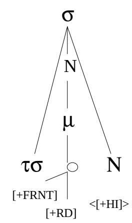
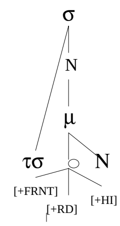
Two anchors within a syllable agree in their values for [RD], iff they agree for [FRONT].

The following tableaux (22) and (23) demonstrate how the parasitic constraint proposed in (21) and its interaction with PARSEHI, *NUC/HI and FILLμ can successfully derive the **ъ ~ Pъ** pair.

Linking a front round high vowel /**ъ**/ to the monomoraic structure in (22) is relatively simple. The high vowel **ъ** must be parsed onto the nuclear mora as in $Cand_1$ even though it violates *NUC/HI. Otherwise, it would violate a highly ranked constraint *NUC/C, as in $Cand_3$, or PARSEHI, as in $Cand_2$. Notice that the parasitic constraint (21) does not play any role in determining an optimal output since there is only one mora in this case.

(22) Output candidates for [τψN^{HL}] 'repeat'

Input	$Cand_1$	$Cand_2$	$Cand_3$

	☞  [τψN^{HL}] 'repeat'	 [τΠN]	 [τψN]
*NUC/C			*!
PARSEHI		*!	
*NUC/HI	*		*

(23) Output candidates for [τΠψN^{MHM}] 'middle'

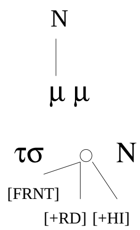
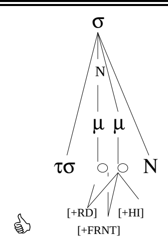
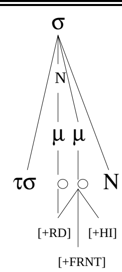
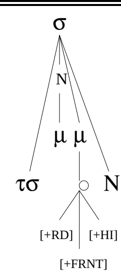
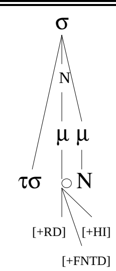
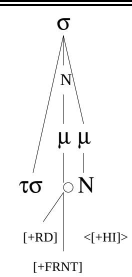
Input	$Cand_1$	$Cand_2$	$Cand_3$	$Cand_4$	$Cand_5$
	 [τΠψN^{MHM}] 'middle'	 [toψN]	 [tεψN]	 [τψN]	 [τΠN]
ParseHi					*!
*Nuc/Hi				*!	*!
Fill-μ			*!		
Paras(Rd, Frnt)		*!			

Tableau (23) shows that violation of ParseHi in $Cand_5$, *Nuc/Hi in $Cand_4$ and Fillμ in $Cand_3$ is out. Compare the first two candidates. $Cand_2$ satisfies Fillμ, but violates Paras(Rd, Frnt), since only the feature Rd links to two moras. The feature Front only links to one mora. The first candidate satisfies all the constraints, hence, is the optimal one. The crucial ranking suggested in this subsection is given in (24) below:

(24) The ranking for the contrast between monophthongs and diphthongs

Lex-μ, Parse, Fill-μ, *Nuc/C, ParseHi >> *Nuc/Hi, Paras(Rd, Frnt)

4.2.3 The tense/lax distinction

As observed in chapter 2, there is a tense/lax distinction between the two types of syllables when a nucleus contains a non-high vowel. It is argued that the tense/lax distinction represents a primary quantity difference with derivative differences in featural content (see chapter 2 section 5 for details). This tense/lax distinction between the two types of syllables is illustrated in (25) below.

(25)		**I** "tight"	Gloss		**II** "loose"	Gloss	Distributions
	a.	tsieN^{HL}	'felt'	d.	tsiEN^{MLM}	'fight'	/E/ → ε ~ E
	b.	κo^{H}	'song'	e.	kO^{MLM}	'individual'	/O/ → o ~ O
	c.	kυα^{ML}	'few, scant'	f.	kuA^{MLM}	'hung up'	/A/ → a ~ A

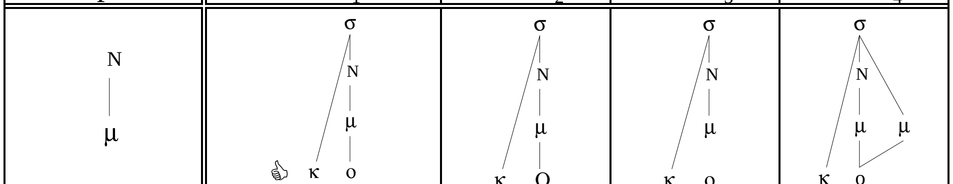
The data in (25) show that mid vowels surface as [ε] and [o] in tight syllables, while they appear as [E] and [O] respectively in the corresponding loose ones. Similarly, a low vowel also varies along the tense/lax dimension. It appears as [α] in the tight syllables and [A] in the corresponding loose ones. If the length distinction for the **e** ~ **Д**, **p** ~ **П** and **б** ~ **A** pairs is primary (which is derived by linking an underlying non-high vowel to a monomoraic structure on the one hand, and a bimoraic structure on the other hand), and the featural distinction (i.e. tense vs. lax) is secondary, we need a constraint assigning the feature [lax] (or whatever other feature appropriately characterizes the distinction between ε, o, α and E, O, A) to a long non-high vowel. Following Cole and Kisseberth's (1995) proposal for Yawelmani vowel lowering (i.e. Vμμ → [Low]), I propose a length dependence constraint in (26), which derives a lax vowel from a non-high vowel linked to a bimoraic structure.

(26) Length Dependent Constraint (Laxing or Vμμ → [Lax])

Iff α is parsed onto two moras, then α is [LAX]. (where $\alpha \neq$ [HI])

What the constraint (26) requires is that the presence of the feature [LAX] depends on the configuration in which a non-high vowel links to two moras. This means that the vowel quality difference rests on their quantity difference. The tableaux (27) and (28) below illustrate that given these constraints, linking of an underlying non-high vowel to the different moraic structures can automatically derive the tense/lax pairs.

(27) Output candidates for [κo^H] 'song'

Input	Cand$_1$	Cand$_2$	Cand$_3$	Cand$_4$
 κ o	[κo^H] "song"	[κO]	[κε]	[κo:]
LEX-μ				*!
PARSERT			*!	
LAXING		*!		

In (27), each of the last two candidates incurs a fatal violation mark since the constraints LEX-μ and PARSERT are undominated. The second candidate violates the length dependent constraint LAXING because the appearance of the feature [LAX] does not depend on the length. The first candidate does not violate anything, hence is optimal. Notice that the length dependent constraint LAXING does play a role in ruling out an inappropriate insertion of LAX in (27), even though there is only one mora in the input.

(28) Output candidates for [κO^{MLM}] 'individual'

Input	Cand$_1$	Cand$_2$	Cand$_3$	Cand$_4$	Cand$_5$
N μ μ κ o	σ N μ μ ☞ κ O [κO^{MLM}] 'individual'	σ N μ μ κ o [κo:]	σ N μ μ κ a o [καo]	σ N μ μ κ o [κo]	σ N μ μ κ o [κo]
Fill-μ				*!	*!
LexF			*!		
Laxing		*!			

(28) differs from (27) in that the input contains two moras (which are determined by tonal specifications). Linking the mid vowel to either mora alone, as in Cand$_4$ and Cand$_5$, would violate Fill-μ. Inserting a feature [Low] as in Cand$_3$ would violate LexF which prohibits insertion of any feature that is not present in an input. Comparing Cand$_2$ with Cand$_1$, the former violates Laxing (i.e. a non-high vowel links to two moras without becoming lax), while the latter violates nothing (i.e. a long mid vowel becomes lax). Cand$_1$, therefore, is optimal. The important constraint that chooses Cand$_1$ over Cand$_2$ is Laxing. Since the optimal outputs in both (27) and (28) satisfy all the constraints, there is no crucial ranking in these cases.

4.2.4 The harmonic restriction on tight syllables

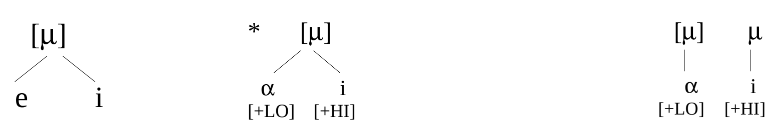
The harmonic restriction on the tight syllables observed in chapter 2 is that when a high vowel and a coda consonant (either a glottal stop or a nasal velar) are both present after a low vowel, the low vowel becomes mid, as shown in (29).

(29)

	I "tight"	Gloss		**II** "loose"	Gloss	Distributions
a.	μει/^{HL}	'strange(lit.)'	e.	μαι/^{MLM}	'strange (collq.)'	ειC ~ αιC
b.	τειN^{ML}	'wait'	f.	ταιN^{MHM}	'chair'	
c.	τσουN^{H}	'stolen goods'	g.	τσαυN^{MLM}	'to bury'	ουC ~ αυC
d.	που/^{HL}	'thin (lit.)'	h.	παυ/^{MLM}	'explode'	

The data in (29) raise a question as to why the low vowels in the loose syllables become mid in the corresponding tight ones. To answer this question, I propose that the presence of a coda consonant may force the high vowel to link to the mora, resulting in both a high vowel and a low vowel linked to the same mora in the "tight" syllables, as in (30a), whereas they link to two different moras in the "loose" syllables, as in (30b). The square brackets indicate the nuclear mora in a syllable.

(30) a. Short diphthongs in "tight" finals b. Long diphthongs in "loose" finals



To account for the corresponding pairs **екO ~ бкO** and **рцO ~ бцO**, I propose that the condition HI/LO (i.e. if +HI, then not +LO) proposed by A & P (1994) applies to the domain of a mora[7], thus forcing either [+LO] or [+HI] to be unparsed in the "tight" syllables. This condition can be formulated as in (31) below:

(31) HI/LO Condition extended into the domain of mora

*HI/LO$^{\mu}$: a mora cannot be filled by both [+HI] and [+LO] F-elements.

The function of (31) is to prevent the features [+HI] and [+LO] from linking to the same mora. If that happens, one of these two features must be underparsed. In terms of Optimality Theory, both *HI/LO$^{\mu}$ and PARSEHI must rank above PARSELO[8]. In other words, it is better to underparse [+LO] than to violate *HI/LO$^{\mu}$ and PARSEHI. The following tableaux (32) and (33) illustrate how syllabification governed by the interaction of *HI/LO$^{\mu}$, PARSEHI and PARSELO derives the alternating pair **екО ~ бкО**.

The last two candidates in (32) each incur a fatal violation mark since *COMPLEXCOD and PARSERT are undominated. Cand$_3$ violates *HI/LO$^{\mu}$, which ranks above the rest of the constraints, and so is out. Compare the first two candidates, both of which satisfy *HI/LO$^{\mu}$ in different ways: underparsing [+HI] in Cand$_2$ results in the diphthong [ae], whereas underparsing [+LO] in Cand$_1$ gives rise to the diphthong [ei]. The former violates PARSEHI, while the latter violates PARSELO. Since PARSEHI ranks higher than

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[7] The grounding condition originally proposed by Archangeli and Pulleyblank (1994) is the path condition that prohibits two phonetically incompatible F-elements from occuring on a single path. For instance, the HI/LO condition prevents the features [+HI] and [+LO] from linking to a single segmental root. The HI/LO condition used here differs from that proposed by Archangeli and Pulleyblank in that it involves two segmental root nodes. In other words, it prevents a high vowel and a low vowel from linking to the same mora rather than prevents them from linking to the same segmental root node.

[8] I am grateful to Pat Shaw and Doug Pulleyblank (p.c.) for suggesting the use of the ranking PARSE-HI >> PARSE-LO to account for this case.

PARSELO, the first candidate wins, even though it violates PARSELO and *NUC/HI, the lowest ranked constraints. The ranking in this case is: *COMPLEXCOD, PARSERT, *HI/LO, PARSEHI >> PARSELO, *NUC/HI.

(32) Candidate outputs [teiN^{ML}] "wait"

Input	Cand$_1$	Cand$_2$	Cand$_3$	Cand$_4$	Cand$_5$
N μ τ α ι N [+LO] [+HI]	σ N μ τ ε ι N ☞ <[+LO]> [+HI] [τειN^{ML}] 'wait'	σ N μ τ α ι N [+LO] <[+HI]> [ταεN]	σ N μ τ α ι N [+LO] [+HI] [ταιN]	σ N μ τ α ι N [+LO] [+HI] [ται]	σ N μ τ α ι N [+LO] [+HI] [ταιN]
*ComplexCod					*!
ParseRt				*!	
*Hi/Lo$^{\mu}$			*!		
ParseHi		*!			
ParseLo	*				
*Nuc/Hi	*		*		

Notice that decomposing the Parse family plays a crucial role in this case. Its internal ranking, namely, ParseRt >> ParseHi >> ParseLo, is important in deriving the correct output. Compare (18) and (32): the former contains the diphthong [ei] in a loose syllable ([πειN^{MLM}] 'combine') while the latter has the diphthong [ei] in a tight syllable ([τειN^{ML}]). The difference between them, however, is that the diphthong [ei] in a loose syllable is long since it links to two moras required by the complex contour tone, whereas the one in a tight syllable is short because it links to a single mora with only a simple tonal contour.

Tableau (33) below shows that once an input contains two moras and a string with a low vowel followed by both a high vowel and a consonant, Parse-hi and Parse-lo play no role in determining the optimal output. Since the syllable contains two moras, both a high vowel and a low vowel are able to be parsed to different moras. Therefore no feature conflict occurs, even though the presence of a coda consonant forces a high vowel to be linked to a mora.

(33) Output candidates for [ταιN^{MHM}] "chair"

Input	$Cand_1$	$Cand_3$	$Cand_4$	$Cand_5$
N μ μ τ α ι N	σ N μ μ ☞ τ α ι N [ταιN] 'chair'	σ N μ μ τ α ι N [ταιN]	σ N μ μ τ α ι N [ταN]	σ N μ μ τ α ι N [τAιN]
*ComplexCod				*!
ParseRt			*!	
*Hi/Lo$^{\mu}$		*!		

The last two candidates in (33) are ruled out by *ComplexCod and ParseRt, respectively. The second candidate violates *Hi/Lo$^{\mu}$, while $Cand_1$ does not. The first candidate, therefore, is better than the second. There is no crucial ranking in this case.

The harmonic restriction demonstrated in this section suggests that *ComplexCod and ParseRt must rank above *Hi/Lo$^{\mu}$, ParseHi, which in turn rank above ParseLo, *Nuc/Hi.

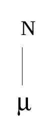
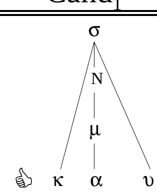
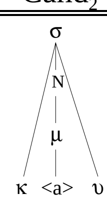
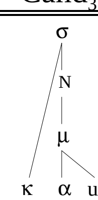
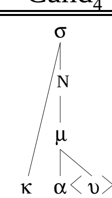
4.2.5 The asymmetric behavior of high vowels

The investigation of Fuzhou tone-vowel interaction in chapter 2 also reveals that a high vowel behaves differently with respect to its relevant syllable positions. It manifests a correspondence between a monophthong and a diphthong when it appears as a nucleus of a syllable (see section 4.2.2 in this chapter), whereas it does not alternate at all when it precedes or follows another non-high vowel. In the latter case, the vowel distribution effect takes place in the non-high vowels along the tense-lax dimension. The asymmetric behavior of the high vowels is illustrated in (34).

(34)		**I** "tight"	Gloss		**II** "loose"	Gloss	Distribution
	a.	kυ^{ML}	'ancient'	b.	koυ^{MLM}	'old; reason'	υ ~ oυ
	c.	kυα^{ML}	'few, scant'	d.	kuA^{MLM}	'hung up'	*υ ~ oυ
	e.	kαυ^{H}	'suburbs'	f.	kAu^{MLM}	'enough'	*υ ~ oυ

(34a-b) show that when a high vowel occurs as a nuclear vowel, it surfaces as [υ] in the tight syllables and as [oυ] in the loose ones. This corresponding pair **ц** ~ **рц** does not show up when the high vowel **ц** precedes (34c-d) or follows (34e-f) a non-high vowel [α]. The asymmetry can be accounted for by the constraint interaction. The tableaux (35) and (37) demonstrate how the inert behavior of a high vowel following a non-high vowel can be accounted for by the interaction between PARSEHI, PARSELO and *NUC/HI.

(35) Output candidates for [kau^{H}] 'suburbs'

Input	Cand$_1$	Cand$_2$	Cand$_3$	Cand$_4$
 κ α υ	 [kαυ^{H}] "suburbs"	 [κευ]	 [καυ]	 [καε]
PARSEHI				*!
*NUC/HI			*!	
PARSELO		*!		

In (35), the last three candidates violate ParseHi, *Nuc/Hi and ParseLo respectively. In particular, underparsing the feature [+Hi] in Cand$_4$ violates ParseHi, while linking both [a] and [u] to the same mora violates *Nuc/Hi in Cand$_3$. Cand$_2$ violates ParseLo because the feature [+Lo] is left unparsed. Only the first one incurs no violation, and is therefore the optimal one. There is no crucial ranking in this case.

When an input is bimoraic it should be possible for **б** and **ц** each to link to a separate mora. In such cases, the low vowel **б** should surface as short and tense in a loose syllable. However, the example (34f) shows that **б** becomes **Λ** when it precedes a high vowel **ц** in a bimoraic syllable even though there is no coda consonant present. To prevent the high vowel **ц** from being parsed onto a non-head mora, a constraint (36) is needed:

(36) Harmonic Mora (Harm$^{\mu}$)

*μ/C >> *μ/Hi >> *μ/Lo.

The effect of (36) is to express the observation that the more sonorous a segment is, the more harmonic a mora it makes. The following tableau illustrates how the constraint Harm$^{\mu}$ interacts with other constraints, giving rise to an optimal output.

In (37), Cand$_4$ is out since the non-nuclear mora is left unfilled. Cand$_3$ violates Harm$^{\mu}$ because the non-head mora is filled by the high vowel **ц**. The first two candidates both satisfy Fill-μ and Harm$^{\mu}$. However, Cand$_2$ violates Laxing because the low vowel is parsed onto two moras without becoming lax. Cand$_1$ satisfies all of them except *Cod/Hi, the lowest ranked constraint, and is therefore optimal.

(37) Output candidates for [kAu^{MLM}] 'enough'

Input	$Cand_1$	$Cand_2$	$Cand_3$	$Cand_4$
N μ μ κ α υ	σ N μ μ ☞ κ Α υ [κΑυ^{MLM}] 'enough'	σ N μ μ κ α υ [κα:υ]	σ N μ μ κ α υ [καυ]	σ N μ μ κ α υ [καευ]
FILL-μ				*!
HARMμ			*!	
LAXING		*!		
*COD/HI	*	*		*

Having explored the possibilities for a high vowel following a low vowel to link directly to either σ or μ, I now turn to the cases where a high vowel precedes a non-high vowel. In traditional Chinese phonology, the high vowel in front of a non-high vowel is called the "on-glide". The data in (34c-d) suggest that the "on-glide" cannot be part of the nuclear mora. If it were linked to the nuclear mora, the low vowel in (34c) would become a high vowel + a mid vowel [**uo**], since the nuclei in these cases are monomoraic. My analysis for the off-glide predicts that linking a high vowel and a low vowel to the same mora would violate the condition *HI/LO$^{\mu}$, thus resulting in underparsing of [+LO]. However, the data in (34c-d) show that the presence of an on-glide has no effect on the low vowel: Namely, a low vowel in these cases does not become a mid vowel; therefore the on-glide must not link to the nuclear mora.

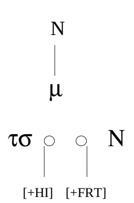
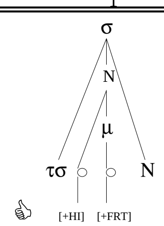
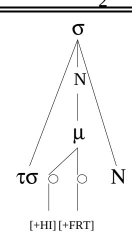
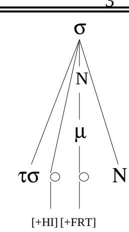
If the on-glide is not part of the nuclear mora, where should it be? One possibility is to treat it as an onset, which directly links to the syllable node. However, the evidence from so-called "cutting-foot" words shows that this is not the case. The "cutting-foot" words in Fuzhou are disyllabic words formed from monosyllabic words by a process resembling partial reduplication. In particular, the first syllable in the output disyllabic words is a monomoraic syllable, which shares the most sonorous vowel and any segmental material before the nuclear vowel with the original syllable. The second syllable of the output retains everything of the original syllable except the onset. The data in (38) exemplify this type of word.

(38)		Original	Derived		Output pattern
	a.	πAιN^{MLM}	πα^{L}λAιN^{MLM}	'turn around'	CV.lVGC
	b.	τια^{HL}	τια^{ML}λια^{HL}	'too tired to keep eyes open'	CGV.lGV
	c.	υαι^{H}	υα^{ML}λυαι^{H}	'aslant'	GV.lGV *GV.<u>lV</u>
	d.	υο^{H}	υο^{ML}λυο^{H}	'put together'	GV.lGV *GV.<u>lV</u>

The examples in (38) show that when an input contains a string CVGC in (38a) and CGV in (38b), the first syllable of the output contains the most sonorous vowel of the input, and any segmental material preceding that vowel, with a new tone; while the second syllable of the output retains everything of the input (including the tone of the input), except that the initial consonant is replaced by a liquid [l]. If the on-glide were treated as an onset, then the input string GV(G) in (38c-d) would yield the output [.GV.lV(G).], where the on-glide in the second syllable is replaced by the liquid [l]. The actual output, however, is [.GV.lGVC.]. The on-glide G is not replaced by the liquid [l], but remains in the second syllable of the output with the addition of a preceding [l]. Therefore, the evidence (38c-d) from the "cutting-foot" words suggests that the on-glide cannot be the onset or part of the onset. Based on the same type of data (i.e. the "cutting-foot" words), Qu (1995) also argues that an on-glide cannot be part of the onset. He proposes for similar reasons that it links to the leftmost nuclear mora together with another non-high vowel. This option has been rejected due to the evidence from the alternating behavior of low vowels. In particular, it is observed that an on-glide behaves differently from an off-glide in triggering the vowel-raising effect. When an off-glide (i.e. a high vowel following a low vowel) is forced to link to a mora with a low vowel, it triggers vowel-raising. However, an on-glide (i.e. a high vowel preceding a low vowel) never triggers a vowel-raising effect. This suggests that an on-glide cannot be parsed onto the same mora as a low vowel. Otherwise, the lack of vowel-raising is left unexplained.

If the on-glide cannot be either an onset (or part of an onset) or the nucleus (or part of the nucleus), where should it link to? I propose that it links to the Nuc node directly, in the same way an initial consonant links to a syllable node directly. If the nucleus is a formal constituent, as argued by Shaw (1992, 1993), in principle nothing can prevent an on-glide from linking to a Nuc node directly. (39) and (40) show that it is optimal to link an on-glide to the Nuc node rather than to link it to a nuclear mora.

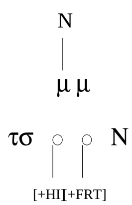
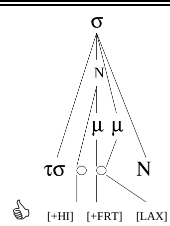
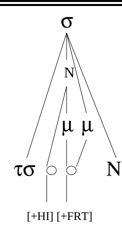
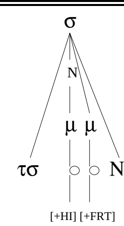
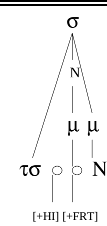
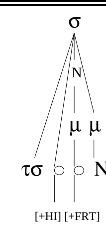
(39) Output candidates [τσιεN^{HL}] 'felt'

Input	$Cand_1$	$Cand_2$	$Cand_3$
	 [τσιεN^{HL}] 'felt'	 [τσιεN]	 [tsieN]
*Complex-Ons			*!
*Nuc/Hi		*!	

In (39) above, the last candidate incurs a violation mark for *Complex-Ons. since both the initial consonant [ts] and the on-glide [i] link to the syllable node directly. $Cand_2$ violates

*NUC/HI, while $Cand_1$ violates no constraints[9]. Therefore, $Cand_1$ is the optimal one.

(40) Candidate Outputs for [τσιEN^{MLM}] 'fight'

Input	$Cand_1$	$Cand_2$	$Cand_3$	$Cand_4$	$Cand_5$
	 [τσιEN^{MLM}] 'fight'	 [τσιε:N]	 [τσιεN]	 [τσεN]	 [τσιεN]
*COMPLEX-ONS					*!
HARM$^{\mu}$				*!	*!
PARSERT				*!	
*NUC/HI			*!		
LAXING		*!			

In tableau (40), the last candidate incurs a fatal violation mark for *COMPLEX-ONS. It also violates HARM$^{\mu}$ since the non-nuclear mora is filled by a consonant rather than a vowel. Parsing a velar nasal to the right mora, as in $Cand_4$, violates HARM$^{\mu}$, since the right mora is not filled with the most sonorous vowel [ε]. It also violates PARSERT, since the high vowel fails to be parsed onto any prosodic constituent. $Cand_3$ violates *NUC/HI, while $Cand_2$ violates LAXING. Only $Cand_1$ satisfies all constraints, and hence is optimal. The

[9] Notice that linking an on-glide to the Nuc node directly, as in $Cand_1$, does not incur a violation for *NUC/HI, since the nuclear mora is defined as a syllable head (see chapter 3), and the Nuc node indicates a syllable head with a mora as its content.

optimal outputs in both (39) and (40) satisfy all constraints, and there is no crucial ranking for these cases.

4.2.6 A summary

I have demonstrated in this section that Fuzhou vowel distributions can be derived by a set of constraints on the linking of vowel features to the existing contrastive syllable structures. First, the correspondence between monophthongs and diphthongs can be achieved by linking the same set of high vowels to the monomoraic syllables on the one hand and bimoraic syllables on the other hand. The lack of a vowel length contrast for the high vowels can be attributed to ranking ParseHi (which requires a high vowel to be parsed onto a prosodic anchor) above *Nuc/Hi (which prohibits a high vowel from being parsed onto a nuclear mora). Second, the tense/lax distinction between the two types of syllables can be captured by the length dependent constraint Laxing, which requires a doubly linked non-high vowel to become lax. Third, the harmonic restriction (i.e. the lack of low-high vowel sequence) on the tight syllables can be explained by the harmonic constraint: $*\text{Hi/Lo}^{\mu}$, which extends the grounding condition "if +Hi, then not +Lo" to the domain of the mora and prevents both [+Hi] and [+Lo] from linking to the same mora. Last, the asymmetric behavior of a high vowel with respect to its relevant syllable positions (i.e. nucleus vs. non-nucleus) can be accounted for by the interaction of ParseHi and *Nuc/Hi. The entire set of constraints and their ranking for Fuzhou syllabification is given in (41):

(41) Constraint Ranking for Fuzhou Syllabification

Lex-μ, Lex-F, Fill-μ, ParseRt, *ComplexOns, *ComplexCod, *Hi/Lo,
*Nuc/C, ParseHi >> ParseLo, *Nuc/Hi, Paras(Rd, Frnt), Laxing >> *Cod/Hi

4.3 Fuqing syllabification

The investigation of Fuqing tone-vowel interaction in chapter 2 shows that as in Fuzhou, there is a correlation between tonal contours and syllable types. This correlation is captured by the prosodic anchor hypothesis proposed in chapter 3. It is also shown that the vowel distributions in Fuqing are similar to those in Fuzhou in four respects. First, there is a tense/lax distinction between the two types of syllables (i.e. the tight syllables and the loose ones). Second, like Fuzhou, the cooccurrence of vocalic features is more restricted in the tight syllables than in the loose ones. In other words, the harmonic restrictions are also active in Fuqing. Third, as in Fuzhou, there is an asymmetry where high vowels behave differently with respect to different syllable positions. In particular, they surface as high in the tight syllables and as mid in the corresponding loose ones when they occur as nuclei of syllables. However, they do not alternate at all when they occur with another non-high vowel. Last, there is a correspondence between monophthongs and diphthongs when there is a on-glide present (or equivalently, a correspondence between diphthongs and triphthongs). Despite these similarities, Fuqing vowel distributions also exhibit some differences from those of Fuzhou. For instance, an underlying high vowel surfaces as high in the tight syllables, whereas it appears as mid in the corresponding loose syllables. This high/mid correspondence does not exist in Fuzhou. The goal of this section is to demonstrate how the set of constraints motivated for Fuzhou can also apply to Fuqing cases and the different vowel distribution effects can be captured by different rankings of the same set of constraints.

Before I go on to discuss Fuqing syllabification, a number of assumptions must be made explicit. First, I assume that the basic structural constraints and the association constraints on linking segments to syllable structures (M & P 1993a, b, P & S 1993) are also suitable for Fuqing. Second, I follow the combinatorial specification proposed by A & P (1994) and assume that features are combined to represent segments. Thus, Fuqing 7 vowels ι, ψ, υ, E (ε/E), © (Π/{), O (o/O), A (α/A/) can be represented as in (42). Fuqing data in this work are all from Feng's (1990, 1993) exhaustive descriptive works.

(42) Fuqing vowel representation

a. F-elements: +LO, +HI, +RD, +FRNT

b.

E_1	A	$ι_1$	O	E_2	υ	$ι_2$	©	*	*	*	ψ	*	*	*	*
	+LO							+LO	+LO	+LO		+LO	+LO	+LO	+LO
		+HI			+HI	+HI		+HI			+HI	+HI	+HI		+HI
			+RD		+RD		+RD		+RD		+RD	+RD		+RD	+RD
				+FRT		+FRT	+FRT			+FRT	+FRT		+FRT	+FRT	+FRT

c. Conditions: HI/LO if +HI, then not +LO.

LO/RD if +LO, then not +RD.

LO/FRT if +LO, then not +FRT.

Four active F-elements are postulated in (42a) and their combinations are represented in (42b). The *'s indicate the impossible combinations ruled out by the feature cooccurrence conditions in (42c).

4.3.1 The high/mid correspondence

I begin with Fuqing syllabification by examining the correspondence between high vowels in tight syllables and mid ones in the corresponding loose syllables. That is, an underlying high vowel appears as a single high vowel in the tight syllables, while it occurs as a mid vowel in the corresponding loose syllables. This correspondence does not exist in Fuzhou, and is illustrated in (43) below.

(43)		I "tight"		Gloss		II "loose"		Gloss	Distributions
	a.	τσι^{HM}	Ö ®	'a pronoun'	b.	τσε^{HL}	×Ö	'character'	/ι/ → i ~ ε
	c.	τσэυ^{HM}	´Ö	'rough'	d.	τэо^{ML}	íÃ	'rabbit'	/υ/ → υ ~ ο
	e.	τσψ^{M}	Öó	'boil'	f.	τσэΠ^{ML}	´¦	'place'	/ψ/ → ψ ~ Π

The data in (43) show that the high vowels [ι], [υ] and [ψ] in the tight syllables correspond to the mid vowels [ε], [ο] and [Π] in the loose syllables, respectively. This high/mid correspondence raises a question as to how the vowel differences in height between these two types of syllables can be achieved, given that the tight/loose distinction is argued to be a light-heavy distinction (i.e. monomoraic vs. bimoraic) of syllable weight (see chapter 2 section 5 for details). Comparing the high/mid correspondence with the similar cases in Fuzhou, where a monophthongal high vowel corresponds to a diphthong containing that high vowel, it is clear that the constraint ranking ParseHi >> *Nuc/Hi established from the monophthong/diphthong distinction in Fuzhou is not sufficient to account for the high/mid correspondence in Fuqing. We need a constraint that prevents a high vowel from linking to two moras within a syllable and a constraint that demands that two moras within a syllable agree in the feature value for [Hi]. These two constraints can be formulated as in (44) and (45), respectively:

(44) *Hi-μμ

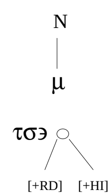
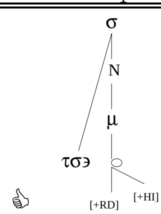
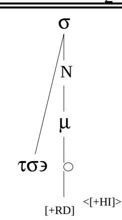
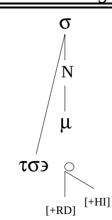
A feature [+Hi] cannot link to two moras within a syllable.

(45) Height Agreement within a syllable (HtAgrμμ)

Two moras within a syllable must agree in feature value for height.

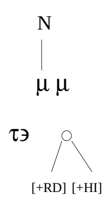
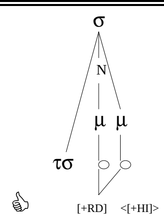
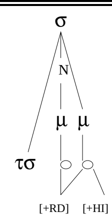
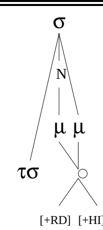
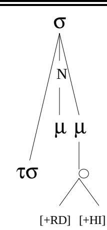
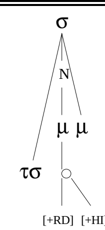
Combination of these two constraints will rule out cases where a high vowel links to two moras in a bimoraic syllable or either one of the two moras. The effect of *Hi-μμ and HtAgrμμ on deriving the high/mid distinction in <u>Fuqing</u> will be demonstrated in tableaux (46) and (47). Linking an underlying high vowel to a monomoraic syllable is simple, as is shown in (46).

(46) Output candidates for [τσэυ^{HM}] 'rough'

Input	Cand$_1$	Cand$_2$	Cand$_3$
	 [τσэυ^{HL}] 'rough'	 [τσo]	 [τσε]
ParseRt			*!
ParseHi		*!	
*Nuc/Hi	*		

The last candidate in (46) incurs a fatal violation for ParseRt, since the high vowel [u] fails to be parsed onto a prosodic anchor. There are two candidates left to compete with one another. Cand$_2$ violates ParseHi, while Cand$_1$ violates *Nuc/Hi. The ranking between these two constraints established in <u>Fuzhou</u> is ParseHi >> *Nuc/Hi. Thus, the first candidate wins since it only violates *Nuc/Hi, the lowest ranked constraint. Notice that the constraints *Hi-μμ and HtAgrμμ proposed above are not included in tableau (46) since these constraints only affect a bimoraic syllable and there is only one mora in this case. They will become important in determining an optimal output in a bimoraic syllable (47). It is important to point out that the ranking ParseHi >> *Nuc/Hi motivated by the correspondence between monophthongs and diphthongs in <u>Fuzhou</u> works equally well in determining the optimal output for the tight syllables for the high/mid distinction in <u>Fuqing</u>.

(47) Output candidates for [τɔo^{ML}] 'rabbit'

Input	$Cand_1$	$Cand_2$	$Cand_3$	$Cand_4$	$Cand_5$
	 [τɔo^{ML}] 'rabbit'	 [tsou]	 [τσυ:]	 [tsεu]	 [τσυε]
Fill-μ				*!	*!
*Hi-μμ			*!		
HtAgrμμ		*!		*!	*!
ParseHi	*				
*Nuc/Hi			*		*

In (47), the last two candidates all violate Fill-μ, since one of the two moras in each of them is left unfilled. The middle two candidates violate *Hi-μμ and HtAgrμμ, respectively. In particular, linking a high vowel to both moras, as in $Cand_3$, violates *Hi-μμ, whereas parsing it to the right mora only, allowing the feature [Rd] to fill the nuclear mora (as in $Cand_2$), violates HtAgrμμ because the two moras within a syllable do not agree in the feature value for height (i.e. the left mora is [-Hi], while the right mora is [+Hi]). The first candidate satisfies all constraints except ParseHi. Notice that underparsing [+Hi] is the only way to satisfy the three constraints Fillμ, *Hi-μμ and HtAgrμμ. In other words, not ranking these three constraints forces [+Hi] to be unparsed, resulting in a long mid vowel. The crucial ranking for the high/mid correspondence is: ParseRt, Fillμ, *Hi-μμ, HtAgrμμ >> ParseHi >> *Nuc/Hi.

4.3.2 The tense/lax distinction

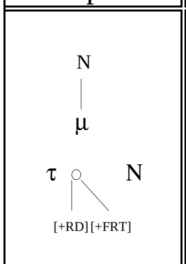
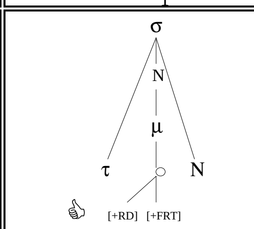
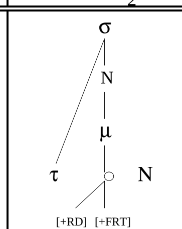
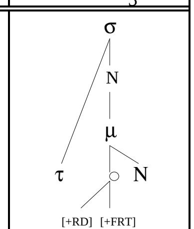
As in Fuzhou, Fuqing vowel distribution also exhibits a tense/lax distinction between the two types of syllables. This kind of vowel quality difference is argued to represent primarily a length distinction which has certain featural content (see chapter 2 section 5 for details). That is, when a non-high vowel links to a monomoraic structure, it becomes a tense vowel (i.e. [ε], [o], [Π] or [α]) in the tight syllables. When a non-high vowel links to a bimoraic structure, it appears as a lax vowel (i.e. [E], [O], [{] or [A]) in the loose syllables. This is illustrated in (48) below.

(48)	**I** "tight"		Gloss		**II** "loose"		Gloss	Distributions
a.	νιεN^{M}	È¾	'dye'	b.	NιE^{HL}	Ò Õ	'art'	/e/ → ε ~ E
c.	τσэψo N^{H}	Ç½	'wall'	d.	τσэψON ^{ML}	³ª	'sing'	/o/ → o ~ O
e.	τΠN^{HM}	¶¬	'winter'	f.	τ{N^{HL}	¶¯	'to move'	/© / → Π ~ {
g.	πα^{HM}	°×	'white'	h.	πA^{ML}	°Ù	'hundred'	/a/ → α ~ A

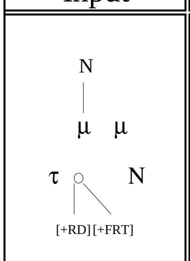
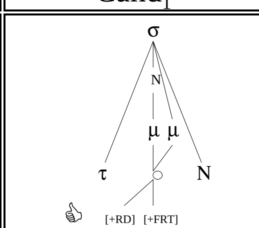
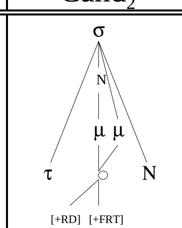
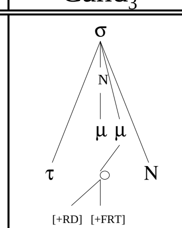
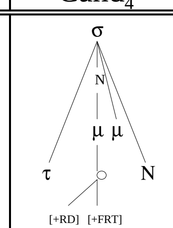
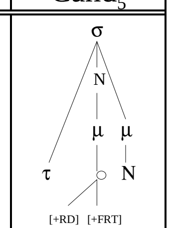
To account for the tense/lax distinction shown in (48), the Length Dependent Constraint (Laxing) in (26) (i.e. If α is parsed onto two moras, then α is [Lax]) proposed for the similar case in Fuzhou is suitable here. I demonstrate in the following tableaux (49) and (50) that it is the constraint Laxing, along with the faithfulness Fill-μ, that gives the tense/lax distinction for the non-high vowels.

The two candidates in (49) show that linking the velar consonant [N] to a mora in $Cand_3$ violates *Nuc/C, while underparsing it in $Cand_2$ violates ParseRt. The violation is avoided in $Cand_1$ by linking the consonant to the syllable node. Since $Cand_1$ satisfies both constraints, it is the optimal one. Notice that the constraint Laxing plays no role here since the input for this case is a monomoraic structure.

(49) Output candidates for [τΠN^{HM}] 'winter'

Input	$Cand_1$	$Cand_2$	$Cand_3$
	 [τΠN^{HM}] 'winter'	 [τΠ]	 [τΠN]
*Nuc/C			*!
ParseRt		*!	

(50) Output candidates for [τ{N^{HL}] 'to move'

Input	$Cand_1$	$Cand_2$	$Cand_3$	$Cand_4$	$Cand_5$
	 [τ{N^{HL}] 'to move'	 [τΠ:N]	 [τεΠN]	 [τΠεN]	 [τΠN]
*μ/C					*!
Fill-μ			*!	*!	
Laxing		*!			

In (50), the violations of *μ/C and FILL-μ in the last three candidates are fatal. Compare the first two candidates. $Cand_2$ violates LAXING (i.e. a front round vowel links to two moras without becoming lax) while $Cand_1$ does not. Thus, the first candidate wins. Notice that in these cases, there is no crucial ranking among these constraints since the optimal outputs satisfy all constraints.

4.3.3 The harmonic restrictions on the tight syllables

The vowel distributions in Fuqing also exhibit the harmonic restrictions on the tight syllables, as found in Fuzhou. The difference between these two languages in this regard is that the prohibition of the low-high sequence within a monomoraic syllable and the agreement in roundness and frontness are required at the same time in Fuqing, whereas these two restrictions apply to different cases separately in Fuzhou. The data in (51) illustrate these restrictions.

(51)	**I** "tight"		Gloss		**II** "loose"		Gloss	Distribution
a.	πιευ^{M}	±í	'watch'	b.	κι υ^{HL}	½Î	'sedan'	ιευ ~ ι υ
c.	πυοι^{HM}	±-	'cup'	d.	πυ ι^{ML}	±´	'shell'	υοι ~ υ ι

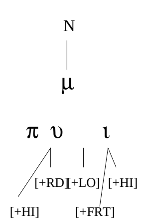
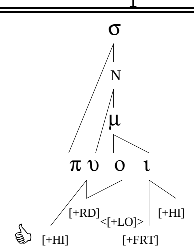
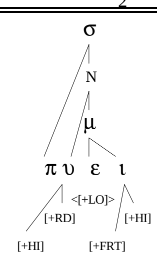
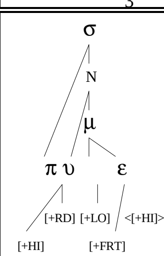
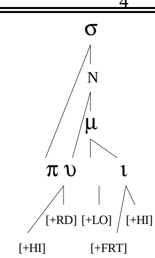
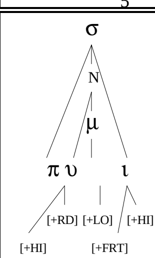
Two generalizations that can be abstracted from the data in (51) are (i) a mid vowel in the tight syllables corresponds to a low vowel in the loose syllables when it is flanked by two high vowels; (ii) the mid vowels in the tight syllables (51a, c) agree in frontness and roundness with the preceding high vowel but not with the following high vowel. The first generalization can be explained by the *HI/LO^{μ} condition proposed for Fuzhou. That is, linking both a low and a high vowel to the same mora is disallowed. Since the tight syllables are monomoraic, the only way to satisfy the *HI/LO^{μ} condition is to underparse either the feature [+HI] or the feature [+LO]. To ensure that the feature that is underparsed is [+LO] but not [+HI], PARSEHI must rank above PARSELO, as in <u>Fuzhou</u>. Moreover, to account for the second generalization, i.e., the feature agreement between the mid vowel and its preceding high vowel in the tight syllables, I propose that the roundness and frontness agreement between an on-glide and its following non-low vowel can be achieved by a feature agreement constraint, as stated in (52):

(52) Feature Agreement Constraint (F-AGR[RD] or [FRNT])

A non-low nuclear vowel must agree with its preceding on-glide in feature value for [RD] and [FRONT].

The function of (52) is to demand a harmonic feature cooccurrence between a nuclear vowel and its preceding on-glide. Thus, the roundness and frontness agreement are accounted for. Tableaux (53) and (54) demonstrate how F-AGR[RD] interacts with other constraints, such as *HI/LO$^{\mu}$, PARSEHI and PARSELO in deriving the optimal outputs.

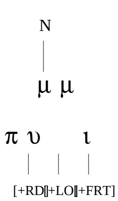
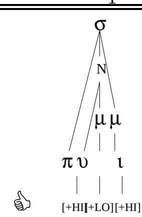
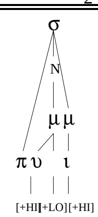
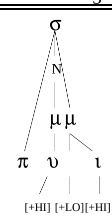
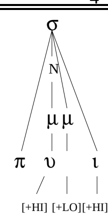
(53) Output candidates for [πυοι^{HM}] 'cup'

Input	Cand$_1$	Cand$_2$	Cand$_3$	Cand$_4$	Cand$_5$
	 [πυοι^{HM}] 'cup'	 [πυει]	 [πυ ε]	 [πυ ι]	 [πυ ι]
*COD/HI					*!
*HI/LO$^{\mu}$				*!	*!
PARSEHI			*!		

F-Agr[Rd]		*!	*!		
ParseLo	*	*			

In (53), the last two candidates violate *Cod/Hi and *Hi/Lo$^{\mu}$ respectively, since the high vowel [i] is parsed onto a syllable node directly in Cand$_5$, and the nuclear mora is filled by both the high and low vowels in Cand$_4$. The first three candidates violate ParseHi, F-Agr[Rd] and ParseLo respectively. In Cand$_1$, the feature [+Lo] is unparsed, while in Cand$_3$, the feature [+Hi] is unparsed. Cand$_2$ violates F-Agr[Rd], because the nuclear non-low vowel does not agree with its preceding on-glide in feature value [+RD]. Since ParseHi and F-Agr[Rd] rank above ParseLo, Cand$_1$ wins. The crucial ranking in this case is that *Cod/Hi, *Hi/Lo$^{\mu}$, ParseHi, and F-Agr[Rd] must rank above ParseLo.

(54) Output candidates for [πυ ι^{ML}] 'shell'

Input	Cand$_1$	Cand$_2$	Cand$_3$	Cand$_4$
	 [πυ ι^{ML}] 'shell'	 [πυ ι]	 [πυ ι]	 [πυ ι]
*Cod/Hi				*!
*Nuc/Hi		*!	*!	*!
*Hi/Lo$^{\mu}$		*!	*!	

Now let's turn to the case in (54) where the input contains two moras. All candidates except the first one incur a violation mark. That is, Cand$_4$ violates both *Cod/Hi and *Nuc/Hi, whereas Cand$_2$ and Cand$_3$ violate both *Nuc/Hi and *Hi/Lo$^{\mu}$. Only the first candidate does not violate any of these constraints, thus is the optimal one. Notice that the constraints (i.e. *Hi/Lo$^{\mu}$, ParseHi, F-Agr[Rd], ParseLo) and their ranking that are crucial in (53) no longer matter in (54), since the input is bimoraic, allowing both the high and low vowels to link to a separate mora.

4.3.4 The asymmetry of the high vowels

The asymmetric behavior of high vowels with respect to their syllable positions in Fuqing is similar to that found in Fuzhou. The data in (55a-d) show that a high vowel in the tight syllables corresponds to a mid vowel in the loose syllables. However, this kind of vowel distribution does not show up in (55e-h). The difference between the high vowels in (55a-d) and the ones in (55e-h) is the syllable positions they occur in. In particular, the high vowels in the former appear as syllable nuclei, whereas the ones in the latter case occur with other non-high vowels (i.e. as on-glides).

(55)	**I** "tight"		Gloss		**II**"loose"		Gloss	Distributions
a.	τσι$^{\text{HM}}$	Ö ®	'a pronoun'	b.	τσε$^{\text{HL}}$	×Ö	'character'	i ~ ε
c.	τσ϶υ$^{\text{HM}}$	´Ö	'rough'	d.	τ϶ο$^{\text{ML}}$	íÃ	'rabbit'	υ ~ ο
e.	σιαΝ$^{\text{HM}}$	Éù	'sound'	f.	σιΑΝ$^{\text{ML}}$	Ïß	'line'	* i ~ e
g.	πυαΝ$^{\text{H}}$	Åì	'dish'	h.	πυΑΝ$^{\text{ML}}$	°ë	'half'	* u ~ o

The different syllable positions affecting the behavior of the high vowels can be accounted for in the prosodic anchor hypothesis proposed since the linking between syllable structures and vowel features is direct and is governed by the interaction of the constraints, such as the faithfulness Fill-μ, ParseHi, and the association constraints like

*NUC/HI. The tableaux (56) and (57) below show how the non-alternation of a high vowel in a pre-nuclear position is achieved.

(56) Output candidates for [σιαN^{HM}] 'sound'

Input	Cand$_1$	Cand$_3$	Cand$_4$	Cand$_5$	Cand$_2$
N μ σ ι α N	σ N μ ☞ σ ι α N [σιαN^{HM}] 'sound'	σ N μ σ ι <a>N [σιN]	σ N μ σ <i> α N [σαN]	σ N μ σ ι α N [σιαN]	σ N μ σ ι α N [σιαN]
*Nuc/C					*!
*Hi/Lo$^{\mu}$				*!	
ParseHi			*!		
ParseLo		*!			

In (56), linking both a low vowel and a velar consonant to the same mora, as in Cand$_5$, violates *Nuc/C, whereas linking a high vowel and a low vowel to the same mora, as in Cand$_4$, violates the harmonic condition *Hi/Lo$^{\mu}$. Both the last two candidates are out. Compare the middle two candidates. Underparsing either [+Hi] or [+Lo] violates ParseHi or ParseLo, as in Cand$_3$ and Cand$_2$ respectively. Cand$_1$ violates no constraints, thus is optimal.

When an input is bimoraic, it is possible for a low vowel and its following consonant to link to separate moras. In such a case the Harmonic Mora constraint (Harm$^{\mu}$) proposed in (36) plays an important role in determining the optimal output. What Harm$^{\mu}$ requires is that the most sonorous segment makes the most harmonic mora (i.e. *μ/C >> *μ/Hi >> *μ/Lo). Tableau (57) illustrates how Harm$^{\mu}$ and its interaction with other constraints such as *Nuc/Hi and Laxing, give rise to an optimal output in a loose syllable.

(57) Output candidates for [σιAN^{ML}] 'line'

Input	Cand$_1$	Cand$_2$	Cand$_3$	Cand$_4$
N μ μ σ ι α N	σ N μ μ ☞ σ ι A N [σιAN^{ML}] 'line'	σ N μ μ σ ι α N [σια:N]	σ N μ μ σ ι αN [σιαN]	σ N μ μ σ ι αN [σιαN]
Harm$^{\mu}$			*!	*!
*Nuc/Hi			*!	
Laxing		*!		

In (57), the last two candidates violate Harm$^{\mu}$ in different ways. In Cand$_4$, the right mora is filled by a consonant, while in Cand$_3$, the left mora is filled by a high vowel. The first two candidates satisfy both Harm$^{\mu}$ and *Nuc/Hi by linking the low vowel to both moras. However, the second candidate violates the length dependent constraint Laxing, because a doubly linked non-high vowel does not become [lax] in Cand$_2$. The first candidate satisfies all constraints, and therefore is the best output. Since the optimal outputs in this pair satisfy all constraints, there is no crucial ranking in these cases.

4.3.5 The diphthongs vs. triphthongs

The correspondence between diphthongs and triphthongs in Fuqing differs from that between monophthongs and diphthongs in Fuzhou in that it involves two high vowels. In particular, the triphthongs occur in the loose syllables only when there are two high vowels present. This is shown in (58) below.

(58)	**I** "tight"		Gloss		**II** "loose"		Gloss	Distributions
a.	τυι^{H}	΄.	'thump'	b.	τυοι^{HL}	¶Ó	'team'	υι ~ υοι
c.	τσэιυ^{H} M	Çï	'autumn'	d.	κιευ^{HL}	¾ Ë	'uncle'	ιυ ~ ιευ

Two properties emerge from the examination of the data in (58). One is that when an input contains two high vowels in the tight syllables, the corresponding loose syllables have the form of a mid vowel flanked by the two high vowels. The other one is that the mid vowel must agree in roundness and frontness with its preceding high vowel but not with its following high vowel. Under the current theory, the first property is expected, since the tight/loose distinction is identified as a weight distinction between the monomoraic and bimoraic syllables. It is natural for a bimoraic syllable to contain one more segment than a monomoraic syllable. The second property, namely, the roundness and frontness harmony, is by no mean a unique property for this type of distinction. It is also found in the corresponding pairs **црк** ~ **ц□к** and **кец** ~ **к□ц** in which **црк** and **кец** occur in the tight syllables. Comparing the data in (58) with the data in (51), it becomes clear that the harmonic restrictions for the feature [RD] and [FRONT] between a non-low nuclear vowel and its preceding on-glide is a general property in Fuqing. It applies to both types of syllables. Therefore, the Feature Agreement Constraint (F-AGR[RD] or [FRNT]) proposed in (52) for the harmonic restriction on the tight syllables also applies to the loose syllables here. Moreover, it is important to note that in a tight syllable, it should be possible for either **к** or **ц** in (58a) and (58c) to link to the nuclear mora. Our account proposed for the data in (51) shows that a high vowel linked to a syllable node directly is disallowed by the constraint *COD/HI, and that a mid vowel is analyzed as absence of +LO and +HI. The constraint *COD/HI is also applicable in the current case. The tableaux (59) and (60) show how the constraints F-AGR[RD] and *COD/HI, as well as their interaction with *NUC/HI and FILL-μ are sufficient to derive the **цк** ~ **црк** pair.

(59) Output candidates for [τυι^{H}] 'thump'

Input	Cand$_1$	Cand$_2$	Cand$_3$	Cand$_4$
N μ τ υ ι [+RD] [+FRT]	σ N μ τ υ ι ☞ [+RD] [+FRT] [τυι^{H}] 'thump'	σ N μ τ υ ι [+RD] [+FRT] [τυι]	σ N μ τ υ ι [+RD] [+FRT] [τυ]	σ N μ τ υ ι [+RD][+FRT] [τι]
ParseRt			*!	*!
*Cod/Hi		*!		

In (59), the last two candidates violate ParseRt, since one of the two high vowels is left unparsed in each of the candidates. Compare the first two candidates. Cand$_2$ violates *Cod/Hi (that is, a high vowel is not allowed to link to a syllable node directly), while Cand$_1$ does not. Therefore, the first one is optimal since it does not violate anything.

(60) Output candidates for [τυοι^{HL}] 'team'

Input	Cand$_1$	Cand$_2$	Cand$_3$	Cand$_4$
N μ μ τ υ ι [+RD] [+FRT] [+HI]	σ N μ μ τ υ ○ ι ☞ [+RD] [+FRT] [τυοι^{HL}] 'team'	σ N μ μ τ υ ι [+RD] [+FRT] [τυοι]	σ N μ μ τ υ ι [+RD] [+FRT] [τυι]	σ N μ μ τ υ ○ ι [+RD] [+FRT] [τΠι]
*Cod/Hi				*!
*Nuc/Hi			*!	*!
Fill-μ		*!		

In (60), the last candidate violates *Cod/Hi and *Nuc/Hi since the two high vowels **ц** and **к** are parsed onto the nuclear mora and the syllable node respectively. $Cand_2$ violates Fill-μ while $Cand_1$ violates nothing. Therefore, the first candidate wins. Since all constraints are respected in the optimal outputs, there is no crucial ranking for this pair.

4.3.6 A summary

Fuqing syllabification demonstrated in this section shows that the different vowel distribution pairs can be derived by linking the same sets of vocalic features to the distinctive syllable structures which are determined by the tonal specifications. Five types of vowel distribution between the tight and the loose syllables are captured in this section: (i) the high/mid contrast; (ii) the tense/lax distinction; (iii) the harmonic restrictions on the tight syllables; (iv) the asymmetric behavior of high vowels with respect to their different syllable positions; and (v) the correspondence between diphthongs and triphthongs in the case where the input contains two high vowels. Constraints invoked in Fuqing syllabification are summarized in (61) and their ranking is given in (62):

(61) Constraints for Fuqing syllabification

a. Faithfulness: Fill-μ, ParseRt, ParseHi, ParseLo
b. Segmental sonority: *Nuc/Hi, *Nuc/C, *Cod/Hi, Harm$^{\mu}$
c. Harmonic: HtAgrμμ, F-Agr [Rd], *Hi/Lo$^{\mu}$,
d. Parasitic: *Hi-μμ, Laxing

(62) Constraint ranking in Fuqing

Lex-μ, Fill-μ, ParseRt, *Nuc/C, *Cod/Hi, *μ/C, HtAgrμμ, F-Agr [Rd], *Hi/Lo$^{\mu}$, Harm$^{\mu}$, *Hi-μμ, Laxing, ParseHi >> ParseLo, *Nuc/Hi

4.4 Conclusion

I have motivated a set of constraints governing linking of vowels to the distinctive moraic structures in both Fuzhou and Fuqing, and demonstrated that the interaction of the constraints is successful in deriving the vowel distribution pairs in these two languages. The constraints governing syllabification in Fuzhou and Fuqing are of four types. The first type are the faithfulness constraints, such as the Parse family (i.e. ParseRt, ParseHi, ParseLo), the Fill family (i.e. Fill-μ), and the Lex family (i.e. Lex-μ, Lex-F). The second type of constraints are the ones encoding the intrinsic segmental sonority to certain syllable positions, such as *Nuc/Hi, *Nuc/C, *Cod/Hi. The third type are the harmonic ones like HtAgrμμ, F-Agr [Rd], *Hi/Lo$^{\mu}$. This set of constraints requires certain featural agreement within a certain prosodic domain or prohibits conflicting features from occurring the same domain. The last type of constraints is the parasitic group, such as *Hi-μμ and Laxing. This set of constraints is related to syllable length. They either prevent a high vowel from linking to two moras or assigning a certain feature to a segmental root doubly linked to two moras. The vowel distribution patterns in both Fuzhou and Fuqing are derived by the different rankings of the crucial constraints, as shown in (63) and (64), respectively.

(63) Fuzhou ranking

*Nuc/C >> *Nuc/Hi >> *Cod/Hi

(64) Fuqing ranking

*Nuc/C, *Cod/Hi >> *Nuc/Hi

Notice that the majority of the constraints proposed are common in both languages. Both Fuzhou and Fuqing, for instance, invoke the same types of faithfulness, such as Lex and FILL which are undominated in these languages. The internal ranking of the PARSE family is that both PARSERT and PARSEHI must dominate PARSELO. Moreover, there is a difference between these two languages in terms of ranking schema of the constraint restricting certain segments to certain syllable positions. In Fuzhou, *NUC/C must rank above *NUC/HI, which in turn ranks above *COD/HI, whereas in Fuqing, both *NUC/C and *COD/HI dominate *NUC/HI. The third difference between these two languages in terms of ranking is the relation between *HI/LO$^{\mu}$ and LAXING. *HI/LO$^{\mu}$ must rank above LAXING in Fuzhou, while they are not crucially ranked with respect to each other in Fuqing.

CHAPTER 5

Stress effects on tone-vowel interaction

5.0 Introduction

Two asymmetries regarding tone sandhi and vowel alternation in Fuzhou and Fuqing emerge from the investigation of disyllabic words in chapter 2. One is the asymmetric behavior of syllables in different positions within a disyllabic domain. In particular, a syllable in a non-final position (i.e., σ_1 of a sequence $\sigma_1\sigma_2$) usually undergoes either tonal or both tonal and vocalic changes. In contrast, the syllables in a final position (i.e., σ_2 of a sequence $\sigma_1\sigma_2$) do not change their lexical properties (either tone or vowel quality). The other asymmetry is the different behavior of the tight syllables and the loose ones in the very same non-final position. The loose syllables in a non-final position always undergo both tonal and vocalic changes, whereas the tight syllables in the same position never change their vowels, even though some of them do have tonal changes. Furthermore, there is an identical patterning between vowel alternations and distributions. That is, the vowel alternation patterns involved in the disyllabic words are the same as the vowel distribution patterns exhibited in monosyllabic words. Moreover, the tonal changes in the loose syllables are predictable. That is, the outputs of the changed tones must fall into the tonal categories in the tight syllables.

Four questions arise from the observations described above. (i) Why do tone sandhi and vocalic changes only happen to a non-final syllable within a disyllabic domain? In other words, what is the difference between a final syllable and a non-final syllable in that domain? (ii) Why do only the loose syllables undergo the vocalic change but not the tight ones? (iii) Why do the vocalic changes in disyllabic words follow the vowel distributional patterns in the monosyllabic words, namely, the changes are from the loose syllables to the tight ones, but not vice versa? (iv) Are tone sandhi and vocalic changes related to each other? If not, what triggers their changes?

This chapter aims at providing an answer for these questions. First, I address the question of how stress affects tone-vowel interactions and identify what are the exact factors that govern the asymmetry of the syllables in different positions within the same domain and the asymmetry between the loose syllables and the tight ones in the same position (i.e., the non-final position). Second, I extend the analysis proposed for the vowel distributions in monosyllabic words to the vowel alternations in disyllabic compounds, and investigate whether the prosodic anchor hypothesis proposed in chapter 3 and the constraints on syllabification motivated in chapter 4 can account for the identical patterns between vowel distributions and alternations. Third, I explore the vowel alternations in the reduplication forms, and provide an account for the vowel changes between a base and a reduplicant based on the prosodic anchor hypothesis and prosodic morphology within the OT framework (M & P 1993a, b, 1994, 1995). Last, I examine the similarities and differences between the reduplication forms and Fanqie words (i.e., the "cutting foot words"), showing that the apparent different outputs between these two types of forms (i.e., the full copy in the reduplications and the partial copy in the Fanqie words) lies in the interaction of alignment constraints and structural constraints. Thus, the vowel variations in various forms (i.e., disyllabic compounds, reduplications and Fanqie words) in Fuzhou and Fuqing can be uniformly explained.

5.1 How does stress affect tone-vowel interaction?

This section focuses on the asymmetric behavior of syllables with respect to their different positions within a disyllabic domain, and examines how stress actually affects tone-vowel interaction. By a close examination of the spectrographic evidence provided by Wright (1983), I attempt to identify the exact factors that govern these asymmetries. I will then propose a set of constraints which incorporate Wright's insight and account for the asymmetries observed. I will further demonstrate how featural stability on the one hand and the lack of featural stability on the other hand can be achieved by the interaction of these constraints.

5.1.1 Identifying stress effects

The first asymmetry observed in chapter 2 is that the loose syllables in both Fuzhou and Fuqing behave differently with respect to the different positions in a disyllabic compound. They undergo both tonal and vocalic changes when they do not occur domain-finally. The tonal and vowel changes of the loose syllables in a non-final position are illustrated in (1). The data of Fuzhou disyllabic compound nouns are from Liang (1983a). The morphemes that undergo changes are emphasized by shading. The underscore indicates the tone and vowels that will undergo changes in the shaded column, and their corresponding outputs in the disyllabic column. The dots in the compounds signal syllable/morpheme breaks.

(1)		Morph.	Gloss +	Morph.	Gloss	→	Disyllabic N	Gloss
	a.	κι$\underline{\text{A}}$N$^{\underline{MLM}}$	'mirror'	συοN^{H}	'box'	→	κι$\underline{\alpha}$N$^{\underline{H}}$.νυοN^{H}	'jewellery box'
	b.	η$\underline{\text{ου}}$N$^{\underline{MHM}}$	'neck'	λιEN^{MHM}	'chain'	→	η$\underline{\upsilon}$N$^{\underline{HM}}$.λιEN^{MHM}	'necklace'

The first morpheme (i.e., the ones in the shaded column) of a compound in both (1a) and (1b) contains a complex contour tone: that is, a MLM contour in (1a) and a MHM contour in (1b). They are loose syllables. When they combine with a following morpheme to form a compound, the vowel [A] in (1a) becomes its tense counterpart [α], and the diphthong [οʋ] in (1b) becomes its tight counterpart monophthongal [ʋ]. Furthermore, the complex tonal contours in both (1a) and (1b) are simplified in the compounds. The MLM contour in (1a) changes into a H level tone, while the MHM contour in (1b) changes into a simple contour HM. Of interest is that not only the vowel changes are from the vowels in the loose syllables to the forms in the tight syllables, the output tones of the changed syllables also belong to the tonal categories in the tight syllables. The similarities between the syllables in a non-final position within a disyllabic domain and the tight syllables standing alone as monosyllabic words suggest that these two forms must have something in common. This kind of co-variation between tone and vowels in (1), however, does not show up in (2), where the loose syllables occur in a final position within a disyllabic compound. That is, the morphemes in the shaded cells become the second morphemes in the disyllabic compounds.

(2)		Morph	Gloss	+	Morph.	Gloss	→	Disyllabic N	Gloss
	a.	μι$^{\underline{ML}}$	'rice'		τOψ^{MHM}	'bag'	→	μι$^{\underline{H}}$.λOψ^{MHM}	'rice bag'
	b.	κιε$^{\underline{H}}$	'platform'		τσO^{MHM}	'step'	→	κιε$^{\underline{HM}}$.ZO^{MHM}	'steps'
	c.	τιαN$^{\underline{ML}}$	'pot'		π϶ιEN^{MLM}	'thin piece'	→	τιαN$^{\underline{H}}$.μιEN^{MLM}	'lid, cover'
	d.	σαι$^{\underline{ML}}$	'be bossy'		τσ϶υOι^{MLM}	'beak'	→	σαι$^{\underline{H}}$.ZυOι^{MLM}	'servant'

Like the morphemes in the shaded cells in (1), the ones in the shaded column in (2) contain complex tonal contours (i.e., either MLM or MHM), hence are loose syllables.

When they occur domain-finally in a disyllabic compound (i.e., the column after the arrows), their tonal contours and vocalic properties remain unchanged[1].

Comparing the lack of feature changes in the domain-final syllables in (2) with the changes of the tone and vowels in the non-final position in (1), it becomes clear that different positions within a disyllabic domain play a crucial role for the contrast between the featural stability on the one hand and the featural change on the other. The question that arises from these observations is what makes these positions different from each other. In other words, how can we explain the contrast between the featural stability in final position and the lack of featural stability in non-final position within the same domain?

The other asymmetry observed in chapter 2 is that tight syllables in a disyllabic domain behave differently from the loose ones in the same domain. They do not change their vowels no matter whether they occur domain-finally or not. That is, the contrast between a non-final and a final position exhibited in (1) and (2) does not show up in (3), where both morphemes within a disyllabic compound are tight syllables. The Fuzhou data in (3) are from Liang (1983a).

(3)	Morph.	Gloss	+	Morph.	Gloss	→	Disyllabic N	Gloss
a.	ηαι$^{\underline{HM}}$	'earthenware'		κυο^{H}	'pot'	→	ηαι$^{\underline{ML}}$.κυο^{H}	'earthenware pot'
b.	α^{H}	'girl'		κэυαN^{HM}	'circle'	→	α^{H}.κэυαN^{HM}	'maid'

---

[1] Notice that the consonants [τσ] and [τσэ] in (2b, d) become [Z] intervocalically, and [πэ] in (2c) becomes [μ] when it follows a nasal of its preceding morpheme. Since this thesis focuses its attention on tone-vowel interaction, this kind of consonant change will not be discussed.

c. τσειN$^{\underline{ML}}$ 'cut' ψN^{HM} 'flannel' → τσειN$^{\underline{L}}$.NψN^{HM} 'cotton flannel'

The morphemes in the compounds in (3) contain either a H level tone or a simple contour tone (i.e., HM or ML), hence they are tight syllables. This type of syllable does not exhibit vowel changes at all, no matter where the vowels occur. For instance, the compound noun [ηαι$^{\underline{ML}}$ κυο^{H}] 'earthenware pot' in (3a) is comprised by the two morphemes [ηαι$^{\underline{HM}}$] 'earthenware' and [κυο^{H}] 'pot', whose vowels [αι] in the non-final position and [υο] in the final position remain unchanged. The same kind of vowel stability is also observed in (3b) and (3c). The question raised from the comparison of the lack of contrast in (3) with the contrast in (1) and (2) is that if the vowel changes were due to the different positions within a disyllabic domain, why don't the different positions in the same domain trigger any vowel alternations for the tight syllables in (3)? The two asymmetries observed in (1), (2) and (3) can be summarized in (4).

(4) Two asymmetries of syllables in a disyllabic domain

DOMAIN: [σ_1 σ_2]	σ_1		σ_2	
	tight σ	loose σ	tight σ	loose σ
VOWEL CHANGE	NO	YES	NO	NO
TONAL CHANGE	SOME	ALL	NO	NO

The chart (4) shows that the contrast between σ_1 and σ_2 in terms of their feature stability is quite straightforward. That is, the second syllable (i.e., σ_2) within a disyllabic domain never changes its lexical properties, no matter whether it is tight or loose. On the other hand, the change of features in the first syllable within a disyllabic domain is more complex. Different syllables in this position behave differently. In particular, the tight syllables do not have any vowel changes, even though some of them might have tonal changes. Conversely, the loose syllables in this position always have both tonal and vowel changes. Our task then is to find an explanation for these asymmetries.

Attempting to account for the tone sandhi and vowel alternations in Fuzhou, Wright (1983) conducted a series of experimental studies, and found that the length of the first syllable in a disyllabic word reduces nearly two thirds in duration from its citation form (i.e., the form which stands alone as a monosyllabic word). Some of the examples provided by Wright (1983) are given in (5) below. The duration in milliseconds of each monosyllabic morpheme is listed in the left shaded column. The right shaded column indicates the duration of a disyllabic word with the numbers before "/" for the first syllable and the ones after "/" for the second syllable. The dots in the disyllabic words indicate syllable and/or morpheme boundaries. The underscore indicates tonal and vocalic changes.

(5) Duration change for loose syllables in Fuzhou (Wright 1983:36-38)

	morph[2]		Gloss	msec.	disyl. word		Gloss	msec. σ_1/σ_2
a.	κει^{12}	¼Ç	'record'	320	κι^{52}.αυ^{12}	¼ÇºÅ	'mark, sign'	136/432
b.	κου^{12}	¹Í	'rent'	400	κυ^{52}.τσωΟ^{12}	¹Í	'rent house'	152/432
c.	τοι^{12}	¶Ô	'facing'	368	τΠψ^{52}.πι^{22}	¶Ô±È	'to contrast'	144/280

[2] The 12 tone in this column belongs to the category of *Yin Qu*, which is a MLM contour tone in our representation.

The morphemes in (5) contain a tonal category and vocalic forms that belong to the loose syllables. When they combine with a following morpheme to form a disyllabic compound, they change both their tonal contour and vowel features. Comparing the numbers in the two shaded columns, the monosyllabic morpheme [κει^{12}] 'record' in (5a) has a duration of 320 msec. When it co-occurs with a following morpheme in a disyllabic compound [κι^{52}.αυ^{12}] 'mark, sign', its duration reduces to 136 msec. The same pattern of duration reduction is also observed in (5b) and (5c), where the morphemes [κου^{12}] 'rent' and [τοι^{12}] 'facing' reduce their duration from 400 msec. and 368 msec. to 152 msec. and 144 msec., respectively. Moreover, comparing the numbers before the slash "/" with the ones after the slash "/" in the last column, shows clearly that the duration of the first syllable is significantly shorter than that of the second syllable within the same domain.

The data in (5) seems to suggest a correlation between duration reduction and the change of vowel features for the non-final syllables. A closer examination of the same type of data in (6), however, shows that the evidence for the apparent correlation between the shortening of syllable and the change of features in (5) is inconclusive. Cases where syllables in a non-final position reduce their duration without involving any vocalic change are also found in Wright's spectrographic studies. The examples in (6) are drawn from Wright (1983).

(6) Duration change for tight syllables in Fuzhou (Wright 1983:36-38)

	morph[3]		Gloss	msec.	disyl. word		Gloss	msec. σ_1/σ_2
a.	ηι^{44}	·É	'fly'	304	ηι^{44}.κι^{44}	·É»ú	'airplane'	112/280
b.	κυ^{52}	ºý	'paste'	400	κυ^{22}.τσαι^{22}	ºýÖ½	'paste paper'	144/366

[3] The 44 and 53 tones in this column belong to the categories of *Yin Ping* and *Yang Ping* respectively. They are H level and HM contour tones in our representation.

c.	τσΠψ$^{\underline{52}}$	²Ã	'to cut'	456	τΠψ$^{\underline{22}}$.πυν^{5} 2	²Ã·ì	'tailor'	128/336

All morphemes in (6) have tones that belong to the tight syllables. Comparing the two shaded columns, the duration of the morpheme [ηι^{44}] 'fly' in (6a) is 304 msec. When it combines with another morpheme to form a disyllabic compound [ηι^{44}.κι^{44}] 'airplane', its duration reduces to 112 msec., nearly one third of its duration as a citation form. The same shortening effect is also observed in [κυ$^{\underline{52}}$] 'paste' (6b) and [τσΠψ$^{\underline{52}}$] 'to cut' (6c), where the duration for these monosyllabic morphemes reduces from 400 msec. and 456 msec. to 144 msec. and 128 msec., respectively. Note that, unlike the data in (5) where the shortening of duration is accompanied by the vocalic changes, the vowels in the non-final syllables in (6) do not undergo any change, even though their duration has been shortened and some of them have tonal changes, such as the examples in (6b) and (6c). Comparing (5) with (6), reveals that the vowel alternations in a disyllabic compound relate to, but do not necessarily result from, the duration reduction.

Based on these findings, Wright claims that the tone sandhi and the vowel alternations in Fuzhou are independently triggered by stress, and that stress in Fuzhou is assigned to an iambic foot with the final syllable being a metrical head. The stress effect on tone sandhi is more direct. That is, the shortening of an unstressed syllable (or "weakly stressed syllable" in Wright's term) in a disyllabic domain gives rise to the loss of a mora, hence triggering tone sandhi. However, the relation between the shortening of the non-final syllables and the vowel alternations is not quite obvious. Wright proposes a constraint that prohibits an unstressed syllable from having a branching nucleus. As a result, only syllables violating this constraint undergo the vocalic changes, whereas the ones which do not violate this constraint do not undergo any vocalic change.

Wright's proposal focuses on the change of the tones and vowels in the non-final syllables (i.e., the unstressed syllables), hence is only partially successful in accounting for the contrast between the change of tones and vowels in a non-final position and the lack of changes in a final position. As for the featural stability exhibited in the final syllables, one could infer from Wright's proposal that since stress is assigned to an iambic foot, the final syllable of a disyllabic domain always bears a stress, hence neither loss of mora nor violation of the constraint (that disallows a branching nucleus) takes place in a stressed syllable. Therefore, the tonal and vowel features must be retained in a domain-final syllable. Thus the first asymmetry, that is, the contrast between the different positions within a disyllabic domain is accounted for explicitly and implicitly by Wright's proposal.

Although Wright's proposal says nothing about the contrast between the lack of the vowel changes in the tight syllables and the change of vowel in the loose ones in the same non-final position, as shown in (4), and the similarities between the vowel alternation in the disyllabic compounds and the vowel distributions in the monosyllabic words, she does provide strong evidence showing that the difference between the two positions in a disyllabic domain is their **duration**. Phonetically, duration is diagnosed as one of the strongest correlates of stress (Fry 1958, 1976). Phonologically, vowel quality or other segmental features often interact with stress, such that schwa in some languages is stressless (Hayes 1991, 1995). The Fuzhou data examined above provide another type of phonological diagnostic for stress. That is, the featural content in the stressed syllable (i.e., the domain-final syllable) is more stable than that of the unstressed syllables within a disyllabic domain.

Based on the observations from the Fuzhou data in (1), (2) and (3), as well as the experimental evidence provided by Wright (1983) in (5) and (6), I build on Wright's insight and propose that the stress effect on tone-vowel interaction is twofold. On the one hand, it preserves all lexical properties in the stressed syllable; on the other hand, it reduces the weight of an unstressed syllable, hence triggering various tonal and vocalic changes. To assign prominence to the final syllable within a disyllabic domain, I propose

Prominence Alignment (7) which assigns a metrical grid mark to the rightmost syllable of a disyllabic domain, and Prominence Reduction (8) which prevents an unstressed syllable from being bimoraic.

(7) Prominence Alignment (PROMALIGN)

Given a domain *x*, a metrical grid mark must be aligned to the right edge of *x*.

x = morphonological word.

(8) Prominence Reduction (PROMREDUC)

If α is not assigned a metrical grid mark, α cannot be bimoraic.

The function of PROMREDUC is to require a non-prominent syllable to be monomoraic, triggering both tonal and vowel changes in the non-final syllable, if that syllable is bimoraic in the first place. This constraint reflects the spirit of Prince's (1990:358) "Weight-to-Stress Principle" in that it makes the weak weaker.

It must be pointed out that the constraints proposed above aim to account for one of the asymmetries summarized in (4). That is, the contrast between the feature stability in σ_2 and the tonal and vowel changes in σ_1. The other asymmetry in (4), namely, the contrast between the tonal and vowel changes in the loose syllables and the lack of vowel changes in the tight ones follows from our proposal accounting for the tonal and vowel distributions in the monosyllabic words. It will be discussed in detail in the latter part of this chapter.

5.1.2 Asymmetric behavior of syllables in Fuzhou

Having proposed the relevant constraints for the contrast between different positions within the same domain, I now proceed to demonstrate how these constraints and their interaction with the constraints on tonal distribution can successfully derive (i) the featural stability in final position, (ii) the possible tonal and vowel changes in non-final position of the same domain, and (iii) the identical tonal pattern between the output of the tone sandhi in the loose syllables and the output of the tonal distributions in the tight syllables.

Fuzhou tonal distributions demonstrated in chapter 3 show that there are two types of syllables: tight and loose. The former are monomoraic, and the latter bimoraic. Their combinations in a disyllabic domain give four possibilities: (i) loose-loose, (ii) loose-tight, (iii) tight-loose, (iv) tight-tight. In the following, I show how the surface forms for each of the four pairs of syllables in a disyllabic domain can be achieved by the constraints proposed in the last section and the constraints on tonal distributions proposed in chapter 3.

I assume that the PROMALIGN (which assigns prominence to the rightmost syllable within a domain) is highly ranked; there are no constraints higher than PROMALIGN that could cause it to be violated. Outputs violating this constraint will therefore not be included in tableaux below. The square brackets without a subscribed symbol "σ" indicate the head of a syllable, namely, the nuclear mora.

(9) Loose-loose compounds in Fuzhou

"Input"[4]	Cand$_1$	Cand$_2$	Cand$_3$
T T T T T T [[μ]μ]$_\sigma$[[μ]μ]$_\sigma$ RT RT RT RT	T T T T T T [[μ]]$_\sigma$[[μ]μ]$_\sigma$ ☞ RT RT RT RT	T T T T T T [[μ]$_\sigma$[[μ]μ]$_\sigma$ RT RT RT RT	T T T T T T [[μ]μ]$_\sigma$[[μ]μ]$_\sigma$ RT RT RT RT
PromReduc			*!
HdBin		*!	
ParseTn	*		

The input in tableau (9) contains two bimoraic syllables. It is shown that violation of PromReduc or HdBin (which is motivated by the tonal distribution in Fuzhou, see the detailed arguments in section 3.3.1) is fatal since these constraints are highly ranked. Cand$_3$ violates PromReduc because the unstressed syllable has a bimoraic structure. The first two candidates satisfy PromReduc in the same way. That is, the non-final syllable in both of them lost one of their two moras, hence is monomoraic. The difference between them is that the tone left by the loss of the mora in Cand$_2$ is parsed onto the remaining mora, resulting in a HdBin violation, whereas the tone left by the loss of mora in Cand$_1$ stays unparsed, a violation of ParseTn, the lowly ranked constraint. Cand$_1$, therefore, is optimal. The crucial ranking for the loose-loose compound in Fuzhou is PromReduc, HdBin >> ParseTn.

It is important to notice that by satisfying PromReduc, there is a concomitant violation of Faithfulness: namely, the bimoraic structure of the first syllable in a disyllabic form becomes monomoraic in both (9) and (10).

[4] By "Input", I mean the form that would be optimal on its own. It is not necessarily an input in the sense of "underlying representation".

(10) differs from (9) in that its input is a loose-tight compound rather than loose-loose one. The last candidate violates the faithfulness constraint Lexμ (which prohibits insertion of any F-element that is not present in the input) because the domain-final syllable with a single mora in the input becomes bimoraic. $Cand_3$ violates PromReduc because the unstressed syllable keeps its two moras. Comparing the first two candidates, $Cand_2$ violates HdBin by linking three tones to one mora, while $Cand_1$ violates ParseTn by leaving a tone unparsed. Since ParseTn is the lowest ranked constraint, $Cand_1$ wins. Again, the ranking established in (9) also applies to this case.

(10) Loose-tight compounds in Fuzhou

"Input"	$Cand_1$	$Cand_2$	$Cand_3$	$Cand_4$
T T T T(T) $[\,[\mu]\mu\,]_\sigma[\,[\mu]\,]_\sigma$ RT RT RT(RT)	T T T T(T) $[\,[\mu]\,]_\sigma[\,[\mu]\,]_\sigma$ ☞ RT RT RT(RT)	T T T T(T) $[\,[\mu]\,]_\sigma[\,[\mu]\,]_\sigma$ RT RT RT(RT)	T T T T(T) $[\,[\mu]\mu\,]_\sigma[\,[\mu]\,]_\sigma$ RT RT RT(RT)	T T T T T $[\,[\mu]\,]_\sigma[\,[\mu]\mu\,]_\sigma$ RT RT RT
Lexμ				*!
PromReduc			*!	
HdBin		*!		
ParseTn	*			

Both (11) and (12) have one property in common, that is, the non-final syllable in both cases is monomoraic. Their difference lies in the final syllable. It is a loose syllable in (11) and a tight one in (12). The last two candidates in each of them incur two violation marks for Parse. This time, it is the tone and the segmental root in the non-final syllable that get unparsed. Only the first candidate in each case incurs no violations, hence is optimal.

(11) Tight-loose compounds in <u>Fuzhou</u>

"Input"	$Cand_1$	$Cand_2$	$Cand_3$
T(T) T T T $[\,[\mu]\,]_\sigma[\,[\mu]\mu\,]_\sigma$ RT(RT) RT RT	T(T) T T T $[\,[\mu]\,]_\sigma[\,[\mu]\mu\,]_\sigma$ ☞ RT(RT) RT RT	T(T) T T T $[\,[\mu]\,]_\sigma[\,[\mu]\mu\,]_\sigma$ RT(RT) RT RT	T(T) T T T $[\,[\mu]\,]_\sigma[\,[\mu]\mu\,]_\sigma$ RT(RT) RT RT
PROMREDUC			
PARSETN		*!*	*!*

(12) Tight-tight compounds in <u>Fuzhou</u>

"Input"	$Cand_1$	$Cand_2$	$Cand_3$
T(T) T(T) $[\,[\mu]\,]_\sigma[\,[\mu]\,]_\sigma$ RT(RT) RT(RT)	T(T) T(T) $[\,[\mu]\,]_\sigma[\,[\mu]\,]_\sigma$ ☞ RT(RT) RT(RT)	T(T) T(T) $[\,[\mu]\,]_\sigma[\,[\mu]\,]_\sigma$ RT(RT) RT(RT)	T(T) T(T) $[\,[\mu]\,]_\sigma[\,[\mu]\,]_\sigma$ RT(RT) RT(RT)
PROMREDUC			
PARSETN		*!*	*!*

Notice that the constraints PROMREDUC and HDBIN do not play any role in determining the optimal output in (11) and (12) since the inputs in these cases contain a tight syllable in the non-final position.

I have shown in this section that regardless of what combinations of the two types of syllables are in a disyllabic domain, the rightmost syllable within this domain always keeps its lexical properties. This is because the alignment constraint PROMALIGN and LEXμ are highly ranked. Any loss of lexical properties (either prosodic or featural) would be prevented. The asymmetrical behavior between the loose syllables and the tight ones in the non-final position can be accounted for by the constraint PROMREDUC in the following way. Since the input for a loose syllable contains two moras while a tight one only contains a single mora, the former violates PROMREDUC, hence triggering tonal and vowel changes, whereas the latter does not violate PROMREDUC, therefore, no vowel changes take place. I also demonstrate that the identical output tone sandhi between the non-final loose syllables and the tonal distributions in the tight syllables can be achieved by the interaction of the constraints on stress effects, namely, PROMALIGN and PROMREDUC with the constraint on tonal distributions HDBIN proposed in chapter 3, as well as the faithfulness constraint PARSETN.

5.1.3 Asymmetric behavior of syllables in Fuqing

Fuqing disyllabic compounds also exhibit the same types of asymmetries as those observed in Fuzhou. First, the loose syllables, i.e., the syllables with a falling tonal contour containing a L tone, and undergo both tonal and vocalic changes when they combine with a following morpheme to form a disyllabic compound. In other words, when a loose syllable occurs in a non-final position, its vowel changes into the corresponding tight form, and its tone also becomes a tone belonging to the tight categories. These kinds of tonal and vocalic changes in the loose syllables are illustrated in (13).

(13)	Morph	Gloss	+	Morph	Gloss	→	Disyl. word		Gloss
a.	Nε^{HL}	'ear'		πα^{H}	'pick'	→	Nι^{H} πα^{H}	¶ú°Ç	'earpick'
b.	πoN^{ML}	'excrement'		τэΠN^{M}	'bucket'	→	πυN^{HM} τэΠN^{M}	·àí°	'manure bucket'
c.	τΠ/^{ML}	'bamboo'		τσэψo^{HM}	'mat'	→	τψ/^{H} τσэψo^{HM}	Öñï¯	'bamboo mat'

The morphemes in (13) all have a contour tone that is comprised of a non-L tone (i.e., either H or M) and a L tone. Therefore, they belong to the loose type of syllables, and hence are bimoraic. When they occur in a non-final position, their vowel [ε], [o] and [Π] become the corresponding tight forms [ι], [υ] and [ψ], respectively. Meanwhile, their tones also get changed, and the tonal changes are precisely the loss of the L part of the entire tonal contour. For instance, the morpheme [Nε^{HL}] 'ear' in (13a) has a contour tone HL. When it occurs in the non-final position within a disyllabic compound [Nι^{H} πα^{H}] 'earpick', its original tonal contour gets simplified and becomes a H level tone. Its vowel [ε] changes into the corresponding tight form [ι]. The same patterns of tonal and vocalic change are also observed in (13b) and (13c).

(14)	Morph	Gloss	+	Morph	Gloss	→	Disyl. word		Gloss
a.	τιEN^{HL}	'electricity'		πιευ^{M}	'watch'	→	τιεN^{H} πιευ^{M}	μç±í	'meter'
b.	νON^{ML}	'tender'		μυOι^{ML}	'sister'	→	νoN^{HM} μυOι^{ML}	ÄÛÃ Ã	'young sister'
c.	πυAN^{ML}	'half'		νι/^{H}	'day'	→	πυαN^{H} νι/^{H}	°ëÈÕ	'half a day'

As in (13), the morphemes in the left column in (14) contain a tone with a L tone as the second part of the contour, hence they are loose syllables with a bimoraic structure. When they occur in a non-final position in a disyllabic compound, their main vowels [E], [O] and [A] become the corresponding tight forms [ε], [o] and [α], respectively. Meanwhile, the L tone in their original tonal contour gets lost. For example, the monosyllabic morpheme [τιEN^{HL}] 'electricity' in (14a) changes into [τιεN^{H}] when it co-occurs with another morpheme in a disyllabic compound [τιεN^{H} πιευ^{M}] 'meter'. The vowel change in this case is from [E] to [ε], and the tonal change is from HL to H, that is, the loss of the L part of the entire tonal contour. Compare the two morphemes [νON^{ML}]

'tender' and [μυΟι^{ML}] 'sister' in (14b), they both have the same ML contour tone, and their vowels include [O], hence they are loose syllables. When they occur together as a disyllabic compound [<u>νοΝ^{HM}</u> μυΟι^{ML}] 'young sister', the first morpheme changes its vowel from [O] to [o], and its tone from ML to HM. The tonal and vowel changes in the first morpheme, however, do not happen to the second morpheme, the one which occurs domain-finally. This contrast shows clearly that different positions within a disyllabic domain play a crucial role in determining the featural change on the one hand, and the featural stability on the other.

However, the tonal and vowel changes of the non-final morphemes exhibited in (13) and (14) are not found in (15), where the non-final syllables in the disyllabic compounds are originally tight. In particular, the vowels [ε], [o] and [α] in the tight syllables in (15a), (15b) and (15c) do not change into their corresponding forms [ι], [υ] and [A]. Their tonal change is not the same type of change observed in (13) and (14).

(15)		Morph	Gloss	+	Morph	Gloss	→	Disyl. word		Gloss
	a.	σε^{M}	'wash'		τσэιυ^{HM}	'hand'	→	σε$^{\underline{ML}}$ τσэιυ^{HM}	Ï´ÊÖ	'wash hands'
	b.	τοΝ^{HM}	'become'		Να^{HM}	'family'	→	τοΝ$^{\underline{H}}$ Να^{HM}	µ±¼Ò	'decision-maker'
	c.	ηα/^{H}	'combine'		πα/^{2}	'arm'	→	ηα/$^{\underline{ML}}$ πα/^{2}	ºÏ±Û	'purse'

Comparing the lack of vowel change in (15) with the vowel alternations in (13) and (14), it becomes clear that different types of syllables behave differently with respect to their moraic structures. The vowel alternations take place only in the bimoraic syllables occurring in a non-final position, whereas no vowel alternations happen to the monomoraic syllables, whether they occur domain-finally or not. This finding is compatible with the constraints proposed for Fuzhou disyllabic compounds. In particular, the non-final syllable in a disyllabic domain is unstressed, hence subject to the constraint Prominence Reduction, which requires an unstressed syllable to be monomoraic. A bimoraic syllable in that position must be made monomoraic syllable, triggering the vowel change. A tight syllable, however, is monomoraic; and does not violate this constraint; hence it need not change its vowel. As for the contrast between a loose syllable in different positions within a disyllabic domain, it can be accounted for by the constraint Prominence Preservation, which ensures that all lexical properties of a stressed syllable, i.e., the final syllable, must remain unchanged.

Now we have clearly identified (i) the contrast between the loose syllables in different positions in a disyllabic domain, (ii) the contrast between the loose syllables and the tight ones in the same position of a disyllabic domain, and (iii) the identical patterning between tone sandhi and vowel alternations in the loose syllables, and the tonal and vowel distribution in the tight ones. In the following, I will demonstrate how the constraints proposed for Fuzhou disyllabic compounds can be extended to the Fuqing cases, accounting for the same types of asymmetries and identities between tonal and vowel distributions in the tight syllables and their alternations in the loose ones.

(16) Loose-loose compound in Fuqing

"Input"	$Cand_1$	$Cand_2$	$Cand_3$
T L T L $[\,[\mu]\mu\,]_\sigma[\,[\mu]\mu\,]_\sigma$ RT RT RT RT	☞ T L T L $[\,[\mu]_\sigma[\,[\mu]\mu\,]_\sigma$ RT RT RT RT	T L T L $[\,[\mu]_\sigma[\,[\mu]\mu\,]_\sigma$ RT RT RT RT	T L T L $[\,[\mu]\mu\,]_\sigma[\,[\mu]\mu\,]_\sigma$ RT RT RT RT
PROMREDUC			*!
*NUC/[-RSD]		*!	
PARSETN	*		

The input in tableau (16) contains two bimoraic syllables. It is shown that violation of PromReduc or *Nuc/[-Rsd] is fatal since these constraints are highly ranked. Leaving everything in the input unchanged, as in $Cand_3$, violates PromReduc since an unstressed syllable (i.e., the non-final syllable) has two moras. The first two candidates satisfy PromReduc in the same way. That is, all lexical properties in the rightmost syllable are left unchanged, and the non-final syllable in both of them has lost one of their two moras, hence is monomoraic. The difference between them is that the L tone left by the loss of mora in $Cand_2$ is parsed onto the remaining mora, resulting in a *Nuc/[-Rsd] violation, whereas the L tone left by the loss of mora in $Cand_1$ stays unparsed, a violation of ParseTn. Since *Nuc/[-Rsd] ranks above ParseTn, $Cand_1$, therefore, is the optimal one. As for the loose-loose compound in <u>Fuzhou</u>, the crucial ranking for the loose-loose compound in <u>Fuqing</u> is PromReduc, *Nuc/[-Rsd] >> ParseTn.

(17) Loose-tight compounds in <u>Fuqing</u>

"Input"	$Cand_1$	$Cand_2$	$Cand_3$
T L T(T) [[μ]μ]$_σ$ [[μ]]$_σ$ RT RT RT(RT)	☞ T L T(T) [[μ]]$_σ$ [[μ]]$_σ$ RT RT RT(RT)	T L T(T) [[μ]]$_σ$ [[μ]]$_σ$ RT RT RT(RT)	T L T(T) [[μ]μ]$_σ$ [[μ]]$_σ$ RT RT RT(RT)
PromReduc			*!
*Nuc/[-Rsd]		*!	
ParseTn	*		

(17) differs from (16) in that its input is a loose-tight compound rather than a loose-loose one. As in (16), $Cand_3$ violates PromReduc because the unstressed syllable (i.e., the left syllable) is bimoraic, and so is out. Comparing the first two candidates, $Cand_2$ violates

*NUC/[-RSD] by linking the L tone to the nuclear mora, while $Cand_1$ violates PARSETN by leaving the L tone unparsed. Since PARSETN is the lowest ranked constraint, $Cand_1$ wins. Again, the ranking established in (16) also applies to this case.

(18) Tight-loose compounds in <u>Fuqing</u>

"Input"	$Cand_1$	$Cand_2$	$Cand_3$
T(T) T L $[\,[\mu]\,]_\sigma[\,[\mu]\mu\,]_\sigma$ RT(RT) RT RT	T(T) T L $[\,[\mu]\,]_\sigma[\,[\mu]\mu\,]_\sigma$ ☞ RT(RT) RT RT	T(T) T L $[\,[\mu]\,]_\sigma[\,[\mu]\mu\,]_\sigma$ RT(RT) RT RT	T(T) T L $[\,[\mu]\,]_\sigma[\,[\mu]\mu\,]_\sigma$ RT(RT) RT RT
PROMREDUC			
PARSE		*!*	*!*

Both (18) and (19) have one property in common, that is, the non-final syllable in both cases is monomoraic. Their difference lies in the final syllable. It is a loose syllable in (18) and a tight one in (19). The last two candidates in each of them incur two violation marks for PARSE. This time, it is the tone and the segmental root in the non-final syllable that get unparsed. Only the first candidate in each case violates nothing, and hence is optimal. Notice that the constraint PROMREDUC plays no role in determining the optimal output in (18) and (19) since the "Input"s in these cases contain a tight syllable, hence are monomoraic in the non-final position.

(19) Tight-tight compounds in <u>Fuqing</u>

"Input"	$Cand_1$	$Cand_2$	$Cand_3$
T(T) T(T) $[\,[\mu]\,]_\sigma[\,[\mu]\,]_\sigma$ RT(RT) RT(RT)	T(T) T(T) $[\,[\mu]\,]_\sigma[\,[\mu]\,]_\sigma$ ☞ RT(RT) RT(RT)	T(T) T(T) $[\,[\mu]\,]_\sigma[\,[\mu]\,]_\sigma$ RT(RT) RT(RT)	T(T) T(T) $[\,[\mu]\,]_\sigma[\,[\mu]\,]_\sigma$ RT(RT) RT(RT)
PROMREDUC			
PARSE		*!*	*!*

I have shown in this section that no matter what combinations of the two types of syllables are in a disyllabic domain, the rightmost syllable within this domain always keeps its lexical properties. This is because the alignment constraint PROMALIGN is highly ranked. The asymmetrical behavior between the loose syllables and the tight ones in the non-final position can be explained by the constraint PROMREDUC, since the input for a loose syllable contains two moras while a tight one only contains a single mora. The former violates PROMREDUC, hence triggering tonal and vowel changes, while the latter does not violate PROMREDUC, hence no vowel changes take place. I also demonstrate that the identical output tone sandhi between the non-final loose syllables and the tonal distributions in the tight syllables can be achieved by the interaction of the constraints on stress effects, namely, PROMALIGN and PROMREDUC with the constraint on tonal distributions *NUC/[-RSD] proposed in chapter 3, as well as the faithfulness constraint PARSE.

5.1.4 A summary

I have identified two asymmetries regarding syllables in different positions within a disyllabic compound. The first one is the contrast between the featural stability in a final syllable and the lack of featural stability in a non-final syllable. The spectrographic data provided by Wright (1983) show that the duration of a non-final syllable is significantly shorter than one in a final position. This shortening effect in the non-final position is characterized as a stress effect which causes tone sandhi and vowel change in an unstressed syllable (Wright 1983). Following Wright's insight, I propose two constraints, Prominence Alignment and Prominence Reduction, to account for the contrast between the featural stability on the one hand and the featural change on the other.

The second asymmetry is that different types of syllables in the same non-final position of a disyllabic compound behave differently. The loose syllables in this position always change their tone and vowels, and the tone sandhi and vowel alternations for these types of syllable are identical to the tonal and vowel distributions observed in the tight syllables. On the other hand, the tight syllables in the very same position never change their vowels, even though some of them do have tonal changes. This contrast between the loose and tight syllables in the same position is identified as being due to their different moraic structures. That is, the loose syllables are bimoraic, hence subject to the constraint Prominence Reduction which requires an unstressed syllable to be monomoraic. On the other hand, the tight syllables are monomoraic; hence not subject to Prominence Reduction; therefore, do not have any vowel change.

My proposal differs from Wright's account in that it encodes the different moraic structures between the two types of syllables into the constraint on an unstressed syllable, namely, Prominence Reduction, correctly predicting that only the bimoraic syllables (i.e., the loose syllables) undergo vowel changes but not the monomoraic syllables (i.e., the tight ones). Since the different moraic structures for the different types of syllables have already been motivated by their tonal distributions in chapter 3, and this structural difference affects their vowel distributions in monosyllabic words, it is expected that the vowel alternation in the bimoraic syllables of the disyllabic compounds would be identical to the vowel distributions in the tight syllables of the monosyllabic words. Thus, we achieve a unified account for the vowel distributions and alternations in both monomoraic and bimoraic forms. Moreover, I have shown that the striking similarity between the tone sandhi in the loose syllables and the tonal categories in the tight syllables lies in the interaction of the constraint Prominence Reduction with the constraints on the tonal distributions HdBin and *Nuc/[-Rsd], as well as the faithfulness constraint ParseTn.

5.2 Vowel alternations in disyllabic compounds

In the last section I proposed a set of constraints on stress, successfully predicting the contrast between the featural stability in the final syllables on one hand, and the featural change in the non-final syllables on the other hand. In particular, the feature stability is guaranteed by Prominence Alignment (which assigns a final syllable) and PARSE (which prevents a final syllable from losing its lexical properties), whereas the featural change is triggered by Prominence Reduction which requires an unstressed syllable to be monomoraic. In this section, I focus on the identical patterning between the vowel alternations in the loose syllables that do not occur domain-finally and the vowel distributions in the tight syllables, and answer the question of why the vocalic changes involved in the non-final syllables always fall into the vowel distributional patterns between the loose syllables and the tight ones in monosyllabic words. In other words, the outputs of the vocalic changes in the non-final position are always the forms occurring in the tight type of monosyllabic words, and not vice versa. Under the prosodic anchor hypothesis proposed in chapter 3, the tight-loose distinction is argued to be a structural difference (see chapter 3). That is, the loose syllables are bimoraic, while the tight ones are monomoraic. If the effect of Prominence Reduction is to require the non-final position to be monomoraic, then the identical patterning between the vowel alternations and the vowel distributions is expected. Since the tight syllables and the syllables that undergo changes in the non-final position have identical moraic structure (i.e., monomoraic), their featural similarities are no longer a mystery.

The task of this section is to demonstrate how the interaction of the sets of constraints, that is, the constraints on stress proposed in the last section and the constraints on syllabification proposed in chapter 4, can successfully account for the identical patterning between the vowel alternations in the disyllabic compounds and distributions in the monosyllabic words.

5.2.1 Fuzhou disyllabic words

As shown in section 5.1.2, Fuzhou disyllabic words exhibit three characteristics. First, syllables in a non-final position in a disyllabic domain undergo certain changes, whereas syllables in a final position of the same domain never change anything. Second, syllables in the same non-final position behave differently with respect to their moraic structure. In particular, loose syllables (i.e., bimoraic syllables) always change both tone and vowels, while tight syllables (i.e., monomoraic ones) never have any vocalic change, even though they may or may not change their tone depending on the particular tonal configuration. Third, the vowel alternations in non-final loose syllables are identical to their corresponding tight forms in the monosyllabic words. These properties are illustrated again in (20).

(20)	Morph.	Gloss	+	Morph.	Gloss	→	Disyllabic N	Gloss
a.	ηουN^{MHM}	'neck'		λιEN^{MHM}	'chain'	→	ηυN^{HM}.λιEN^{MHM}	'necklace'
b.	ηαι^{HM}	'earthenware'		κυο^{H}	'pot'	→	ηαι^{ML}.κυο^{H}	'earthenware pot'

The disyllabic word [ηυN^{HM}.λιEN^{MHM}] 'necklace' in (20a) is composed of two monosyllabic morphemes [ηουN^{MHM}] 'neck' and [λιEN^{MHM}] 'chain'. They both contain a complex tonal contour that belongs to the loose type of syllables, and hence are bimoraic. Interestingly, the output of the disyllabic word shows that the tonal and vocalic features in the first syllable of this disyllabic word differ from the tonal contour and the vowels in the morpheme [ηουN^{MHM}] 'neck'. The diphthong [ου] becomes a monophthongal [υ], and the MHM tonal contour becomes HM. On the other hand, the tonal contour and the vowels in the second syllable of this disyllabic word remain unchanged. Recall that an underlying high vowel /ʋ/ surfaces as a monophthongal [ʋ] in a tight syllable and as diphthong containing the high vowel [oʋ] in a corresponding loose syllable; it becomes clear that the change from [oʋ] to [ʋ] in (20a) is exactly the same as the corresponding pair **ц ~ pц** in monosyllabic words. This identical relation between the vowel alternations in disyllabic words and the vowel distributions in monosyllabic words can be explained easily under the theory proposed in this work. That is, since the tight syllable is monomoraic and the loose syllables bimoraic, linking of an underlying high vowel /ʋ/ to the distinctive moraic structures would give rise to the monophthongal [ʋ] in a tight syllable on the one hand, and the diphthong [oʋ] in a loose syllable on the other hand. Now the question is why does the diphthong [oʋ] in a non-final loose syllable become [ʋ], but not *[**p**]? The answer is that the constraint Prominence Reduction only allows a monomoraic syllable in that non-final position, forcing the loose syllable in that position to lose a mora. As a result, the [oʋ] which underlyingly is a high vowel /ʋ/ becomes a monophthongal [ʋ] but not [o]. In other words, the stress effect forces a non-final loose syllable to lose a mora, giving rise to a monomoraic structure which is the same as the moraic structure for the tight syllables, therefore, the vowel alternation pattern **ц ~ pц** follows. The following tableau (21) shows how the change from **pц** to **ц** can be achieved by the interaction of the two sets of constraints, that is, the constraints related to stress, i.e., PromAlign and PromReduc, and the ones on syllabification, such as ParseHi. Following the conventional notation for representing stress, the x's on top of σ's stand for stressed syllables, while the dots on top of σ's indicate unstressed syllables

The input in (21) contains two bimoraic morphemes (i.e., two loose syllables). The last candidate violates PromAlign (which requires a metrical grid to be aligned to the rightmost syllable within a word) since the prominence indicated by the "x" on top of the syllable node is aligned to the left, resulting in a misplacement of stress. Leaving everything unchanged, as in $Cand_3$, violates PromReduc, so $Cand_3$ is out. Comparing the first two candidates, both satisfy the stress-related constraints. The difference between them is that the high vowel [υ] which stands for the root node containing a feature [+HI] gets parsed onto a prosodic anchor in Cand$_1$, while in Cand$_2$ it is left unparsed, resulting in violation of PARSEHI. Since Cand$_1$ satisfies all constraints, it is the optimal output. There is no crucial ranking in this case.

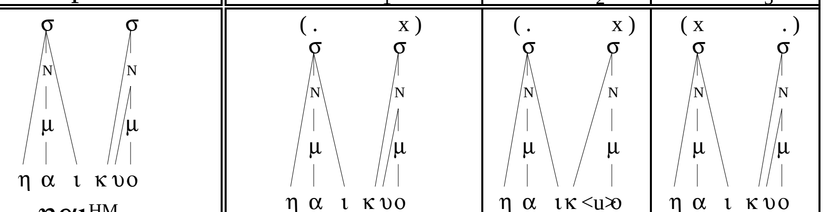
(21) Output candidates for [ηυ̲N$^{\underline{HM}}$.λιEN^{MHM}] 'necklace' in Fuzhou

"Input"	Cand$_1$	Cand$_2$	Cand$_3$	Cand$_4$
σ σ N N μμ μμ η ου N λ ι E N ηο̲υ̲N$^{\underline{MHM}}$ 'neck' + λιEN^{MHM} 'chain'	(. x) σ σ N N μμ μμ η υ N λ ι E N [ηυ̲N$^{\underline{HM}}$.λιEN^{MHM}] 'necklace'	(. x) σ σ N N μμ μμ η o<u>Nλ ιE N [ηoN.λιEN]	(. x) σ σ N N μμ μμ η ου Nλ ιE N [ηουN.λιEN]	(x .) σ σ N N μμ μ η ου Nλ ιε N [ηουN.λιεN]
PROMALIGN				*!
PROMREDUC			*!	*!
PARSEHI		*!		

Notice that once the constraints related to stress have been satisfied, the output vocalic form is determined by the constraints on syllabification, which are the same as that used for the vowel distributions in monosyllabic words. This explains why the output of vowel changes in a loose syllable is always identical to the output of the vowel distributions in a tight syllable.

An examination of the data in (20b) shows that when a disyllabic word [ηαι$^{\underline{ML}}$.κυο^{H}] 'earthenware pot' is comprised of two morphemes [ηαι$^{\underline{HM}}$] 'earthenware' and [κυο^{H}] 'pot' belonging to the tight type of syllables, neither the first morpheme nor the second one has any vocalic change. The lack of vowel alternation in either the final or the non-final position for the tight type of syllables is expected under the current theory, since there is no structural change involved. This is demonstrated in tableau (22) below.

(22) Output candidates for [ηαι$^{\underline{ML}}$.κυο^{H}] 'earthernware pot' in <u>Fuzhou</u>



"Input"	Cand$_1$	Cand$_2$	Cand$_3$
ηαι^{HM} 'earthernware' + κυο^{H} 'pot'	[ηαι^{ML}.κυο^{H}] 'earthernware pot'	[ηαι.κο]	[ηαι.κυο]
PROMALIGN			*!
PARSE		*!	

The last candidate in (22) violates PROMALIGN because the prominence is aligned to the left rather than to the rightmost syllable of the word. The middle candidate satisfies PROMALIGN by aligning the stress to the rightmost syllable of the word. However, it violates PARSE since the high vowel [u] in the final syllable is left unparsed. Only the first candidate violates no constraint, and is optimal. Notice that the constraint PROMREDUC is not violated in any member of the candidate set, since the morphemes involved are all monomoraic.

5.2.2 <u>Fuqing</u> disyllabic words

As shown in <u>Fuzhou</u>, <u>Fuqing</u> disyllabic words also exhibit three characteristics. First, syllables in a non-final position in a disyllabic domain undergo certain changes, whereas syllables in a final position of the same domain never change anything. Second, syllables in the same non-final position behave differently with respect to their moraic structure. In particular, loose syllables (i.e., bimoraic syllables) always change both tone and vowels, while tight syllables (i.e., monomoraic ones) never have any vocalic change, even though they may or may not change their tone. Third, the vowel alternations in non-final loose syllables are identical to their corresponding tight forms in the monosyllabic words. These properties are illustrated here in (23) for convenience.

(23)		<u>Morph</u>	<u>Gloss</u> +	<u>Morph</u>	<u>Gloss</u>	→	<u>Disyl</u>. <u>word</u>		<u>Gloss</u>
	a.	$\nu\underline{O}N^{\underline{ML}}$	'tender'	$\mu\upsilon O\iota^{ML}$	'sister'	→	$\nu o N^{\underline{HM}}$ $\mu\upsilon O\iota^{ML}$	ÄÛÃ Ã	'young sister'
	b.	$\tau o N^{\underline{HM}}$	'become'	$N\alpha^{HM}$	'family'	→	$\tau o N^{\underline{H}}$ $N\alpha^{HM}$	µ±¼Ò	'decision-maker'

The disyllabic word [$\nu o N^{\underline{HM}}$ $\mu\upsilon O\iota^{ML}$] 'young sister' in (23a) contains two monosyllabic morphemes [$\nu ON^{\underline{ML}}$] 'tender' and [$\mu\upsilon O\iota^{ML}$] 'sister'. They both have a tonal contour that includes a L tone, hence are loose syllables (i.e., bimoraic). The output of the disyllabic word shows that the tonal and vocalic features in the first syllable of this disyllabic word differ from the tone and the vowels in the morpheme [$\nu\underline{O}N^{\underline{ML}}$] 'tender'. The lax mid [O] becomes its tense counterpart [o], and the ML tone becomes HM. On the other hand, the tone and the vowel in the second syllable of this disyllabic word remain unchanged. Recall that an underlying mid vowel /O/ surfaces as tense [o] in a tight syllable and as lax [O] in a corresponding loose syllable; it becomes clear that the change from [O] to [o] in (23a) is exactly the same as the distributing pair **p ~ Π** in monosyllabic words. As in <u>Fuzhou</u>, this identical relation between the vowel alternations in disyllabic words and the vowel distributions in monosyllabic words can be easily explained in the current theory. In particular, the constraint on stress forces a bimoraic syllable in a non-final position to become monomoraic, the moraic structure that is identical to the tight syllables. Thus, the vowel alternation pattern **p ~ II** follows. The following tableau (24) shows how the change from **II** to **p** can be achieved by the interaction of the constraints related to stress and those constraining syllabification.

The input in (24) contains two bimoraic morphemes (i.e., two loose syllables). The last candidate violates PROMALIGN (which requires a metrical head to be aligned to the rightmost syllable within a word) since the prominence indicated by the "x" on top of the syllable node is aligned to the left, resulting in a misplacement of stress. It also violates PROMREDUC because of the bimoraic syllable in the unstressed position. The middle candidate violates PROMREDUC because of the bimoraic structure in the unstressed syllable. The first candidate wins since it violates no constraints.

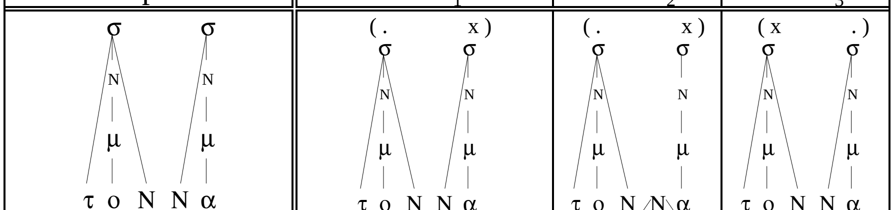
(24) Output candidates for [<u>νoN</u>^{HM} μυOι^{ML}] 'young sister' in <u>Fuqing</u>

"Input"	Cand$_1$	Cand$_2$	Cand$_3$
σ σ N N μμ μμ ν O Nμ υO ι ν<u>O</u>N$^{\underline{ML}}$ 'tender' + μυOι^{ML} 'sister'	(. x) σ σ N N μμ μμ ν o N μυO ι [<u>νoN</u>^{HM} μυOι^{ML}] 'young sister'	(. x) σ σ N N μμ μμ ν O N μυO ι [νON.μυOι]	(x .) σ σ N N μμ μμ ν O N μυO ι [νON.μυOι]
PROMALIGN			*!
PROMREDUC		*!	*!

The examination of the data in (23b) shows that when a disyllabic word [τoN$^{\underline{H}}$ Nα^{HM}] "decision-maker" is comprised of two morphemes [τoN^{HM}] 'become' and [Nα^{HM}] 'family' belonging to the tight type of syllables, neither the first morpheme nor the second one has any vocalic change. The lack of vowel alternation in either the final or the non-final position for the tight type of syllables is expected under the current theory, since there is no structural change involved. This is demonstrated in tableau (25) below.

The last candidate in (25) violates PROMALIGN because the prominence is aligned to the left rather than the rightmost of the word. The middle candidate satisfies PROMALIGN by aligning stress to the rightmost syllable of the word. However, it violates PARSE since the onset consonant [N] in the final syllable gets underparsed. Only the first candidate incurs no violations, and thus is optimal. Notice that the constraint PROMREDUC is not violated in any member of the candidate set, since the morphemes involved are all monomoraic.

(25) Output candidates for [$\tau o N^{H}\, N\alpha^{HM}$] 'decision-maker' in <u>Fuqing</u>



"Input"	$Cand_1$	$Cand_2$	$Cand_3$
$\tau o N^{H}$ 'become' + $N\alpha^{HM}$ 'family'	[$\tau o N^{\underline{H}}\, N\alpha^{HM}$] 'decision-maker'	[$\tau o N.\alpha$]	[$\tau o N.N\alpha$]
PROMALIGN			*!
PROMREDUC			
PARSE		*!	

5.2.3 A summary

The demonstration above shows that the identical patterning between vowel distributions in monosyllabic words and vowel alternations in disyllabic words is fully predictable under the proposed theory. This is because a moraic contrast (i.e., monomoraic vs. bimoraic) exists in monosyllabic morphemes. Once the stress effect takes one mora away from a loose syllable (i.e., bimoraic syllable) in a non-final position, that syllable becomes monomoraic, hence its vocalic output is the same as that in the tight monosyllabic words. Our theory also correctly predicts that a tight morpheme does not undergo any vocalic change, whether it occurs domain-finally or not, since it is monomoraic, and does not violates any stress-related constraint.

5.3 Vowel alternations in disyllabic reduplications

Vowel alternation in disyllabic reduplications exhibits the same characteristics as that in disyllabic compound nouns. First, the segmental properties in a reduplicant are identical to those in its base, if the base is the tight type of morphemes. That is, the copy of segments from the base is total for tight morpheme. In contrast, the segmental identity between a reduplicant and its base exhibited in the tight type of morphemes does not show up in the loose type of morphemes. In particular, if the base is the loose type of morpheme, the tone and vowels in the reduplicant are not totally the same as those in the base. Some modification occurs in the reduplicant. Second, non-identical segmental properties between the reduplicant and the base (only for the loose type of syllables), rather, vocalic segmental properties in the reduplicant of the loose syllables are identical to the corresponding forms in the tight ones. In a disyllabic reduplication, the reduplicant and the base are identical in their segmental properties

The questions that arise are why are the vowel alternations in disyllabic reduplications the same as in disyllabic compounds? In other words, why is the segmental change from a base to its reduplicant the same as the vocalic changes from a loose morpheme to its corresponding tight one? Is there anything in common among the three types of morphemes (i.e., reduplicants, morphemes in a non-final position, and tight morphemes)?

In this section, I start by investigating the segmental relation between the reduplicants and their base in Fuzhou, and explore its deeper relation with other types of morphemes (such as the tight morphemes in monosyllabic words and the loose ones undergoing vocalic changes in a non-final position) by examining their similarities in terms of their prosodic structures. I will argue that the similarity among these types of morphemes lies in their identical moraic structure, that is, they all have a monomoraic structure. Once this structural property has been identified, I then introduce a set of constraints on reduplication that are relevant to the present context, and show that the vowel alternation between a reduplicant and its base follows from the analysis proposed for the vowel distributions in chapter 4.

5.3.1 Fuzhou verb reduplications

Fuzhou morphology exhibits a rich reduplication system. It has nominal reduplication (Liang 1983a), adjective reduplication (Chen & Zheng 1990, Zheng 1988) and verbal reduplication (Zheng 1983, Li 1984). In this section, I focus on verb reduplication. In particular, I examine vowel alternations between a reduplicant and its base, and answer the question of why the alternations in this kind of reduplication are identical to the vowel distributions in monosyllabic words.

Reduplication of monosyllabic verbs in Fuzhou is very common. Zheng (1983) reports that 921 out of 1019 monosyllabic verbs he investigated can be reduplicated in different ways. The Fuzhou verb reduplication data are from Zheng (1983). The underscore indicates tonal and vowel changes from the base to the reduplicant. The dots in the reduplicated verbs signal syllable and/morpheme boundaries.

(26)	Verbs	Gloss →	Redupl. Vs		Gloss	Alternation
a.	πει^{MLM}	'to comb'	πι^{HM}.πει^{MLM}	±Í±Í	'just comb hair'	ει → ι
b.	σου^{MLM}	'to count'	συ^{HM} .σου^{MLM}	ÊýÊý	'just count'	ου → υ
c.	τσэΠψ^{MLM}	'to look'	τσэψ^{HM} .τσэΠψ^{MLM}	□□	'just take a look'	Πψ → ψ

The data in (26) show that when a monosyllabic verb becomes disyllabic by reduplication, the tone and vowels of the second syllable are identical to those of the monosyllabic verb, whereas the tone and vowels of the first syllable differ from those of the monosyllabic verb. For example, the monosyllabic verb in (26a) is [πει^{MLM}] 'to comb', when it becomes a reduplicated disyllabic verb, its first syllable has the form [πι^{HM}], that is different from the original monosyllabic form, while its second syllable [πει^{MLM}] is the same as the original form. The same is true for (26b) and (26c). The tonal change involved can be characterized as tonal simplification, since the original tonal contour MLM is complex, while the changed tonal contour is simple HM. Of interest are the vocalic changes. In particular, the diphthongs [ει], [ου] and [Πψ] of the original verbs in (26a), (26b) and (26c) become monophthongal high vowel [ι], [υ] and [ψ], respectively. This kind of vowel alternation, i.e., **к ~ ек**, **р ~ рц** and **ъ ~ Ръ**, is exactly the same as the vowel alternation in the disyllabic compounds, as well as the contrast between monophthongs and diphthongs as exhibited in the monosyllabic words.

Furthermore, the data in (27) show that the lax non-high vowels [E], [O] and [A] in the monosyllabic verbs become their tense counterparts [ε], [o] and [α], respectively, in the first syllable of the disyllabic reduplicated verbs. Again, these alternating pairs **е ~ Д, р ~ П, б ~ А** are identical to the tense/lax distinction exhibited in the vowel distributions in the monosyllabic words.

(27)	Verbs	Gloss	→	Redupl. Vs	Glo ss	Gloss	Alternation
a.	κэι<u>E</u>^{MHM}	'stand against'		<u>κэιε^{HM}</u> .κэιE^{MHM}	ÒĐÒ Đ	'stand everywhere'	E → ε
b.	μυ<u>O</u>N^{MLM}	'ask'		<u>μυoN^{HM}</u>. μυON^{MLM}	ÎÊÎÊ	'just ask'	O → o
c.	κэ<u>A</u>N^{MLM}	'look'		<u>κэαN^{HM}</u> .κэAN^{MLM}	¿´¿´	'just take a look'	A → α

Moreover, the examples in (28) reveal that the diphthongs [αι] and [Oψ] in the original verbs become [ει] and [Πψ] respectively in the first syllable of the disyllabic reduplicates. Recall that vowel distributions exhibit some feature co-occurrence and feature agreement restrictions in the tight syllables. In particular, a low-high sequence of vowels is disallowed in the tight syllables so that a diphthong **бк** in the loose syllables corresponds to a diphthong **ек** in the tight ones. Also, frontness agreement between the two elements of a diphthong is more restrictive in the tight syllables than in the loose ones. That is, a diphthong like [Oψ] with frontness disagreement is only allowed in the loose syllables, and becomes [Πψ] in its corresponding tight ones. These two pairs **ек** ~ **бк** and **Ръ** ~ **Пъ** are exactly the vowel alternations observed in the verb reduplications in (28).

(28)	Verbs	Gloss	→	Redupl. Vs	Glo ss	Gloss	Alternation
a.	κэ<u>αι</u>N^{MLM}	'to cover'		<u>κэειN^{HM}</u> κэαιN^{MLM}	¸Ç¸Ç	'just cover it'	Aι → ει

b.	σOψN^{MLM}	'to see sb. off'	σΠψN^{HM}.σOψN^{MLM}	ËíËí	'just see sb. off'	Oψ → Πψ

However, unlike the vowel alternations in the verb reduplication observed in (26), (27) and (28), (29) does not exhibit any vowel alternation: the original monosyllabic verbs all contain a simple contour tone (i.e., H, HM or ML) that belongs to the tight syllables.

(29)	Verbs		Gloss →	Redupl. Vs		Gloss
a.	λιN^{H}	Áà	'carry sth.'	λιN^{H}.λιN^{H}	ÁàÁà	'carry everywhere'
b.	νψ/^{H}	□	'step on'	νψ$^{\underline{ML}}$. λψ/^{H}	□ □	'step on everywhere'
c.	π϶υN^{HM}	Åõ	'hold with hands'	π϶υN$^{\underline{ML}}$. π϶υN^{HM}	ÅõÅõ	'hold with hands'
d.	τσ϶ο^{H}	´ê	'rob with hands'	τσ϶ο^{H} .τσ϶ο^{H}	´ê´ê	'keep robbing with hands'
e.	νιεN^{H}	Äé	'weight in hand'	νιεN^{H} .νιεN^{H}	ÄéÄé	'pick up sth'
f.	σια^{ML}	Ð´	'write'	σια$^{\underline{MH}}$.σια^{ML}	Ð´Ð´	'write everywhere'

The question then is why don't the tight type of verbs have any vowel alternation when they reduplicate? What is the difference between verbs with a complex contour tone and those with a simple contour or a level tone? The answer provided by the prosodic anchor hypothesis and the constraints on tonal distributions in chapter 3 is that the difference between morphemes with a complex contour tone and ones with a simple contour or a level tone lies in their moraic structure. That is, the former are bimoraic and the latter are monomoraic. Then a further question is what does this distinctive moraic structure have to do with vowel alternations in verb reduplication? In other words, why should the distinctive moraic structure determine whether a reduplicated disyllabic verb should change its vowel or not? The answer offered by the analysis of the vowel alternations in disyllabic compounds in the earlier part of this chapter is that the different moraic structures are closely related to stress. In particular, a bimoraic morpheme in an unstressed position is disallowed, hence has to become monomoraic. Consequently, the tonal and vocalic features must change accordingly. Now applying this analysis to the verb reduplication case, it is obvious that it is the first syllable but not the second one in a bimoraic verb reduplication that has to change its lexical properties, since that particular position in a disyllabic domain is unstressed, hence subject to PROMINENCE REDUCTION. On the other hand, a monomoraic verb is not subject to this constraint, so there is a lack of vowel alternations for this type of verb reduplication.

Having argued that the identical patterning between vowel alternations and distributions among the three types of morphemes (i.e., reduplications, disyllabic compounds, and monosyllabic words with the tight/loose distinction) is due to their moraic structure, it remains to show how these vowel alternations can be achieved. First, I treat the reduplicant RED as prefix, a morpheme having solely a prosodic category without featural content, that is, RED = σ. Second, I show that this morpheme RED gets its featural content from its base (i.e., the second syllable of the reduplicate). The theory of prosodic morphology developed by M & P (1986, 1993a, b) provides us with a relevant constraint ANCHORING, which is given in (30) below:

(30) ANCHORING (M & P 1993a:63)

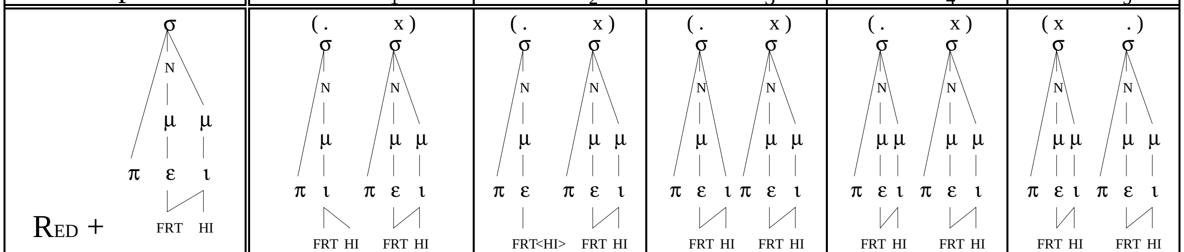
In R + B, the initial element in R is identical to the initial element in B.

In B + R, the final element in R is identical to the final element in B.

What ANCHORING requires is that the reduplicant R and the Base B must share an edge element, initial in prefixing reduplication, final in suffixing reduplication (M & P

1986:94, 1993:63). In the following, I first demonstrate how the different sets of constraints interact with each other in deriving the alternating pair **eκ ~ κ** in (31).

(31) Output candidates for [<u>πι^{HM}</u> πει^{MLM}] ±í±í 'just comb hair' in <u>Fuzhou</u> (ει → ι)



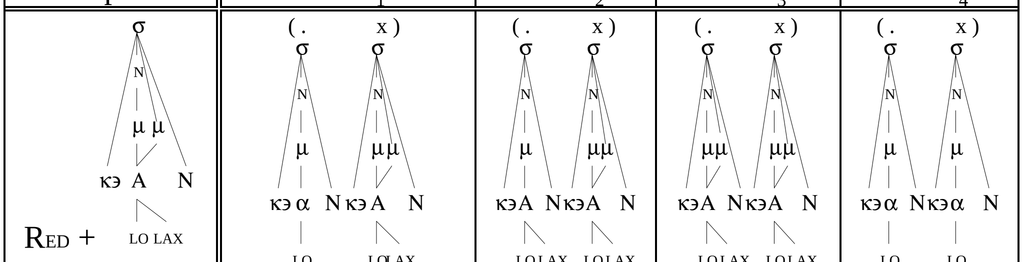
"Input"	$Cand_1$	$Cand_2$	$Cand_3$	$Cand_4$	$Cand_5$
Red + πει^{MLM} 'to comb'	[<u>πι^{HM}</u> πει^{MLM}] 'just comb hair'	[πε.πει]	[πει.πει]	[πει.πει]	[πει.πει]
PromAlign					*!
PromReduc				*!	*!
*Cod/Hi			*!		
ParseHi		*!			

The last candidate in (31) incurs two fatal violation marks for PromAlign and PromReduc since the metrical grid is aligned at the left edge rather than the right one and the unstressed syllable is bimoraic. $Cand_4$ violates PromReduc in the same way as the last candidate, and so is out. $Cand_3$ satisfies PromReduc by making the first syllable monomoraic. However, it violates *Cod/Hi because the high vowel [i] is parsed onto the syllable node directly. Both of the first two candidates satisfy PromAlign, PromReduc and *Cod/Hi. The difference between them is that both features [Hi] and [Front] in $Cand_1$ are parsed onto the prosodic anchor, giving rise to a monophthongal high vowel [i], whereas only the feature [Front] but not [Hi] is parsed in $Cand_2$, resulting in a monophthongal [e]. Since $Cand_2$ violates ParseHi, while $Cand_1$ violates nothing, $Cand_1$ wins.

Second, I demonstrate the interaction of constraints on deriving the vowel alternation from lax to tense in (32). Since the constraint PROMALIGN is highly ranked, and any output violating it must be out, I will not include it in the following tableaux.

All of the candidates in (32) incur a fatal violation mark. The last candidate violates PARSEμ since the stressed syllable reduces its mora. $Cand_3$ violates PROMREDUC because of the bimoraic structure in the unstressed position. It is interesting to compare the first two candidates. $Cand_2$ violates the parasitic constraint LAXING (which requires a long non-high vowel to be lax), because a low vowel becomes lax without being doubly parsed onto two moras. The first candidate satisfies LAXING by simply not incorporating the feature [lax] into the segmental root. Since the first candidate violates nothing, it is optimal.

(32) Output candidates for [κэαN^HM κэAN^MLM] ¿´¿´ 'just take a look' in Fuzhou (A → α)



"Input"	$Cand_1$	$Cand_2$	$Cand_3$	$Cand_4$
RED + κэAN^MLM 'to look'	[κэαN^HM κэAN^MLM] 'just take a look'	[κэAN.κэAN]	[κэAN.κэAN]	[κэαN.κэαN]
PARSEμ				*!
PROMREDUC			*!	
LAXING		*!		

It is important to notice that in this case, the vowel change from the base to RED is governed by the constraint proposed for the vowel distribution in chapter 4; we haven't introduced any new constraints on vowel alternations.

Lastly, I illustrate in (33) the case where the vowel change from the base to the RED involves the constraint on feature co-occurrence proposed for the monosyllabic words. Tableau (33) shows that the last candidate is the worst output since it violates PARSEμ (because the stressed syllable loses a mora), PROMREDUC (because the unstressed syllable has two moras) and PARSEHI (i.e., the high vowel [i] in the second syllable is left unparsed). Cand_3 violates *HI/LOμ because both the high vowel and the low vowel are linked to the same mora in unstressed position. It is interesting to compare the first two candidates. Cand_2 violates PARSEHI, while Cand_1 violates PARSELO. Since PARSEHI ranks above PARSELO, Cand_1 wins.

(33) Output candidates for [<u>κэειN^HM</u> κэαιN^MLM] ¸Ç¸Ç 'just cover it' in <u>Fuzhou</u> (Aι → ει)

"Input"	Cand_1	Cand_2	Cand_3	Cand_4
σ N μ μ RED + κ α ι N κэαιN^MLM 'to cover'	(. x) σ σ N N μ μμ κ<α> ι N κ α ι N [<u>κэειN^HM</u> κэαιN^MLM] 'just cover it'	(. x) σ σ N N μ μμ κ α<ι> N κ α ι N [καN.καιN]	(. x) σ σ N N μ μμ κ α ι N κ α ι N [καιN.καιN]	(. x) σ σ N N μμ μ κ α ι N κ α<ι> N [κιαN.νυοN]
PARSEμ				*!
PROMREDUC				*!
*HI/LOμ			*!	
PARSEHI		*!		*!
PARSELO	*			

The interesting point in this case is that the constraints *HI/LO$^{\mu}$, PARSEHI and PARSELO and the ranking *HI/LO$^{\mu}$, PARSEHI >> PARSELO established for the vowel distributions in chapter 4, play a crucial role in determining the optimal vowel alternating form. We have not proposed any particular constraint for reduplication alone. The full range of vowel alternation effects in the reduplication cases follows from the constraints on vowel distributions and the constraints on stress assignment in the disyllabic compounds, which is a desirable result.

5.3.2 Fuqing reduplications

Fuqing morphology also exhibits various types of reduplications: nominal reduplication, adjective reduplication, adverb reduplication, and verbal reduplication (Feng 1993). In this section, I examine vowel alternations between a reduplicant and its base, and explore the similarities among different types of morphemes regarding their output vocalic forms.

Reduplicated adjectives, adverbs and verbs in Fuqing denote intensity, momentarity, etc. The data in (34) show that when a monosyllabic word becomes disyllabic by reduplication, the tone and vowels of the second syllable are identical to those of the original form, whereas the tone and vowels of the first syllable undergo some changes. For example, the monosyllabic word in (34a) is [σɛ^{ML}] 'thin and long', but when it becomes a reduplicated disyllabic word, the vowel in the first syllable changes from [ɛ] to [ɩ], while the tone and vowel in the second syllable [σɛ^{ML}] are the same as those in the original form. Note that all of the morphemes that undergo reduplication in (34) contain a L tone in their tonal contour, hence belong to the loose type of syllables. Interestingly, the vocalic changes involved in these cases mirror the vowel distributing pairs between tight/loose morphemes. For instance, the lax non-high vowels [E], [O] and [A] in (34b), (34c) and (34d) become their tense counterparts [ɛ], [o] and [α], respectively, in the first syllable of the disyllabic reduplicated forms. These alternating pairs **е ~ Д, р ~ П, б ~ A** are identical to the tense/lax distinction exhibited in the vowel distributions in the monosyllabic words. Further, the example in (34e) reveals that the triphthong [ιευ] becomes a diphthong [ιυ] in the first syllable of the disyllabic reduplicant. Recall that vowel distributions exhibit a contrast between diphthongs in tight syllables and triphthongs in the corresponding loose syllables. That is, diphthongs [υι] and [ιυ] in tight syllables correspond to the triphthong [υοι] and [ιευ] in loose syllables, respectively. They are the same as the alternating pair **кец** ~ **кц** in (34e). The tonal change that occurs in these cases is exactly the loss of the L part from the tonal contours in the original words.

(34)		monosyl	→	Redupl. words		Gloss	Alternation
	a.	σε^{ML}	Ï¸	σι^{HM}.σε^{ML}	Ï¸Ï¸	'very thin and long'	ε → ι
	b.	μEN^{HL}	Âý	μεN^{H} .μEN^{HL}	ÂýÂý	'slowly'	E → ε
	c.	ηυON^{HL}	Ô¶	ηυοN^{H} .ηυON^{HL}	Ô¶Ô¶	'far away'	O → ο
	d.	τσAN^{ML}	Ôõ	τσαN^{H} .τσAN^{ML}	ÔõÔõ	'how come'	A → α
	e.	τσιευ^{ML}	Ð¦	τσэιυ^{HM}.τσэιε υ^{ML}	Ð¦Ð¦	'just smile'	ιευ → ιυ

However, the vowel alternations in the reduplicated forms observed in (34) do not show up in (35), where the original monosyllabic words do not contain a L tone in their tonal contours. The tones in this set of data are either level tones (i.e., H or M) or a HM contour tone.

(35)	monosyl		Gloss →	Redupl. words		Gloss
a.	πэιεN$^{\underline{HM}}$	Æ«	'on time'	πэιεN$^{\underline{H}}$.μιεN^{HM}	Æ«Æ«	'just in right time'
b.	ηo$^{\underline{M}}$	ºÃ	'good'	ηo$^{\underline{ML}}$.ηo^{HM}	ºÃºÃ	'properly'
c.	ΠN^{H}	ºì	'red'	ΠN^{H}.ΠN^{H}	ºìºì	'very red'
d.	τα$^{\underline{HM}}$	½¹	'dry'	τα$^{\underline{H}}$.τα^{HM}	½¹½¹	'very dry'

What is the difference between the forms in (34) and the ones in (35)? Their tonal patterns in the original forms show that the difference lies in their prosodic structures. That is, the forms in (34) are bimoraic since they have either a HL or a ML tone, whereas the ones in (35) are monomoraic, since they do not have a L tone in their tonal patterns. Extending the analysis proposed for the disyllabic compounds in the earlier part of this chapter to the disyllabic reduplications, the vowel alternations in these cases can be viewed as a stress effect. In particular, since stress is assigned to the rightmost syllable within a disyllabic domain, PROMINENCE REDUCTION requires the first syllable of that domain to be monomoraic. Thus, a bimoraic syllable in that position must lose one of its moras, triggering the vowel alternations. On the other hand, a monomoraic syllable in that position satisfies PROMINENCE REDUCTION, hence such a syllable does not undergo any vocalic changes. The structural distinction (i.e., bimoraic vs. monomoraic), thus explains why the vowel alternations in the reduplicated forms are identical to the vowel alternating pairs in the disyllabic compounds and the vowel corresponding pairs in the tight/loose monosyllabic words.

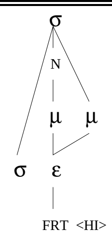
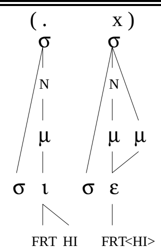
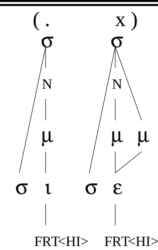
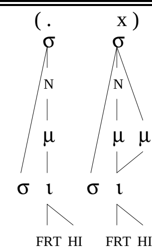
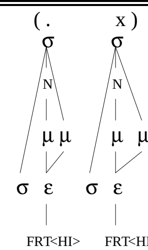
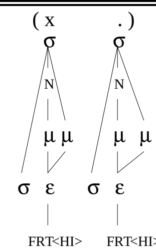
As in Fuzhou reduplication, I assume that the morpheme RED in Fuqing is solely a prosodic category with no phonetic content. It gets featural content by copying from its base. I treat Red as a prefix; subject to the constraint Anchor-L. In the following, I will demonstrate first how the vowel alternation from mid to high is achieved by constraint interaction.

The last candidate in (36) is the worst candidate. It violates PromAlign and PromReduc since the metrical grid is aligned at the left edge rather the right one and the unstressed syllable is bimoraic. It also incurs two counts of ParseHi violation because the feature [Hi] in both syllables is left unparsed. $Cand_4$ is the same as $Cand_5$ except that it does not violate PromAlign. $Cand_3$ satisfies PromReduc by making the first syllable monomoraic. However, it violates *Hiμμ because the high vowel [i] is parsed onto two moras. Both of the first two candidates satisfy PromAlign, PromReduc and *Hiμμ, but violate ParseHi. The difference between them is that $Cand_1$ violates ParseHi once, while $Cand_2$ violates it twice. Therefore, $Cand_1$ wins.

The interesting point in this case is the interaction of the constraints on stress and those on syllabification. As shown in the tableau, the set of constraints on stress ranks higher than the set of constraints on syllabification. More interestingly, the internal ranking of the constraints on syllabification in reduplication is identical to the ranking for the vowel distribution. This explains why the output vocalic forms in Red are identical to those in the tight type of morphemes.

(36) Output candidates for [σι^{HM}.σε^{ML}] 'very thin and long' in Fuqing (ε → ι)

"Input"	$Cand_1$	$Cand_2$	$Cand_3$	$Cand_4$	$Cand_5$

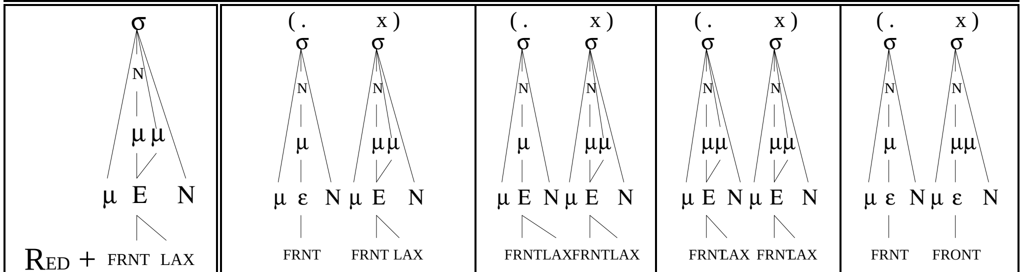
 RED + σε^ML 'thin and long'	 [σι^HM.σε^ML] 'very thin and long'	 [σι.σε]	 [σι.σι]	 [σε.σε]	 [σε.σε]
PROMALIGN					*!
PROMREDUC				*!	*!
*Hiμμ			*!		
PARSEHI	*	*!*		*!*	*!*

The next case I am going to demonstrate is the vowel alternation involving the tense/lax distinction. Since PROMALIGN is highly ranked, any candidate violating it will be out, and hence will not be included in the following tableaux.

All of the candidates except the first in (37) incur a fatal violation mark. The last candidate violates PARSEμ since the stressed syllable loses a mora. $Cand_3$ violates PROMREDUC because the unstressed position has bimoraic structure. It is interesting to compare the first two candidates. $Cand_2$ violates the parasitic constraint LAXING (which requires a long non-high vowel to be lax), because the mid vowel in the first syllable becomes lax without being doubly parsed onto two moras. The first candidate does not violate LAXING simply because there is only one mora, hence no need to copy the feature [lax]. Since the first candidate violates nothing, it is optimal.

(37) Output candidates for [μεN^H.μEN^ML] 'slowly' in Fuqing (E → ε)

"Input"	$Cand_1$	$Cand_2$	$Cand_3$	$Cand_4$



Red + μEN^{ML} 'slow'	[<u>μεN^{H}</u>.μEN^{ML}] 'slowly'	[μEN.μEN]	[μEN.μEN]	[μεN.μεN]
Parseμ				*!
PromReduc			*!	
Laxing		*!		

It is important to note that in this case, the vowel change from the base to Red is governed by the constraint proposed for vowel distribution in chapter 4; we haven't introduced any new constraints solely for vowel alternations.

The last case I illustrate is (38) where the vowel change from the base to the Red involves the constraints on feature alignment in specific syllabic positions, proposed for monosyllabic words in chapter 4. Tableau (38) shows that the last candidate violates PromReduc since the unstressed position has two moras. The middle two candidates violate *Cod/Hi, because the high vowel in both cases links to the syllable node directly. The first candidate violates *Nuc/Hi. Since *Cod/Hi ranks above *Nuc/Hi, Cand$_1$ wins.

(38) Output candidates for [<u>τσɘιυ^{HM}</u>.τσɘιευ^{ML}] 'just smile' in <u>Fuqing</u> (ιευ → ιυ)

"Input"	Cand$_1$	Cand$_2$	Cand$_3$	Cand$_4$

RED + τσ϶ιευ^{ML} 'to smile'	(. x) [<u>τσ϶ιυ^{HM}</u> τσ϶ιευ^{ML}] 'just smile'	(. x) [τσ϶ιευ.τσ϶ιευ]	(. x) [τσ϶ιυ.τσ϶ιευ]	(. x) [τσ϶ιευ.τσ϶ιευ]
PROMREDUC				*!
*COD/HI		*!	*!	
*NUC/HI	*		*	

The interesting point in this case is that the constraints *COD/HI and *NUC/HI and the ranking *COD/HI >> *NUC/HI, established for the vowel distributions in chapter 4, play a crucial role in determining the optimal vowel alternating form. We have not proposed any special constraint for the vowel alternations in reduplication. The full range of vowel alternation effects in the reduplication cases follows from the constraints on vowel distributions and the constraints on stress in the disyllabic compounds, which is a desirable result.

5.3.3 A summary

<u>Fuzhou</u> and <u>Fuqing</u> exhibit the same contrast between the first syllable and the second in a disyllabic reduplication. First, the first syllable always undergoes tonal and vocalic changes, while the second has neither tonal nor vocalic change. Second, the vowel alternations in disyllabic reduplication in both languages are identical to the ones observed in disyllabic compounds. In particular, the vowel changes are always from the forms in the loose syllables to the ones in the tight syllables. The analysis proposed for the reduplication cases is based on the account of the disyllabic compounds. That is, the

set of constraints on stress and its interaction with the set governing vowel distributions. I have show that the interaction of these two sets of constraints is sufficient to derive the full range of vowel alternation pairs. No extra constraint is needed.

5.4 Vowel alternations in Fuzhou Fanqie words

The "cutting-foot" words (data are from Liang 1982) are disyllabic words formed from monosyllabic words by a process resembling partial reduplication. In particular, the first syllable in the output shares the most sonorous vowel and any segmental material before that vowel with the original word, while the second syllable of the output retains the tone and all segmental material of the original word except the onset which is replaced by a new onset [l]. This is illustrated in (1), (2) below.

(1)		Originals	"cutting foot"	Gloss
	a.	κυ^{HM}	κυ^{ML}.λυ^{HM}	'tie up'
	b.	σαN^{H}	σα^{ML}.λαN^{H}	'arrest'
	c.	μιN^{H}	μι^{ML}.λιN^{H}	'hide'
	d.	νψ/^{H}	νψ^{ML}.λψ/^{H}	'fill in; squeeze'

The data in (1) show that when the original word is a CV syllable, like [κυ^{HM}] in (1a), the disyllabic output is [κυ^{ML}.λυ^{HM}], where the segmental material [κυ] in the first syllable is identical to that in the original morpheme, but the tone is different. On the other hand, the second syllable [λυ^{HM}] in the output retains the tone of the original syllable, as well as the segmental material except the onset [l], which is not present in the original morpheme. However, when the original morpheme is a CVC syllable, such as [μιN^{H}] in (1c) and [νψ/^{H}] in (1d), the first syllable in each output does not contain a coda C. Comparing the data in (1) with those in (2), where the original morphemes have more segmental material than those in (1), the first syllable of the output keeps the most sonorous segment and any segmental material before that nucleus.

(2)		Originals	"cutting foot"	Gloss
	a.	τιεN^{H}	τιε^{ML}.λιεN^{H}	'be given to'
	b.	κυοN^{ML}	κυο^{ML}.λυοN^{ML}	'roll up'

The original morphemes in (2a) and (2b) all have a segmental sequence CVVC, the first syllable of the output in each case is CVV, while the second syllable of the output has the form lVVC, where the tonal and segment properties are retained except the onset consonant [l]. The questions that arise are: Why does the first syllable in the output contain the segmental material before but not after the nuclear vowel? Why does the second syllable acquire a new onset?

Prosodic Morphology developed by M & P (1986, 1993a, b, 1994, 1995), provides a framework within which a possible solution can be found. Assume that the Fanqie words are formed by reduplication, and the reduplicant RED is prosodically defined. The question is then what kind of prosodic category might the RED be? Two possible candidates suggest themselves immediately. The first possibility is RED = σ. This is apparently surface-true, because the tonal patterns show that the output of the Fanqie word is disyllabic with one syllable being the base and the other being the reduplicant.

Suppose that the relevant constraints that govern the Fanqie type of reduplication are those in (3), and their interaction with other constraints, such as the structural constraints ONS, -COD, as well as the faithfulness LEX, is given in (4)[1] below.

(3) Constraints on Fanqie reduplication

a. RED = σ/NUC: the reduplicant template is the syllable OR the nucleus.
b. MAX: every element of BASE has a correspondent in RED.
c. LEFTMOST: align RED to the left edge of a syllable.

(4) Output candidates for the Fanqie word [$\tau\iota\varepsilon^{ML}.\lambda\iota\varepsilon N^{H}$] 'be given to' in <u>Fuzhou</u>

Input	$Cand_1$	$Cand_2$	$Cand_3$	$Cand_4$	$Cand_5$	$Cand_6$
/τιεN/	τι.τιεN	τιε.τιεN	τιεN.τιεN	ιε.τιεN	τιε.ιεN	☞ τιε.λιεN
-COD	*	*	**	*	*	*
RED = σ						
LEFTMOST				*		
ONS				*	*	
LEX-F						*
MAX	**	*		**	*	**

$Cand_6$ in tableau (4) is the actual output. However, there is no possible ranking of these constraints that can select this output. For example, if -COD were ranked at the bottom, the output with a total copy of the base (in $Cand_3$) would be the optimal output, since it satisfies all other constraints except -COD. On the other hand, if -COD were ranked on the top, ruling out $Cand_3$, then $Cand_2$ (in which RED copies a continuous string from the base except the coda) would be optimal. The problem here is that there is no way to select a surface true output, no matter how one ranks this set of constraints. Now we are forced to reconsider what other possible prosodic category the reduplicant RED might be.

The other possibility is RED = NUC. If the reduplicant template is a Nucleus, it should contain the segmental material that occurs within NUC. In Fuzhou, this material includes both the nuclear vowel which is dominated by the mora and the one that links to the Nuc node directly, that is, the on-glide. Now that the prosodic category for RED has been redefined, I examine in (5) whether the same set of the constraints as in (4) is successful in selecting the actual output.

(5) Output candidates for the Fanqie word [$\tau\iota\varepsilon^{ML}.\lambda\iota\varepsilon N^{H}$] 'be given to' in <u>Fuzhou</u>
item548

Input	$Cand_1$	$Cand_2$	$Cand_3$	$Cand_4$	$Cand_5$	$Cand_6$
/τιεN/	τι.τιεN	τιε.τιεN	τιεN.τιεN	ιε.τιεN	τιε.ιεN	☞ τιε.λιεN

[1] I thank Pat Shaw for working through the details in tableaux (4) and (5) with me.

Red = Nuc	*!	*!	*!			
Ons				*!	*!	
Max	*!*	*		*!*	*	*
Leftmost					*	*
Lex-F						*
-Cod	*	*	**	*	*	*

The set of output candidates in (5) is identical to that in (4). It is shown that the first three candidates all violate the template Red = Nuc, because both the reduplicant and the base share an identical onset. The last three candidates satisfy the constraint Red = Nuc in different ways. In Cand$_4$ Red is onsetless, while the base has onset that is the same as the original word. Conversely, in Cand$_5$ it is the Red but not the base that has the onset. By violating Leftmost, Cand$_5$ shows that Red in this case is actually a Nuc with two elements inside, namely, an on-glide [ι] and a nuclear vowel [ε]. The same is true for Cand$_6$ since the base does not retain the original onset [t], it has a new onset [λ], which is assumed to be the default consonant in this language. Comparing the first three candidates which violate the template constraint Red = Nuc with the last three candidates which satisfy it, it becomes clear that it is the different onsets in the reduplicant and the base, as well as the lack of coda in the reduplicant, that determines that the reduplicant is a Nuc rather than a syllable. Looking down further, we see that the structural constraint Ons rules out Cand$_4$ and Cand$_5$ because both of them contain an onsetless syllable. The last candidate satisfies Ons by inserting a default consonant in the base, even though it violates Lex-F as a cost. Tableau (5) shows that the templatic constraint Red = Nuc and its interaction with other constraints are successful in selecting the optimal output for the Fanqie words. The constraint ranking for this case is Red = Nuc, Ons >> Max, Lex-F, -Cod.

Now examine the interesting cases in (6), where vowel alternations take place between the original morpheme and the first syllable of the outputs. The underscore in the outputs indicates the changed vowels, and the dots signal syllable boundaries.

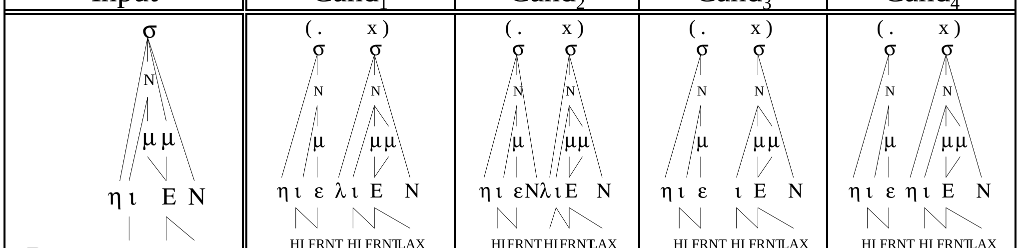
(6)		Originals	"cutting foot"	Gloss	Alternations
	a.	ηιEN^{MLM}	ηι<u>ε</u>^{L}.λιEN^{MLM}	'throughout'	E → ε
	b.	σO/^{MLM}	σ<u>o</u>^{L}.λO/^{MLM}	'tie tightly'	O → o
	c.	λAιN^{MLM}	λ<u>α</u>^{L}.λAιN^{MLM}	'stand on tiptoe'	A → α

The vowels in the original morphemes are [E] in (6a), [O] in (6b) and [A] in (6c). They become [ε], [o] and [α], respectively in the first syllable of the outputs. The vowel change involved is from lax to tense, exactly the same as the tense/lax distinction exhibited in monosyllabic words. That is, the tense non-high vowels only occur in the tight syllables, while their lax counterparts appear only in the corresponding loose syllables. Moreover, this type of vowel alternation also shows up in disyllabic compounds and disyllabic reduplications.

The question that arises from this observation is: Why are the vowel alternations in Fanqie words identical to the distribution patterns in monosyllabic words and the distribution patterns in other types of disyllabic forms. From the structural point of view, I found that the Fanqie words that exhibit vowel alternations in (6) are originally bimoraic, since their original tones are complex contour tones (i.e., MLM). Their original vocalic forms also indicate that they are bimoraic, because the set of lax vowels occur only in loose syllables. By examining their outputs, we found that the first syllable in the output differs from the second syllable in two regards. First, the output tone in the first syllable cannot be a complex contour tone like that in the original morpheme, whereas the second syllables in (6) always keep the complex contour tones. Second, the segmental material in the first syllable is always less than that in the second syllable. It never has a coda C or an off-glide high vowel. Furthermore, the first syllable within a disyllabic domain is always subject to the stress constraint PROMREDUCTION, which prohibits a bimoraic syllable from occurring in that position. Once the monomoraic status of the first syllable in the Fanqie words has been identified, the vowel change that occurs in that position is expected.

Having identified the monomoraic structure for the reduplicant in a Fanqie word, I now demonstrate how the vowel alternations between the reduplicant and the base in the Fanqie words in (6) can be achieved. Following the analysis proposed for the disyllabic compounds and the disyllabic reduplications, I assume here that the constraints on stress, namely, PROMALIGN and PROMREDUC, are highly ranked. Any output candidate violating them will be out, and will not be included in the following tableaux.

(7) Output candidates for [ηιε^{L}.λιEN^{MLM}] 'throughout' in <u>Fuzhou</u>



"Input"	$Cand_1$	$Cand_2$	$Cand_3$	$Cand_4$
RED +	[ηιε^{L}.λιEN^{MLM}] 'throughout'	[ηιεN.λιEN]	[ηιε.ιEN]	[ηιε.ηιEN]
RED = NUC				*!
ONS			*!	
-COD	*	*!*	*	*

The last candidate in (7) violates the constraint RED = NUC because the reduplicant and the base have identical onsets (which shows RED is a syllable rather than a NUC). $Cand_3$ violates ONS because the base is onsetless. Comparing the first two candidates, they both violate -COD. The difference between them is that $Cand_1$ violates it once, while $Cand_2$ does so twice. Thus, the first candidate wins. The ranking for (7) and (5) is the same.

The most interesting cases are those in (8) below, where the first syllable in an output has two alternative forms. The original morphemes in (8) are the ones belonging to the loose type of syllables, since they contain complex contour tones (i.e., MLM), and hence, are bimoraic. The first syllable of the output in each case has two alternative forms. These two alternative forms are respectively from each of the vowels of the diphthongs in the original morpheme. For instance, the original morpheme in (8a) is [τσει/^{MLM}], which contains a diphthong [ει]. The first syllable of the output can be either [τσι^{L}] or [τσε^{L}] with the former as the more preferred output. The original morphemes in (8b) and (8c) are [τσэουN^{MHM}] and [τэΠψ/^{MLM}] respectively. Again, each of them has two optimal outputs. The brackets indicate the less preferred output.

(8)	Original	"cutting foot" word	Gloss	Alternation
a.	τσει/^{MLM}	τσι^{L}(τσε^{L}).λει/^{MLM}	'squeeze'	ι ~ ε
b.	τσэουN^{MHM}	τσэυ^{L}(τσ—ο^{L}).λου N^{MHM}	'wring out wet clothes'	ο ~ υ
c.	τэΠψ/^{MLM}	τэψ^{L}(τэΠ^{L}).λΠψ/^{MLM}	'draw back'	Π ~ ψ

To account for the alternative outputs in (8), I propose in (**Error! Bookmark not defined.**) that the two constraints PARSEHI and *NUC/HI are not ranked with respect to each other. These two constraints play crucial roles in determining the optimal outputs for vowel distributions between the tight syllables and the loose ones (see chapter 4 tableaux (17) and (18) for details).

(9) Output candidates for [τσэυ^{L}.λουN^{MHM}] or [τσэο^{L}.λουN^{MHM}] 'wring out wet clothes'

"Input"	$Cand_1$	$Cand_2$	$Cand_3$	$Cand_4$
σ N μμ τσэου N RED + RDHI	(. x) σ σ N N μ μμ τσэυ λ ου N HI RD RDHI [τσэυ^{L}.λουN^{MHM}]	(. x) σ σ N N μ μμ τσэο λ ου N <HI>RD RDHI [τσэο^{L}.λουN^{MHM}]	(. x) σ σ N N μ μμ τσэυ ου N HI RD RDHI [ηιε.ιEN]	(. x) σ σ N N μ μμ τσэυ τσэου N HI RD RDHI [ηιε.ηιEN]
RED = NUC				*!
ONS			*!	
PARSEHI *NUC/HI	 *	* 		

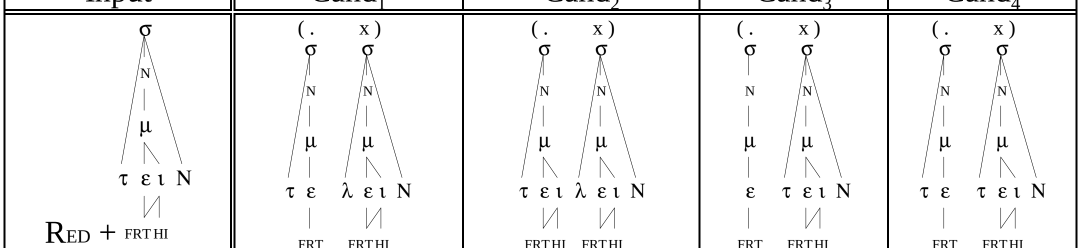
(**Error! Bookmark not defined.**) shows that violation of RED = NUC and ONS is fatal in the last two candidates. $Cand_4$ violates RED = NUC because the reduplicant has identical onset and base. $Cand_3$ violates ONS because the base is onsetless. Comparing the first two candidates, $Cand_2$ violates PARSEHI, while $Cand_1$ violates *NUC/HI. Since these two constraints are not crucially ranked, both candidates are optimal. Thus, the cases where the output has two alternative forms are successfully accounted for by not ranking these two constraints.

Apparent problematic cases for the constraint RED = NUC are those in (10), in which the original words are monomoraic and contain a complex nucleus[2]. If the constraint RED = NUC were fully satisfied, that is, the entire nucleus [ει] in the base gets copied to the reduplicant, the first syllable of the output should have a nucleus [ει] rather than [ε].

(10)	original	"cutting foot"	Gloss
a.	τειN^{H}	τε^{ML}.λειN^{H}	'poke (sand in the shoes)'
b.	Nου/^{H}	Nο^{ML}.λου/^{H}	'look upward'
c.	μΠψN^{H}	μΠ^{ML}.λΠψN^{H}	'puffy'

As can be seen (10), the first syllable of the outputs in (10a), (10b) and (10c) contains a single mid vowel [ε], [o] and [Π], respectively. This suggests that the constraint *COMPLEXNUC (which disallows a nuclear mora from having more than one vowel) must rank above RED = NUC[3]. The question that arises is: why is a complex nucleus allowed in nonreduplicated forms but prohibited in the reduplicant. An explanation comes from the proposals concerning the "emergence of the unmarked" (M & P 1994). A complex nucleus is more marked than a simple nucleus, and it is disallowed unless a higher ranked constraint forces it to be present. In the case of a nonreduplicated base, the constraint PARSERT ranks above *COMPLEXNUC. In other words, all segments must be parsed onto a prosodic anchor, even though it results in a complex nucleus. On the other hand, a reduplicative morpheme contains a solely prosodic constituent without any featural content. It gets its featural content from the base. Even if a reduplicant copies only one vowel from the nucleus of the base, it does not violate PARSERT since segmental roots in the base have already been parsed. In the following tableau, I demonstrate how the constraints *COMPLEXNUC and PARSERT interact with each other in deriving the unmarked type of nucleus in the reduplicant of the "cutting foot words" in (10).

(11) Output candidates for [τε^{ML}.λειN^{H}] 'poke'



"Input"	Cand$_1$	Cand$_2$	Cand$_3$	Cand$_4$
RED + FRT HI [τειN^{H}]	[τε^{ML}.λειN^{H}] 'poke'	[τε^{ML}.λειN^{H}]	[τε^{ML}.λειN^{H}]	[τε^{ML}.λειN^{H}]
RED = NUC				*!
ONS			*!	

[2] I thank E. G. Pulleyblank for bring this case to my attention (p.c.).
[3] I owe this insight to Doug Pulleyblank (p.c.).

ParseRt				
*ComplexNuc		*!		

The last two candidates each incur a fatal violation mark. By copying the onset [t] in the reduplicant, $Cand_4$ violates Red = Nuc because both the reduplicant and the base share the same onset. On the other hand, having an onsetless reduplicant, as in the $Cand_3$, violates the constraint Ons. Comparing the first two candidates, $Cand_2$ violates *ComplexNuc since the reduplicant has a complex nucleus [ɛɩ]. $Cand_1$ does not violate any of the constraints, therefore is optimal.

Notice that $Cand_1$ does not violate ParseRt either because all segmental roots in the base are properly parsed and the reduplicant does not contain any segmental root. Therefore, the constraint ParseRt (which plays a crucial role in deriving the monosyllabic form [τɛɩN^{H}] in the base) is inert in determining the segmental property of the reduplicant. Importantly, the constraint *ComplexNuc seems not to be respected in nonreduplicated forms. However, it plays a crucial role in selecting the optimal reduplicant in the "cutting foot words". This kind of discrepancy between lexical forms and reduplicated forms is exactly the type of case illustrating the emergence of the unmarked, and furnishes support for Optimality Theory.

5.5 Conclusion

I have shown in this chapter that a parallel relation exists among three types of phenomena: (i) vowel alternations between the reduplicant and the base, (ii) vowel alternations between the non-final syllable and the loose syllable in isolation, (iii) vowel distributions between a tight morpheme and a loose one. The factor that governs this relation is the distinctive moraic structure. In particular, the common ground for the three kinds of elements (i.e., the tight morpheme, the non-final syllable in a disyllabic compound, and the reduplicant) is the prosodic anchor, that is, the monomoraic structure, even if this monomoraic structure arises from the effect of different constraints. The constraint deriving the monomoraic structure for the reduplicants and the loose morphemes in the non-final position is PROMREDUCTION, which restricts an unstressed syllable to being monomoraic, while the constraints determining the monomoraic structure for the tight morphemes in isolation are those that govern tonal distributions. It is this particular prosodic structure that unifies the different types of elements.

The constraints on stress have two effects. First, PROMALIGN assigns a metrical grid to the rightmost syllable within a disyllabic domain, giving rise to featural stability in final position. Second, PROMREDUC forces a loose syllable in the non-final position to lose a mora, triggering various vowel changes. The optimal vocalic forms are derived by the same set of constraints on syllabification. This furnishes further support for the prosodic anchor hypothesis in that tone and vowel do not interact directly. Rather, they interact only when the mora gets affected. Moreover, it supports the analysis proposed in chapter 4 for the linking between syllable structures and vowel features in that the vowel distributions exhibited in monosyllabic words are derived by linking the same set of underlying features to different syllable structures.

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