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THE PHONOLOGY AND PHONETICS OF WORD-INITIAL GEMINATES

DISSERTATION

Presented in Partial Fulfillment of the Requirements for

the Degree Doctor of Philosophy in the Graduate School of

The Ohio State University

By

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* * * * *

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ABSTRACT

The phonology and phonetics of word-initial geminate consonants are investigated in this dissertation. The phonology portion concentrates on the patterning and distribution of these sounds in Leti, Chuukese, Cypriot Greek, and Luganda. The observed patterning of initial geminates indicates the need for revision of currently defended models of prosodic representation. Specifically, it is shown that the diverse patterning of geminates in these languages is best accounted for within a framework that assumes the existence of both concrete phonological timing units and abstract prosodic weight units. Crucially, the model that is developed and defended in this work claims that geminates are inherently linked to two timing slots, and may bear prosodic weight (but are not required to), depending upon language-specific requirements.

Complementing the investigation of the abstract behavior of initial geminates is a phonetic investigation of the production and perception of these sounds in Cypriot Greek. The phonetic aspects are of particular interest for one simple reason: these sounds are commonly assumed to be impossible for listeners to distinguish from non-geminate sounds. This is due to the fact that the most salient acoustic feature for geminates, duration, may be indistinguishable when the sound is in word initial position. However,

as will be shown, the production of initial geminates in Cypriot allows listeners to correctly discriminate between initial geminates and singletons in environments that are otherwise lacking in phonetic cues.

In addition to the phonological and phonetic analyses outlined above, this work also contains a database of typological information, reporting on a diverse set of languages that are claimed to have word-initial geminates.

This dissertation represents the first major cross-linguistic study of initial geminates. It is a crucial preliminary step in understanding a significantly understudied class of sounds, thereby providing a more solid empirical basis for the study of language sound systems.

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for my mom



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FIELDS OF STUDY

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CHAPTER 1

INTRODUCTION

This dissertation reports the results of a cross-linguistic investigation of wordinitial geminate consonants. Geminates, also termed 'long' consonants, are segments which exhibit prosodic length. The examination of their behavior in a variety of languages establishes that the word-initial sounds are true geminate consonants, specifically in that they exhibit typical dichotomous geminate behavior and also contribute to prosodic processes unlike short consonants. Based on these investigations, the implications that these segments have for different frameworks of phonological and prosodic representation are evaluated. Furthermore, the phonetic issues relevant to initial geminates are discussed, and preliminary data pertaining to these issues is presented.

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1.1 Motivation of the study

There are a number of compelling reasons motivating the study of initial geminates. First and most simply is the fact that, while these segments are found in a substantial number of languages throughout the world (as indicated by the assortment of languages in Appendix A), they have not yet been the subject of a detailed, cross-linguistic investigation. Previous studies have focused on the patterning of geminate consonants in a few individual languages (such as Hume, Muller and van Engelenhoven 1997 on Leti, or Davis and Torretta 1997 on Chuukese), while other cross-linguistic research on geminates (i.e. Ham 1998) has mentioned the existence of initial geminates only in passing. The patterns of Leti and Chuukese provide intriguing and conflicting evidence regarding the structure of initial geminates, as presented in Davis (1999). However, as noted in that brief work, the behavior of initial geminates may differ according to language-specific parameters and thus research into these segments is a 'rich topic for future research'.

A second reason motivating the study of word-initial geminates is the simple fact that different representational frameworks treat initial geminates differently, especially in comparison to consonant clusters. For example, moraic theory (Hayes 1989) and timingslot theories (Clements and Keyser 1983, Levin 1985) make crucially different predictions with regard to the expected behavior of geminates and consonant clusters in word-initial position, as will be demonstrated in a later section of this chapter.

A final reason for studying word-initial geminates is based in phonetic issues. It has long been held that the primary phonetic correlate of phonological length is duration of articulation. However, duration may be impossible to implement or discern in the word-initial environment, as will be discussed in depth in chapter two. Thus, the study of the production and perception of initial geminates allows for a deeper understanding of how speakers and listeners use phonetic cues to implement phonological contrasts. While the phonetic study presented here is preliminary in nature, the basic facts laid out pave the way for future work.

1.2 Theoretical assumptions

In this section, the assumptions regarding the definition of the term 'geminate' will be clarified, and the characteristics of these segments will be outlined. The assumptions regarding the representation of initial geminates will then be presented. Finally, the theoretical framework in which the analyses in this work are cast, will be presented.

1.2.1 Establishing the existence of initial geminates

The term 'geminate', as used in this work, describes the set of consonants which exhibit any subset of the characteristics outlined below. Importantly, it is assumed that the class of geminates encompasses the segments which in earlier works have been distinguished according to their syllabic environment. For example, Crystal (1992) distinguishes between 'geminates' which crucially span a syllable junction, and 'long consonants' which do not. As will be shown in the following discussion, the initial segments investigated in this work share many characteristics with segments which are

intersyllabic. It is apparent that these segments form a class regardless of their syllable affiliation and so such a terminological division is unwarranted. The use of 'geminate' as a broad term which encompasses all segments which exhibit the typical characteristics (as described below) reflects the widely accepted definition of the term among phonologists (e.g. Kenstowicz 1994).^I

There are a number of characteristics of geminates that are typical of this class of sounds. Although these characteristics are well-attested in various languages, most languages exhibit just one or two of the characteristics. However, the presence of these characteristics serves as diagnostics of geminate status.

The most basic characteristic of geminate consonants is that they contrast with otherwise identical segments on the basis of phonological length. As will be presented in chapter two, phonological length is typically encoded as increased phonetic duration, although other factors may influence duration. Thus, the crucial component is the phonological contrast between the geminates and the shorter segments which are otherwise featurally identical.

All of the languages included in this study have minimal pairs which indicate the geminate/singleton contrast. For example, in Leti *rusa* 'to nail' contrasts with *rrusa* 'they nail'; in Cypriot Greek, *pefti* 'Thursday' is in a minimal pair with *ppefti* 'he falls'; in Chuukese, *kak* 'ring (verb)' contrasts with *kkak* 'ring (noun)'; and in Luganda, *ggula* 'open (imperative)' contrasts with *gula* 'buy (imperative)'.

^t Throughout this dissertation, geminates will be transcribed using both doubled symbols (e.g. [pp]) and the length diacritic (e.g. [p:]). This variation is simply for illustration purposes. For example, some syllable structure is more easily expressed when a geminate is shown with a doubled symbol than with a single one (e.g. [ap.pa]). No theoretical distinction is indicated with these different transcriptions (cf. Crystal 1992).

In addition to contrasting with short consonants, geminates exhibit unique patterns with regard to different phonological processes. For example, geminates may pattern like single segments for processes which target segment quality, and as consonant clusters for processes that target length (duality). They may be entirely immune to some processes which target other segments (inalterability). Finally, they may interact in prosodic processes, such as stress assignment, just as vowels do. Crucially, all of these characteristics are observed regardless of the phonological environment of the segment. Examples of each of these characteristics are outlined below.

As mentioned above, a hallmark of geminate behavior is their dual nature: geminates may act both like single segments and consonant clusters simultaneously (see, e.g. Leben 1980 for typical examples involving medial geminates). Initial geminates exhibit this dual patterning, as can be seen in Moroccan Arabic.

In Moroccan, complete assimilation of the definite article /l-/ to a following coronal yields an initial geminate, as seen in the examples in (1) below.

(1) Assimilation of definite article in Moroccan Arabic:

| l-tub/ | ttub | 'the cloth' |
|---------|--------------|--------------|
| l-ḍhur/ | ḍḍhur | 'the backs' |
| l-neșș/ | nneșș | 'the halves' |
| l-žmel/ | žžmel | 'the camel' |

| cj. | /1-/ before non-coronals | | | |
|-----|--------------------------|---------|--------------|--|
| | /l-bab/ | lbab | 'the door' | |
| | /l-mektub/ | Imektub | 'the pocket' | |

Under the assumption that total assimilation involves the delinking of one feature matrix and the spreading of the remaining features to the empty slot (e.g. Clements

n - Frank Barren - Anne Frank - Frank - Frank - Frank - Frank - Frank - Frank - Frank - Frank - Frank - Frank -Frank - Frank -Frank - Frank -

1985), the assimilation data of (1) suggest that the geminates in Moroccan are monolithic units.

(2) Total assimilation following Clements 1985



Further evidence that suggests that Moroccan geminates are single units rather than sequences of identical segments comes from a consonant inversion language game, as described in Heath (1987). In this game, the order of consonants in a stem is reversed, as shown in (3). As can be seen, adjacent consonants are reordered individually. However, in a form that has a geminate, the geminate is inverted as a unit. If they were simply sequences of like consonants, this pattern would be unexpected. Rather, a from which inverts the two 'halves' of the geminate separately (as in the starred examples) would be expected.

(3) Moroccan Arabic consonant inversion language game (Heath 1987)

| Standard form | Play form | gloss | |
|-------------------------------------|-----------|----------------|----------|
| ktb-na | btk-na | 'we wrote' | |
| ta-n-șum | ta-n-muș | 'I am fasting' | |
| kubb | bukk | 'he poured' | *bkuk |
| mm ^w ingina ² | nnigima | 'clock' | *ngimima |

Other patterns in the language show that geminates and consonant clusters pattern alike, suggesting that they have similar structure. For example, sequences of three consonants trigger schwa epenthesis, as in (4). Crucially, a geminate followed by a short

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² See Heath 1987 for an account of the labialization that accompanies the initial geminate in this form.

consonant patterns like a CCC cluster for this process, as shown below. If a geminate was a short, single consonant, it would not be expected to trigger epenthesis. Incidentally, as demonstrated by the non-surfacing form *[dadra], epenthesis does not split up a geminate, unlike a consonant cluster, providing additional evidence that the Moroccan geminates are monolithic units.

(4) Schwa epenthesis

| | /mskin/ | [məskin] | 'poor' | |
|-----|---------|----------|---------|------------------|
| | /fṛḥan/ | [fərḥan] | 'happy' | |
| | /d:ŗa/ | [əd:əra] | 'corn' | *[dṛa]; *[dədṛa] |
| cf. | /mṛa/ | [mra] | 'woman' | *[məra] |

Similar patterns of geminate behavior are observed in, among other languages, Leti and Cypriot Greek, two languages which will be explored in depth in chapter four. As will be demonstrated, the observation that the geminates in these languages pattern as single segments provides support for the assumption that geminates are not simply sequences of identical consonants, but rather are single segments that are multiply-linked to two prosodic positions. More importantly, the behavior of initial geminates in these languages with regard to processes that target segmental length indicate that they comprise two timing slots. An account of the patterns in these languages is facilitated in a framework that assumes the representation of timing slots. More interestingly, it is demonstrated for Leti that the facts may only be accounted for within a framework that posits these units.

As mentioned above, geminates may be immune to phonological processes that affect other segments. This characteristic is termed inalterability (following Schein and

Steriade 1986, and references therein), and is one example of how geminates are fundamentally different from their singleton counterparts. A potential example of inalterability in initial geminates comes from Moroccan Arabic. It is noted that the stops /b t d k/ are lenited following vowels (Keegan 1986), as in (5 a, b). However, as in the final example, an intervocalic geminate is not lenited.

(5) Moroccan Arabic lenition

| | a. | /sebsi:/ | [seßsi:] | 'pipe' | |
|-----|----|-----------|-----------|------------|---------|
| | b. | /sba:ba:/ | [sba:ßa:] | 'flute' | |
| cf. | c. | /lebbes/ | [lebbes] | 'to dress' | *leββes |

In earlier accounts of inalterability effects, it was proposed that geminates are immune to lenition rules that target singletons due to restrictive interpretations of rule application (e.g. the Uniform Applicability Condition proposed in Schein and Steriade 1986), to rules that apply to both melodic and timing tiers (the 'Linking Constraint' presented in Hayes 1986), or due to aerodynamic constraints (Kirchner 1998).

Presently, there is insufficient data to determine if lenition occurs across word boundaries in Moroccan Arabic and thus conclusive evidence demonstrating that initial geminates are immune to lenition is not available. However, it is unlikely that they behave any differently than underlying medial geminates. First, geminate [$\beta\beta$] is not reported to occur in any environment, word-initially or medially. Second, stems that have underlying initial geminates do not lenite when preceded by a vowel-final prefix: /mua + bba:/ [muabba:] 'over father' *ma $\beta\beta$ a:.

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Evidence of a different type of inalterability comes from Leti, as presented in chapter four. In this language, the affixation of a reduplicant may break up an initial consonant cluster. Thus, a form such as /kriat/ is reduplicated as [kririat] 'to be slow', in which the underlined reduplicant surfaces between the two consonants of the stem. Crucially, the reduplicated forms of words with initial geminates show that the reduplicant does not break up the geminate: [pperat] is reduplicated as [pepperat].

It is commonly observed that intervocalic geminates contribute prosodic weight to a syllable, so that a syllable closed by a geminate is equivalent to one with a long vowel. For example, in Latin, penultimate syllables with long vowels or those closed by geminates attract stress, despite the fact that the typical pattern is antepenultimate stress assignment: marí:tus *mári:tus 'husband' cabél:us *cábel:us 'horse'; cf. príncipem 'first'.

Evidence that initial geminate consonants may contribute prosodic weight to a word comes from their patterning in, for example, word minimality requirements and tone processes in Hatoma, a Ryukuan Japanese dialect. In Hatoma, the minimal word is bimoraic (Lawrence, p.c., Ginstrom ms.). Thus, words that are bisyllabic, or monosyllabic with a long vowel satisfy this requirement. Crucially, words with initial geminate consonants and short vowels also satisfy this requirement, suggesting that the initial geminate helps satisfy the prosodic weight requirement.

(6) Hatoma word minimality:

| kusi mii | | 'back' 'tail' | |
|-------------|----|------------------|-----|
| ffa | .4 | 'child' | *fa |

Tone patterns in Hatoma also indicate that initial geminates bear prosodic weight. In the unmarked tone class, the final syllable is low toned. If that tone is preceded by a short syllable, then the whole word is low; otherwise a HL pattern is observed. Crucially, forms with initial geminates exhibit the HL pattern: ssúmùn 'to wrap'. Since the initial syllable contains a single, short vowel, it appears that the initial geminate is contributing a mora and thus exhibiting the expected tone pattern.

Further processes that suggest the moraic status of initial geminate consonants are found in Chuukese and Luganda, which will be addressed in depth in chapter five. This type of evidence provides support for a central assumption of the prosodic model being defended in this work, that is, a geminate may contribute prosodic weight to a word, regardless of its phonetic environment.

As stated above, the characteristics of a geminate are independent of environment. As such, the difference between geminates and singleton consonants is assumed to be an inherent part of the segment. An example of geminates exhibiting consistent behavior regardless of their environment in the word comes from Luganda. In this language, geminates are unlike singleton consonants in that they may block tone spread processes (see chapter five). Furthermore, they block tone spread regardless of where they surface in the word, medially or initially. Thus, their distinctive behavior is not based on environment but rather is an inherent quality of these sounds. Some singleton consonants may participate in prosodic processes, but only in restricted phonological environments. For example, in some languages, a coda consonant may make a syllable more prominent, such that it receives stress: [.pat.] is stressed while [.pa.] is not. However, there is nothing inherently different about the segment [t], as it does not cause the syllable [.ta.] to receive stress, nor is it the only segment able to make [.pa._.] prominent for stress assignment. In this case, the prosodic difference exhibited by [t] when in the syllable [.pat.] is derived entirely from the environment.

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As alluded to above, few languages exhibit more than one or two of these characteristics; it is possible that a language that has a consonant length contrast lacks the phonological processes which would definitively establish that the sounds are actually geminates. In that case, the role of phonetic implementation may also be considered. As will be discussed in chapter two, it is claimed that the universal phonetic cue to geminate status is increased duration of articulation. Thus, in the absence of phonological evidence for geminate status, significant closure duration differences may indicate phonological length contrasts.

1.2.2 The representation of geminates

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The types of evidence outlined in the previous section will be addressed in more depth in chapters four and five. Essentially, these processes indicate that initial geminates are 'true' geminates in that they exhibit the same type of patterns that medial geminates do. Despite these similarities, initial geminates hold special implications for formal representational frameworks and, as will be presented below, evidence from the

languages studied in this work suggest revisions and refinements to currently accepted models.

The phonological representation of geminates has long been a controversial issue in phonology. In previous work on the topic, it has been proposed that geminates differ representationally from singleton consonants with regard to feature specification (Harms 1968); association to timing slots (McCarthy 1979, Clements and Keyser 1983, Levin 1985); moraicity (Hyman 1985, Hayes 1989); root-node association (Selkirk 1990); or with regard to both timing slot association and moraicity (Hock 1991, Tranel 1991, Hume, Muller and van Engelenhoven 1997).

As the evidence for these proposed representations of geminates comes almost exclusively from intervocalic geminates, it is perhaps unsurprising that they should face some difficulties in representing non-intervocalic geminates. For example, a basic tenet of many of the frameworks mentioned above is that a geminate constitutes both the coda of one syllable as well as the onset of the following syllable. Naturally, when a geminate is in absolute initial position, it is not preceded by another syllable. In order to represent initial geminates, the claims of the earlier frameworks must be modified.

Initial geminates reveal additional problems for some representational models. For example, in Leti, geminates must be analyzed as non-moraic. However, moraic theory claims that all geminate consonants are inherently moraic, as discussed in chapter three, and so it is difficult to account for the Leti patterns in this framework. Similarly, the initial geminates of Chuukese must be analyzed as moraic. However, under both

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timing-slot and moraic theories, only syllable codas may bear moras. Thus, accounting for Chuukese is problematic.

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It is proposed that a representational model that incorporates aspects of earlier frameworks is able to account for the range of behaviors observed Leti and Chuukese. Since the proposed model contains attributes of earlier models, it will be called the Composite Model (CM). By combining elements of earlier models, the CM seeks to create explicit, testable claims regarding prosodic structure, as will be detailed in chapter three.

The basic components of the CM are as follows. First, the universal representation of a geminate consonant is comprised of a single root node multiply-linked to two timing slots. Second, and crucially, a geminate is not inherently moraic. However, the geminate may be assigned prosodic weight, depending upon language-specific parameters. Importantly, the moraic status of geminate consonants is not dependent upon position in the word or syllable, but rather may bear weight in any position. Third, and finally, geminates are not assigned prosodic weight independently of the rest of the prosodic system of a language; it is claimed that there is a harmonic ranking of prosodic structure requirements that establish implicational relationships. For example, it is claimed that if initial geminates are moraic in a language, then coda consonants are also moraic.

The proposed harmonic ranking of these requirements predicts just three types of languages. In the first, only vowels are moraic. In the second type, vowels and coda consonants (including those that comprise the first half of a geminate) may contribute

prosodic weight. In the third type of language, vowels, coda consonants, and initial geminates may contribute prosodic weight to a word. However, there can be no language in which initial geminate consonants act as moraic while word-medial ones do not. Similar to the proposed representation of Hume et al (1997), this model reflects both prosodic weight and length. However, unlike Hume et al. or earlier timing-slot and moraic models, the current model correctly predicts the range of patterns observed cross-linguistically.

The claims of the CM are supported by evidence from the languages presented in chapters four and five: Specifically, Leti and Cypriot Greek exhibit patterns which are best accounted for under the assumption that geminates comprise two explicit timing slots. The behavior of geminates in Chuukese and Luganda are best accounted for by positing that geminates are moraic, even in initial position.

1.2.3 Constraint-based framework

As stated in the preceding section, it is claimed that there are universal requirements for mora contribution that may vary in importance in different languages. This claim is easily presented within a constraint-based framework such as Optimality Theory (Prince and Smolensky, 1993; McCarthy and Prince 1993). In this framework, it is claimed that universal constraints on surface forms may be variably ranked in different languages. Thus, a constraint which requires geminate consonants to contribute prosodic weight to a syllable (such as the 'Gemµ1' constraint introduced in chapter three) may be highly-ranked in one language, and lowly-ranked in another. When constraints that have

conflicting requirements are ranked differently in different languages, various patterns are predicted.

For example, a constraint which conflicts with Gemu is one that prohibits moraic structure of any kind ('* μ ', to be introduced in chapter three). When the requirement that geminates be moraic is more important than the prohibition against moraic structure, a language in which geminates are moraic is predicted. This is illustrated in the tableau in (7). Here, the moraic geminate is selected as the optimal form (as indicated by the ϖ symbol) since it satisfies the highly-ranked requirement that geminates be moraic. Even though this violates the lowly-ranked prohibition against moras (as marked with *), it is a better choice than the non-moraic segment (where *! marks the fatal violation of this high-ranking constraint). As will be presented in chapter three, Luganda and Chuukese are two examples of languages in which this ranking holds.

| input: XX p | Gemµ (geminates must be moraic) | *µ (no moras) |
|-------------------------------|------------------------------------|------------------|
| a. ^{ar} µ XX p | | * |
| b. X X | *į | |

(7) Gem μ outranking * μ :

(8). Here, the non-moraic geminate is selected since the prohibition on moras outranks

the requirement that geminates be moraic. Languages such as Leti and Cypriot Greek are

representative of this pattern.

(8) *µ outranks Gemµ.

| input: X X P | *µ (no moras) | Gemµ (geminates must be moraic) |
|----------------------|------------------|------------------------------------|
| a. μ X X P | *! | |
| b. *X X | | * |

1.3 The structure of this work

The format of the remainder of this dissertation is as follows. Chapter two contains an overview of the phonetic issues related to word-initial geminates, with a focus on the production and perception of voiceless geminate stops in Cypriot Greek. The goal of this chapter is to establish that the phonological length contrast is manifested in a salient manner, such that native listeners may discriminate geminates and singleton stops in environments that are claimed to be poor in acoustic cues that directly indicate closure duration.

Chapter three presents the Composite Model in detail. The specific claims of the model are explored and evidence supporting the claims is discussed. Along with a brief overview of earlier models, the implications of the proposed model will be outlined.

Chapters four and five examine the behavior of initial geminate consonants in a variety of languages. Chapter four presents data from Leti and Cypriot Greek that indicate that geminate consonants are best represented with timing units such as X slots or CV slots. In chapter five, data is represented from Chuukese and Luganda showing that initial geminates in these languages are best represented via prosodic weight units (moras).

Chapter six contains concluding remarks about the significance of this study and also presents topics for future research.

Finally, Appendix A contains summaries of languages with initial geminates that were not addressed in depth in this dissertation. A basic assertion of this work is that while initial geminates are less-commonly attested than their word-medial counterparts, they are prevalent enough to not be dismissed as merely anomalous. Essentially, the fact that they are attested in dozens of the world's languages indicates their relevance for both phonological and phonetic investigation. Appendix A represents the first compilation of data pertaining to word-initial geminates, and allows for some general typological observations.

1. **1.**

CHAPTER 2

THE PRODUCTION AND PERCEPTION OF INITIAL GEMINATES IN CYPRIOT GREEK

Geminates are commonly referred to as 'long' consonants since the phonetic feature most commonly associated with them is duration of articulation (see e.g. Ladefoged and Maddieson 1996). However, most observations regarding the acoustic correlates of geminates come from languages that have word-medial geminates, a fact which is unsurprising considering that geminates are most commonly found in this environment (Thurgood 1993). In fact, the acoustic features of initial geminates as they relate to production and perception have been investigated in depth for just two languages, Pattani Malay (Abramson 1986, 1987, 1991, 1998, 1999) and Thurgovian Swiss German (Kraehenmann 2001).

As Abramson (1999) notes, there are special considerations related to the phonetic realization of initial geminates. Specifically, it is observed that since voiceless stops exhibit no vocal tract excitation during their closure period, there can be "no direct signal of the relative durations of stop closures in utterance-initial position" (p. 591). Since listeners are able to correctly distinguish initial voiceless stops in this language, Abramson concludes that these segments must be produced with secondary acoustic cues that distinguish geminates and singletons, even in initial position.

Based on the assumption that there are acoustic cues other than duration of articulation that may distinguish initial geminates and singletons, I conducted production and perception experiments involving initial geminates in Cypriot Greek. As will be shown, speakers produce initial and medial geminates and singletons in a significantly different manner, and despite the differences in realization, listeners are able to distinguish between geminates and singletons. In the following sections, each experiment will be described and discussed. Section 2.1 presents the production experiment. First, background information is presented which helps to elucidate the specific hypotheses. Then, the methodology and results are presented, followed by discussion. Section 2.2 reports on the perception experiment. The chapter concludes with a general discussion of the findings, specifically addressing how the production and perception findings may relate to each other.

2.1 Production study of voiceless stop geminates in Cypriot Greek

In a detailed investigation of the production of medial geminates in Cypriot Greek, Tserdanelis and Arvaniti (2000, 2001) measured the acoustic features of stops, fricatives, affricates and sonorants. As expected, it was found that for all classes of sounds, the duration of geminates was significantly longer than for singletons¹. In addition to the durational differences, it was also found that the voice onset time (VOT)

¹ It was noted that the results for /k/ showed an unexpected lack of significance, which post-hoc tests indicated was the result of subject idiosyncracy, rather than a systematic difference in the realization of /k/.
duration was significantly longer following the geminate stops than the singletons. As noted, this finding corresponds to the impressionistic observations that Cypriot geminates are heavily aspirated. It was also established that other acoustic cues, including RMS amplitude and relative values of the first two harmonics following consonant release, did not differ significantly or consistently following geminates and singletons.

Based on both the closure duration and VOT differences, Tserdanelis and Arvaniti conclude that the Cypriot stops are best described as geminates rather than simply as aspirated stops². Although their investigation helps to establish the phonetic identity of these segments, and provides much-needed background regarding the production of geminates and singletons in general for this language, the investigators did not study the production of the word-initial geminates in Cypriot Greek.

As alluded to in the introduction, the acoustic features of word-initial geminates have only been investigated in depth for the Austronesian language Pattani Malay and the Swiss German dialect Thurgovian. Abramson (1987) found that the most significant difference between intervocalic geminates and singletons in Pattani Malay is duration of closure. However, he also found that RMS amplitude values and fundamental frequency following the release of an initial geminate are significantly greater than those following a singleton release. Abramson (1999) suggests that these secondary acoustic cues taken together help the listener to identify the category (geminate or singleton) of an initial stop, since the primary cue, duration, is unavailable.

² The majority of scholars who have investigated Cypriot phonology concur that these segments are geminates (Malikouti-Drachman (1987); Arvaniti (in press); Arvaniti and Tserdanelis (2000); Muller (forthcoming)), based on both phonological and phonetic evidence; Charalambopoulos (1982) concludes these segments are simply aspirates, based primarily on impressionistic phonetic observations.

Data from investigations of word-medial geminates supports Abramson's supposition that additional acoustic cues may accompany the production of geminates. For example, Lahiri and Hankamer (1988) found that VOT is significantly shorter following geminates in Turkish, and Hankamer et al (1989) found that RMS amplitude following geminates was significantly different than following singletons for Bengali. The secondary cues found in Lahiri and Hankamer (1988) and Hankamer et al (1989) were observed for medial geminates only; since these languages do not permit geminates in other environments, it is impossible to determine if the realizations of these sounds differed according to phonological environment.

However, the findings of Wright (1996) suggest that speakers are aware of the perceptual difficulties inherent in different environments, and alter their production accordingly. In an investigation of Tsou, Wright found that speakers produced medial stop clusters (as in *tatposa* 'colorful') with no release between the first and second stop. Wright speculates that since a medial cluster is surrounded by vowels, there is sufficient acoustic information (such as formant transitions realized on the vowels) for a listener to identify the stops. However, when the same stop clusters were produced in absolute initial position (as in *tpihi* 'mend'), the speakers produced the clusters with a release between C1 and C2. Wright hypothesized that the speakers recognized that the lack of acoustic information before C1 could hamper the listener's ability to identify that consonant; to compensate, the speakers produce the segment in such a way as to aid perceptibility (assuming that the spectral information of the release burst identified the

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segment). Thus, it appears the production of acoustic cues is within control of the speaker and may take into account the phonological environment of the sound.

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The goal of the current study is to determine what the acoustic features of wordinitial geminates in Cypriot Greek are. Specifically, data will be collected and measured to determine if the characteristics of initial geminates are similar to those found for medial geminates by Tserdanelis and Arvaniti, and whether there are any characteristics that are unique to the word-initial realization of these segments.

It is hypothesized that the durational and VOT differences observed by Tserdanelis and Arvaniti will be present in the findings of the current study, and specifically that the VOT differences will be evident for stops in both word-medial and word-initial position. Extending Wright's (1996) suggestions regarding initial stop clusters, it is also predicted that the acoustic features associated with geminates will be exaggerated in absolute initial position, following the speculations of Wright (1996). Specifically, it is posited that the VOT values for initial geminate stops will be significantly longer than for their medial counterparts, and that the difference between the VOT values of stops and geminates in initial position will be greater than the observed difference in medial position. These hypotheses were tested by measuring the acoustic features of geminates and singletons in both word-initial and word-medial environment, and then conducting analyses of variance on the results.

To establish that initial geminates and singletons differ as medial ones do, the VOT values for stops in these environments were measured and analyzed. Additionally, the duration of fricatives and word-medial stops were measured in order to verify that the geminate closure durations are longer than their singleton counterparts. Thus, the findings will be presented in two sections: one reflecting VOT measurements and another reflecting duration measurements.

2.1.1 Methods

Subjects

Six native speakers of Cypriot Greek, three females and three males ranging in age from 18 to 30 served as subjects for the production study. The subjects were compensated for their time. No subjects reported speech or hearing disorders.

Description of data to be collected

In order to evaluate the central questions regarding the production of word-initial geminate consonants in Cypriot Greek, examples of geminates and singleton consonants were collected representing three different stops (/p/, /t/, /k/) as well as a fricative (/s/). For each sound, two different environments are also represented: word-initial position, as well as word-medial, intervocalic position. For each condition, three individual words were elicited. For example, each speaker produced three different tokens which contained an initial geminate /p/, three that contained an initial singleton /p/, etc. The set of elicited tokens is shown in table 2.1.

| /p/ | Word-initial | | Word-medial | |
|-----------|--------------|--|-------------------|--------------|
| Singleton | token | gloss | token | gloss |
| | pounkiazo | become cold | akopon | uncut |
| | pounta | cold | apelejitos | uneducated |
| | palios | old | antipolo:ume | talk back |
| Geminate | token | gloss | token | gloss |
| | p:ounia | fist | ap:aramouria | horsefly |
| | p:oulin | stamp | aprio | to jump |
| | p:aras | money | kap:arka | caper plant |
| /t/ | Word-initial | | Word-medial | |
| Singleton | token | gloss | token | gloss |
| 1 | taβas | stew | aðita | untied |
| | tora | now | katalaßo | I understand |
| | telaron | cloth frame | katautis | on purpose |
| Geminate | token | gloss | token | gloss |
| | t:aßanin | ceiling | kat:ouðkia | kittens |
| | t:eliazo | fence in | kolokopit:a | pumpkin pie |
| | t:emeniazo | give advice | šet:otos | thorny |
| /k/ | Word-initial | ······································ | Word-medial | |
| Singleton | token | gloss | token | gloss |
| | kafes | coffee | βortakos | frog |
| | kaθisko | sit down | akatarnota | of course |
| | koulumbra | vegetable | kakopaθkiazo | bad event |
| Geminate | token | gloss | token | gloss |
| | k:eliazo | become bold | ak:an:oura | octopus beak |
| | k:epap | grilled meat | kouk:oul:on:o | cover |
| | k:oul:as | ghost | kouk:oufo | bother |
| ľs/ | Word-initial | | Word-medial | |
| Singleton | token | gloss | token | gloss |
| | šoirin | pig | antrošia | chocks |
| | šepet:os | gun | ašelonarin | stable |
| | šonon:0 | pour | ašeropala | hay bale |
| Geminate | token | gloss | token | gloss |
| | š:oinin | robe | rloštiazo | talkative |
| | š:eparnia | axe | θkiaš:elizo | walk |
| | š:ahinin | bird | aš:imi0kiastistos | very ugly |

Table 2.1Elicited words

The tokens were culled from two Cypriot Greek dictionaries (Giagoulles 1994, Chatzeioannou, 2000). Potential tokens were presented to a Cypriot speaker in order to establish that each word is contemporary and common enough to be well-known by subjects. Based on the speaker's comments and suggestions, the final list of elicitation words was developed which included both word-medial and word-initial geminates and singletons.

Tokens were selected with the intent of avoiding independent factors that may alter production. For example, all target segments are adjacent to unstressed vowels, to avoid any effect that stress may have on articulation of the targets. Furthermore, all segments are adjacent only to vowels, to avoid interference with other consonant production.

The target segments, /p/, /t/, /k/, and /š/ do not represent all possible geminates in Cypriot Greek (see chapter 4 for a complete description of the phonemic inventory and phonotactic restrictions of Cypriot)... However these segments are the focus of the current study for two reasons: there is a significant number of common words that contain the target segments in all environments, and the target sounds are affected only minimally by regional variation. An example of a potential target sound that was excluded based on these criteria is the lateral /l/. While word-medial examples of geminate /l:/ are common, there are only two cases of word-initial geminate /l:/, and these words are virtually identical, being etymologically related. Furthermore, laterals are commonly produced as glides before high vowels in some varieties of Cypriot Greek, further restricting the number of potential tokens.

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Procedure

Each subject was recorded individually in a sound booth at the Ohio State University Department of Linguistics Laboratory. The speakers were fitted with a headmounted, unidirectional Shure SM-10a microphone, and their speech was recorded on a Sony Digital Audio Tape (DAT) PCM-1 recorder.

In order to avoid interference from non-standard Cypriot orthography, speakers were presented the tokens aurally rather than visually. During each recording session, the researcher and a Cypriot consultant were present in the recording booth along with each subject, but were not recorded. The researcher read the English gloss of each token to the assistant, who then produced the Cypriot word. The subject was instructed to repeat the word that the assistant said. In addition to eliminating orthographic interference, this method of elicitation also prevented extraneous discussion of the exact translations of each word or the fine semantic meanings of different tokens, making data collection more efficient. Effectively, since each subject was primed to produce a certain token, they could do so at a conversational rate of speech.

Subjects were asked to say token words in isolation as well as in a carrier phrase, which ends in an unstressed vowel (again, ensuring that all target sounds are not adjacent to stressed vowels that may alter production). Thus, each elicited word was produced as follows: 'X. Lalo su X' ('X. I say to you X'). Speakers were instructed to pronounce the utterances in a normal manner, avoiding hyperarticulation. The elicitation list was presented three times, each time in a different random order.

The tokens that were produced in the carrier phrase were transferred to a computer and down-sampled to 11025 Hz. For each token, acoustic features that are indicators of segment duration were measured by examining spectrograms, following standard segmentation procedures. Specifically, for the fricative, the duration of frication was measured. For word-initial stops, voice onset time (VOT) following the release of the consonant was measured as the duration between the release burst of the consonant and the onset of voicing of the following vowel. Since all of the stops in this study are voiceless (reflecting the fact that Cypriot does not permit voiced geminate stops), and since stops are silent throughout their closure duration, measurement of the closure duration of initial stops was impossible³. However, since word-medial target sounds were surrounded by vowels, measurement of both closure duration and VOT for those tokens was possible.

2.1.2 Results

2.1.2.1 Voice Onset Time

The mean values for VOT for geminate and singleton stops in Cypriot Greek are illustrated in figure 2.1. These values were obtained by averaging VOT measurements for all tokens which contain target stops, for all six speakers, for all stops (/p/, /t/, and /k/), and for both phonological environments (initial and medial). As can be seen, the overall mean for geminate VOT is almost exactly three times that of the singleton counterparts.

³ Although the tokens were produced in a carrier phrase, this did not allow for an accurate measurement of initial stop closure duration since speakers frequently paused between the final word of the phrase and the token word. This discontinuous speech prevented any systematic measurement of the closure duration of initial stops.



Figure 2.1: Mean VOT values for all stops in all environments

Figure 2.2 illustrates the VOT values for stops, according to their phonological environment. As can be seen, the VOT value for both geminates and singletons are greater in word-initial environment than in word-medial environment.





Figure 2.2: Mean VOT values, according to phonological environment

The results of the VOT measurements were submitted to a repeated-measures ANOVA with three factors: Environment (word-initial or word-medial); Type (singleton or geminate); and Segment (/p/, /t/, or /k/). Of those factors, Environment was significant (F (1,5) = 23.04, p<.05), as was Type (F (1,5) = 323.63, p<.05); The Segment factor was not significant.

Of the two-way interactions, Environment by Segment was significant (F (2,10) = 12.93, p<.05), as was Type by Segment (F (2,10) = 9.20, p<.05). The three-way interaction of Environment by Type by Segment was also significant (F(2,10) = 14.12, p<.05).

While Segment (i.e. /p/, /t/, /k/) did not contribute significant variation independently, it was significant in interaction with other factors. This interaction is illustrated in the figures below. As can be seen in figure 2.3, the VOT value of singleton /t/ is longer than the other segments, regardless of environment. The VOT values for geminates (as shown in figure 2.4) vary significantly depending upon phonological environment. Specifically, initial geminate /t/ exhibits a shorter VOT than any of the other segments.



Figure 2.3: VOT values for singletons



Figure 2.4: VOT values for geminates

A simple-effects analysis of Type by Environment for the /t/ VOT values reveals that the interaction is significant for the geminates (F (2,10) = 25.5, p < .05). Essentially, this indicates that the only significant variation exhibited by these patterns is due to geminate /t/ in word-initial environment.

As was illustrated in figure 2.2, there is a difference in VOT values depending upon the environment of the stop (word-initial or word-medial). With regard to the absolute difference, for both geminates and singletons, the VOT of initial stops is about 14 ms. longer than the medial value. A simple effects analysis of Type by Environment reveals that for the class of singleton stops, there is a significant difference between the VOT values in the two environments (F (1,5) = 17.6, p<.05). For geminate stops, the effect is also significant: (F (1,5) = 6.9, p<.05).

2.1.2.2 Segment duration

In Figure 2.5, mean duration values for fricatives and word-medial stops are represented separately. As can be seen, geminates of both classes are longer than their singleton counterparts. Furthermore, the duration of the fricative is longer than that of stops. In fact, the mean duration of singleton fricatives was *longer* than that of geminate stops.



Figure 2.5 Mean duration of fricative and stops

Since the values for stops and fricatives were so distinct, and since the relevant factors for each segment group are so different, the results of the duration measurements

were submitted to two separate repeated-measures ANOVAs. For fricatives, there were two factors: Environment (word-initial and word-medial), and Type (singleton and geminate). Note that the Segment factor is irrelevant in this case, since there is only one type of fricative. Environment was significant (F (1,5) = 44.53, p<.05), as was Type (F (1,5) = 177, p<.05). There was no significant two-way interaction. Figure 2.6 illustrates the different duration values for fricatives in both word-initial and medial environments.



Figure 2.6 Duration of fricatives according to word environment

Stops were submitted to a repeated-measures ANOVA with two between-subject factors: Type (singleton and geminate), and Segment (/p/, /t/, /k/). Note that the Environment factor is irrelevant since the only stops that are suitable for duration measurement are in the word-medial position. The Type factor was significant (F (1,5) =

46.53, p<.05), as was the Segment factor (F (2,10) = 4.43, p<.05). This is illustrated in figure 2.7, where it can be seen that there is variation of duration values depending on place of articulation, across both geminates and singletons.



Figure 2.7: Mean closure duration for stops

2.1.3 Discussion

In this experiment, two hypotheses regarding the production of initial geminate stops in Cypriot Greek were tested. The first was that geminates and singletons differ with regard to their acoustic characteristics. More specifically, it was hypothesized that VOT is significantly different for geminates and singleton stops, in all positions, including word-initial. The second was that this difference would be exaggerated in word-initial position, possibly in an attempt by the speaker to aid the listener in distinguishing singletons from geminates.

2.1.3.1 Hypothesis 1

The results indicate that the first hypothesis is supported, in both the general and specific assumptions. First, geminates were shown to be longer than singletons (for the segments for which duration is measurable, i.e. the fricatives and medial stops), and second, the geminate stops were shown to exhibit longer VOT values than the singleton counterparts in all environments.

The finding that VOT is significantly longer following geminates than singletons is not unexpected in light of the results of Tserdanelis and Arvaniti (1999). However, there are two interesting points to make regarding this acoustic feature. The first is that this is clearly not a universal characteristic of geminate stop articulation and the second is that even in languages where VOT appears to be a secondary acoustic cue for geminates, it is not manifested in a uniform way.

In a cross-linguistic examination of the production of medial geminate consonants, Ham (1998) found that VOT is not a significant factor for Levantine Arabic, Hungarian and Madurese. As reported earlier, Abramson (1992) shows that in Pattani Malay, RMS amplitude and F0 are significantly different following geminate release. However, VOT is not a significant factor for voiceless stops in this language (Abramson, p.c.). Thus, the finding that Cypriot Greek exhibits significant VOT differences in distinguishing geminates and singletons does not represent a cross-linguistic universal. Rather, this finding, together with the findings of other studies, indicates that there are language-specific strategies employed to encode a phonological length contrast.

A second important point is that the manifestation of a secondary acoustic cue is not uniform across languages. In Cypriot, the mean VOT following the release of a geminate is 107.5 ms., while that following a singleton is 36 ms., a difference of 71.5 ms. In Turkish, the mean VOT following a geminate is 34 ms., 11 ms. *shorter* than that of a singleton, at 45 ms. While this difference was found to be significant by Lahiri and Hankamer, it is clearly not as robust as the difference exhibited in Cypriot. It is notable that the difference between the means for Turkish is at the lower end of the range of 'just noticeable difference (JND)', as proposed in Lehiste (1970). As discussed in that work, the JND is taken to be the minimal durational difference which a human listener is capable of noticing. Since the difference in VOT for Turkish is assumed to be barely distinguishable according to this parameter, it is questionable as to whether this cue is meaningful with regard to speech production or perception. However, the 71.5 ms. difference exhibited in Cypriot is well above the JND boundary, suggesting that this is a truly robust difference...

I speculate that the nature of the VOT difference in Cypriot (specifically, that VOT is so much longer following geminates than singletons) is attributable to the relative importance of VOT as a marker of geminate status, particularly in word-initial position. In other words, while duration generally indicates whether a segment is a geminate or a singleton, VOT must be crucially relied upon when duration is difficult or impossible to discern, such as in word-initial position. Since VOT is relied upon so heavily in this language to encode the geminate-singleton contrast, it is manifested robustly and consistently.

The converse of this assumption is that a cue such as VOT would not be so robust in a language where the primary cue for geminates, duration, is easily discerned for all geminates. This assumption is supported by the results of studies that investigate wordmedial geminates. For example, in Ham (1998), languages with medial geminates are investigated⁴, and as was reported above, were found to not differ significantly with regard to VOT. Since all of the geminates are medial, there is always acoustic information on each side of the segment which may aid in distinguishing that segment. Because of this, the production of an additional acoustic cue such as VOT is unnecessary.

The hypothesis that a secondary acoustic cue will be employed to encode contrast in a phonological system where the primary acoustic cue is not reliably available will provide the focus of future empirical studies.

2.1.3.2 Hypothesis 2

While the data clearly support the hypothesis that geminate production is significantly different from singleton production in all environments, the second hypothesis does not appear to be supported. The second prediction of this investigation was that the acoustic features of geminates would be exaggerated in initial position,

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⁴ One notable exception is Bernese, which has very limited examples of initial geminates, which arise from a morphophonemic vowel reduction process. However, due to syntactic restrictions, the forms that exhibit these initial geminates would never be in absolute phrase-initial position, and so it is questionable as to whether a cue other than closure duration would ever be necessary for listeners to distinguish geminates and singletons.

possibly in an attempt by the speaker to enhance perception of consonant length in an environment where other cues are obscured.

The data indicate that VOT is longer for both geminates and singletons in wordinitial position, but that the difference between mean VOT values are consistent regardless of environment. Specifically, the difference between geminate and singleton VOT in word-initial environment is 71 ms.; the difference between these segments in medial environment is 72 ms. According to the 'cue-enhancement' hypothesis, if the speakers were intentionally exaggerating cues in word-initial environment, a greater difference for the word-initial values would be expected.

While the second hypothesis was not supported, the observations regarding VOT differences according to environment are still worthy of comment. As shown, VOT values for both geminates and stops were about 14 ms. longer in word-initial position than in word-medial position. This was shown to be significant for both classes of sounds. This pattern mirrors findings of other studies. For example, in an investigation of the production of voiceless stops in Swedish, Lofqvist (1980) found that the mean VOT value for */t/* in initial position was 31 ms. when followed by an unstressed vowel, while the mean VOT value for medial */t/* was 18.6 ms. when followed by an unstressed vowel⁵. It is unclear whether this difference is significant based on the information presented. Similarly, Keating (1984) demonstrates that VOT values are longer in the realization of initial stops in English than in their medial counterparts. While not conclusive, these findings seem to suggest that the VOT differences observed in Cypriot

⁵ Since the focus of Lofqvist's study was not specifically VOT values, these numbers are averaged from other data tables included in that work.

Greek reflect a cross-linguistic tendency for voicing lag to be longer in initial position than in medial position.

2.1.3.3 Other findings

As shown in Lisker and Abramson (1964), and supported in Cho and Ladefoged (1997), there is a general cross-linguistic tendency for velar stops to exhibit a VOT value that is longer than coronals, which in turn is longer than that of the labials. However, VOT values for the different stops in Cypriot Greek do not exhibit the expected pattern with regard to place of articulation. With regard to the VOT values for singleton stops (as illustrated in Figure 2.3), it can be seen that velars exhibit VOT values that are shorter than the coronal values. This pattern is not reflected in any of the 17 languages evaluated by Cho and Ladefoged (1997), and appears to be otherwise unattested. The VOT values for geminates (shown in Figure 2.4) exhibit another unexpected pattern: the values for /t:/ are shorter than those of labials and velars; this again conflicts with the patterns revealed in Cho and Ladefoged, in that alveolars are expected to exhibit a VOT value between that of the labials and the velars. This pattern is similar to that of the unaspirated stops in Navaho, which is shown by McDonough and Ladefoged (1993) to have a mean VOT of 6 ms. for ht, and 12 ms. for /p/.

The figure below compiles the VOT values of Cypriot geminate stops according to place, and illustrates the fundamental issue. These values were obtained by averaging the VOT values across environments for geminates and singletons. Thus, the lowest value for each segment represents the mean VOT value for singletons, while the highest

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represents the mean VOT values for geminates; the difference between the shorter and longer durations are shown in parentheses. As can be seen, the range of values for both /p/ and /k/ are much larger than for /t/. In other words, the VOT values for /t/ do not vary depending upon segment type as much as they do for the other segments.



Figure 2.8: Range of VOT values by place

This lack of extreme variation results in /t/ VOT values that appear unexpectedly long for singletons, and unexpectedly short for geminates. It is unclear at this time why a single segment in Cypriot appears to be subject to restrictions on VOT variation; whether or not this observation reflects a language-wide pattern must remain the focus of future research.

2.2 Perception Study

In various investigations of listeners' ability to distinguish word-initial voiceless geminate and singleton stops in Pattani Malay, Abramson discovered that secondary cues which accompany geminate production in that language aid in perception. Specifically, significant RMS amplitude differences following geminates and singletons helped listeners distinguish between the two types of segments (1991), as did fundamental frequency differences (1999). However, these acoustic cues play subsidiary roles to segment duration, which is found to be the most salient cue indicating segment duration in environments where it is available (i.e. word-medially) (1986). Similar results were obtained by Lahiri and Hankamer (1988) in their investigation of perception of geminates in Turkish and Bengali. That is, although there are secondary acoustic cues which may aid in discrimination, segment duration played the most prominent role in identification.

Although Aravaniti and Tserdanelis (2000, 2001) did not conduct perceptual experiments involving the Cypriot geminates, they did note that VOT 'provides a ... consistent and powerful cue', which they speculate is 'hard to miss, even utterance-initially'.

Based on these findings, I focused on two goals for the present investigation of duration perception in Cypriot Greek. The primary purpose of this experiment was to determine whether speakers could correctly identify word-initial geminates and consonants, and the secondary goal was to determine if there were any differences in successful identification rates between the different types of segments.

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Since Cypriot contains few perfect minimal pairs that contrast initial geminates and singletons, subjects were exposed to the initial syllables of words and asked to identify each word in an identification task. For example, the listeners heard the syllable /t:el/, and were asked to decide if this syllable came from the Cypriot word *telaron* or *t:eliazo*. The subjects were presented with examples of four word-initial target sounds (/p/, /t/, /k/, /s/), in two different phrasal environments: in a carrier phrase, such that the target sound was preceded by a vowel, and in isolation, such that the target sound was preceded by silence.

In general, it is hypothesized that listeners are able to take advantage of different acoustic cues in order to discern the identity of word-initial geminate and singleton consonants (regardless of their phrasal environment), and thus should exhibit successful identification rates at a level better than chance. However, it is also predicted that listeners will exhibit different rates of successful identification depending upon the category and environment of the sound in question. Specifically, it is hypothesized that listeners will be able to distinguish geminate stops from singletons better when the target sound is phrase-medial. As presented earlier, when a sound is intervocalic, there are multiple acoustic cues that may aid in its identification despite the fact that voiceless stops are characterized by a period of silence during articulation. With regard to medial stops, the target sound is both preceded and followed by noise, its duration is simply the period of silence. At the same time, an intervocalic stop also possesses other acoustic cues to its identity, such as longer VOT values. Since there are relatively more acoustic features that indicate the identity of an intervocalic stop, it is predicted that listeners will perform better in identifying those sounds.

Another hypothesis is that listeners will be able to discriminate fricatives better than stops in word-initial position. Again, although it is found that stops are produced with salient VOT values which may aid in identification, I assume that the actual duration of articulation that is evident throughout fricative production will be the most crucial cue in distinguishing geminates from singletons. Basically, this hypothesis assumes that closure duration is a more salient cue than VOT when it comes to determining the category of an initial segment; this hypothesis reflects the findings presented in Abramson (1986) as well as Lahiri and Hankamer (1988) in which closure duration is shown to be the most salient cue for discrimination.

2.2.1 Methods

Subjects

The subjects who participated in this experiment were the same as those in the production study.

Stimulus material

A native Cypriot speaker was recorded saying words with the initial target sounds /p/, /t/, /k/ and /s/. These recordings were then edited and used as stimuli. Additionally, words that did not contain target sounds were also collected to serve as 'training' items

for the subjects to learn the structure of the experiment. The recorded speaker was compensated for her time.

The words selected as sources for stimuli were identified as being common and contemporary by the speaker. Furthermore, they were chosen to ensure that the initial syllable of each pair was identical, so that editing would yield a pair that was identical in all aspects except the identity of the initial segment⁶.

The speaker was asked to produce each word twenty times: five repetitions of the target word in a phrase ('Lalo su X', 'I say to you X'), and fifteen repetitions of the word in isolation. The speaker produced the carrier phrase so that there was no pause between the final vowel of the phrase and the target sound, so that the target sound was truly intervocalic. The repetitions of the words from which the tokens were derived ensured that identification results were not skewed by a single, atypical token that was presented over and over to listeners. Acoustic measurements of the token words mirrored the results of the production experiment: the VOT duration following the release of the geminate stops was significantly longer than that following singletons (F (1,4) = 77.5, p<.05), and the durations of the geminate fricatives were significantly longer than those of the singletons (F (1,4) = 12.7, p<.05).

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⁶ As pointed out by Keith Johnson (p.c.), the vowels in some of the token pairs are not identical (e.g. telaron vs. treliazo), leading to the possibility that listeners could attune to vowel-to-vowel coarticulation in distinguishing the words. However, the results indicate that there is no significant variation in identification in cases where the vowels differed, and those in which they did not. This suggests that any possible coarticulatory effect is obscured, or absent.

(1) Words used as sources for stimuli

| | singleton | geminate |
|---------|-----------|----------|
| /p/: | pountiazo | p:ounia |
| /t/:::: | telaron | t:eliazo |
| /k/: | koulumbra | k:oul:as |
| /ś/: | šoirin | š:oinin |

The speaker was recorded in a sound booth at the Ohio State University Department of Linguistics phonetics laboratory, using a head-mounted unidirectional Shure microphone. The tokens were recorded on a Sony Digital Audio Tape (DAT) deck. Each token was transferred to a computer and down-sampled to 11025 Hz, then edited using speech analysis software.

Each word of each geminate/singleton token pair was edited so that with the exception of the initial consonant, the remaining word-part was virtually identical. Thus, for the target sound /t/, the words *telaron* and *t:eliazo* were edited so that the initial coronal stop was followed by a vowel of approximately 20 ms., and a lateral of approximately 20 ms. Spectrograms of two stimuli are illustrated in figure 2.9. As can be seen, the duration of the vowels and laterals in each token are virtually identical⁷.

⁷ The difference in the articulation of the /l/ represents token idiosyncracy rather than any consistent difference between these two tokens:



Figure 2.9: Sample spectrograms of [tel] and [t:el] stimuli

The edited stimuli were grouped according to target sound, and according to whether they were produced in a carrier phrase or produced in isolation. These sets of stimuli were recorded onto a DAT tape, with a three second interval between each token and a 10 second interval between each group. The experimental stimuli were prefaced by sample stimuli that were designed to serve as a training session for subjects.

Procedure

Subjects participated in the identification tests in a sound-proof booth in the Ohio State University Department of Linguistics phonetics laboratory. The subjects were seated at a desk, and were fitted with stereo headphones in order to listen to the DAT recording of the experiment stimuli. They were given a set of 'answer sheets' on which to mark their responses, as well as a writing implement.

The experiment design was described by the researcher to the subjects; instructions were also printed on the top sheet of the papers the subjects were given. Following the instructions, subjects were exposed to a short sample experiment, in which they listened to a word-part stimulus in a phrase, and to two different stimuli produced in isolation (the words included in the sample did not contrast initial geminates and singletons, they were simply minimal pairs). Following the sample test, the subjects had an opportunity to ask the researcher any questions about the experiment procedure. The researcher also asked the subjects a series of questions to ensure that they understood the design.

The listeners were instructed to listen to each example and to decide which word they heard. For each token they were given two possible options: the word began with a singleton consonant, and the word began with the geminate. Subjects were required to pick one, even if they were not entirely sure of their answer. The listeners were also instructed not to rewind the DAT recording in an effort to hear tokens more than once.

During the experiment, the subjects marked their answers on the answer sheet by circling the word they believed they heard. The experiment lasted for approximately 15 minutes.

2.2.2 Results

Overall, listeners were able to correctly identify the category of the target sounds in over 92% of the tokens presented to them. This percentage is obtained by averaging the responses for all listeners, across all target sounds, and for both phrase environments. The result indicates that the main hypothesis of this study is supported: listeners are able to successfully distinguish geminates from singletons.

The success rates for identification of segments in the two phrasal environments are demonstrated in Figure 2.10 As can be seen, stops are correctly discerned by the listeners in both phrase-medial and phrase-initial position at a higher rate than fricatives. Furthermore, there is a substantial difference in the successful identification rates of fricatives and stops. Across both environments, singleton and geminate stops are correctly recognized 97.4 percent of time, while fricatives are recognized just 74.4 percent of the time.



Figure 2:10: Identification of stops and fricatives by environment

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The identification percentage values were transformed to their arcsine values so as to fit the assumptions of the ANOVA model. The transformed values across all categories were submitted to a repeated-measures ANOVA with three factors: Type

(fricative or stop); Category (geminate or singleton); and Environment (phrase-medial or -initial). Type was significant (F (1,5) = 22.2, p < .05), as was Environment (F (1,5) = 8.1, p < .05). Furthermore, the interaction between Type and Environment was also significant (F (1,5) = 7.2, p < .05).



The identification results for phrase-initial segments were submitted to a repeatedmeasures ANOVA with two factors: Type (Stop or Fricative), and Category (geminate or singleton). Note that Environment is not a factor since only phrase-initial segment identification rate is being evaluated. The results of the ANOVA indicate that only Type is significant (F (1,5) = 27.1, p<.05). As indicated by the identification values in the graphs, it is evident that the stops are identified at a significantly higher rate than the fricatives.

As can be seen in figure 2.10, there is a very slight difference between the successful identification rates of stops in different environments. The results were submitted to a repeated-measures ANOVA with two factors: Category (geminate or singleton) and Environment (phrase-initial or -medial). Note that Type is not a factor since only stops are evaluated for this test. The ANOVA reveals no significant difference between the identification rates of stops in different environments.

2.2.3 Discussion

One general hypothesis and two specific hypotheses were tested in this experiment. First, it was predicted that in general, listeners would be able to correctly identify the category of a word-initial sound (i.e. whether it is a geminate or a singleton). The overwhelming 92% success rate indicates that this hypothesis is supported. Although perfect minimal pairs were not used in this experiment (to ensure consistent stimuli across all categories, as described in the Procedures section), there are various near minimal pairs in Cypriot Greek that contrast initial consonant length, and so the ability to discriminate in this environment is relevant to the native listener.



Neither of the specific hypotheses were supported. For example, it was predicted that listeners would be able to correctly identify medial stops more frequently than initial stops, based on the assumption that duration of articulation is a more salient cue indicating segment category than VOT alone. However, the listeners identified the stops equally well in phrase-medial and phrase-initial environments.

It was also predicted that listeners would be able to discriminate fricative geminates and singletons better than stops in initial position, based on the assumption that the noise evident throughout the articulation of the fricative would serve as a clear indicator of that segment's length, while the VOT of an initial stop would not be as direct a marker. As was shown, the opposite result obtained. That is, stops were identified at a significantly better rate than fricatives in the phrase-initial environment.

These findings seem to conflict with those of Abramson (1986) and Lahiri and Hankamer (1988), in which it was shown that duration was the primary and most salient indicator of segment category (geminate or singleton). The Cypriot results indicate that closure duration is not the most salient cue marking geminate status (despite the fact that, as indicated by the production study, closure duration of geminates does differ significantly from that of singletons). Specifically, although fricatives are characterized by noise throughout their production, this direct indicator of closure duration does not aid in discrimination: stops that lack noise indicating duration were identified better than fricatives. Also, although the duration of intervocalic stops may be characterized as the silent period between two flanking vowels, the presence of this feature does not aid in

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discrimination: initial stops that lacked this feature were identified just as well as medial ones.

2.3 Summary

The results of the production and perception studies taken together indicate that speakers distinguish geminates and singletons in Cypriot Greek, and that these differences are salient enough for listeners to correctly identify geminates and singletons, even in absolute initial position.

Based upon these studies, it would appear that VOT is the acoustic feature which is employed by speakers and listeners to distinguish length of initial stops. However, it is crucial to point out that there is the possibility that there are other acoustic cues which are responsible for distinguishing segments, even in light of Arvaniti and Tserdanelis' (2000) findings. For example, Abramson (1991, 1999) has identified two distinct cues, RMS amplitude and F0, as aiding Pattani Malay listeners in identifying initial geminates; Abramson's forthcoming work investigates how these two cues work in concert to distinguish these stops. Based on these findings, it is possible that the realization of geminates in Cypriot Greek is manifested not only with increased VOT values but also with other cues. Furthermore, it is possible that these additional acoustic features are also utilized by listeners to help them distinguish sounds. The tokens that were used for stimuli in the discrimination experiment were taken from natural speech, meaning that all acoustic features (including those not investigated in the current study) were present in the tokens which the listeners heard. Thus, it is possible that the listeners were attending to these other unknown cues as discrimination aids.

While it is unknown whether VOT is the only relevant cue other than duration which marks geminates in Cypriot, the fact that VOT is identified as an important factor holds important implications for cross-linguistic generalizations. Specifically, the Cypriot findings suggest that there are no universals with regard to the secondary cues that accompany geminate production. In no other investigation of geminates (whether medial or initial) was VOF found to be implemented in the same manner and so significantly. Thus, it appears that there are language-specific strategies which are employed to help encode contrast.

The results of the production study bear on the proposed phonological representation of geminates (which will be presented in chapter three). As was shown, stop and fricative geminates have a significantly longer closure duration than their singleton counterparts (recall that this result is based on fricatives and word-medial stops). This finding is consistent with earlier studies of non-initial geminates in diverse languages (e.g. Ham 1998; Dunn 1993). I claim that this durational difference is directly reflected in their phonological structure. As discussed in chapter three, geminate consonants are underlyingly linked to two timing units; these timing units indicate relative phonetic duration.

Naturally, the timing units are not claimed to indicate absolute durational values; there is extensive evidence that shows that values may be affected by independent factors such as inherent segment duration, location in a syllable, or speaking rate (see, e.g. Lehiste 1970). However, it is claimed that the timing units dictate relative duration values. Specifically, a segment which is associated to two timing slots (as a geminate is assumed to be) will be longer than an otherwise identical segment that is associated to a single timing slot.

The basic claim that timing slots and phonetic duration are related is central to earlier timing-slot frameworks (Clements and Keyser 1983; Levin 1985). However, it is posited here that this relationship extends to initial geminates even when the physical manifestation of duration may not be apparent. For example, although the closure duration of the initial stops in Cypriot was not measured, it is assumed that they exhibit durational differences just as the word-medial ones do. Future research on the actual production of these segments (such as studies on the muscle activity during articulation (EMG), or articulator contact (palatograms)) will help to test this hypothesis.

Although it is claimed that initial geminates have increased articulation duration, this cannot serve as a cue to phonological length for all segment types. As presented in the introduction to this chapter, voiceless stops are characterized by silence throughout their closure; when preceded by silence (as in absolute initial position) the duration of such a segment is impossible to perceive. However, this perceptual concern is not assumed to alter the basic production of geminate consonants; as stated above they are assumed to be longer than their singleton counterparts.

The obscure nature of duration in the word-initial environment does not prevent listeners from successfully identifying geminates. As was shown by the results of the perceptual experiment, listeners utilize the secondary acoustic cues (in this case, VOT

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differences) to help them identify geminates and singletons in this phonetically impoverished environment.

However, while phonological structure reflects relative phonetic duration, it is crucial to point out that it is not claimed that phonological structure predicts the types of secondary acoustic cues that will be utilized. As indicated earlier, acoustic cues other than duration can differ depending on the language. The choice of which secondary cues are used to mark gemination (i.e. cues other than durational differences) is limited according to the characteristics of the language's segmental inventory. For example, as was shown in Cypriot Greek, increased VOT is correlated to geminate production, while in Pattani Malay, RMS amplitude differences are associated to geminates. Crucially, the segmental inventory of these two languages are different. In Cypriot Greek, there is no voicing contrast in the stop series (see Appendix A or chapter four for the segmental inventory of this language). Voicing contrasts are typically manifested as a VOT contrast (Abramson and Lisker 1964, Muller ms.) Since Cypriot Greek does not have a voicing contrast, it is free to utilize the VOT contrast to indicate another phonetic distinction; using VOT to discriminate geminates and singletons will not interfere with discriminating voiced and voiceless stops. Conversely, in Pattani Malay, there is a voicing contrast in the stop series (again, see Appendix A for the full segmental inventory). Furthermore, geminates and singletons are not distinguished via a VOT contrast (Abramson p.c.). I speculate that this is because VOT contrast is utilized in this language only to distinguish voicing; the speakers must rely on another cue to distinguish gemination.

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Given the patterns observed in Cypriot Greek and Pattani Malay, I propose that the cues implemented in an individual language are constrained by the segmental inventory. Generally, I predict that only those acoustic features that are not used to distinguish a categorical contrast in a particular language will be available for use as secondary cues. The relationship between segmental inventories and secondary acoustic cues must remain the focus of future empirical study.

In summary, it is claimed that phonological structure, specifically association to timing slots, reflects the most basic phonetic characteristic associated to length contrasttheir duration of articulation. Secondary acoustic cues, which may aid in the perception of phonological contrast in 'difficult' environments (such as the consonant length contrast in word-initial position), are not encoded by phonological structure but rather are constrained by the segmental inventory of a particular language.

CHAPTER 3

THEORETICAL ASSUMPTIONS

The purpose of any model of prosodic representation is to provide a coherent, unified account for observed patterns. Optimally, a model is comprised of a constrained set of elements which can be used to account for a wide range of phenomena. Unfortunately, the prosodic models which have been traditionally defended, including prosodic timing theories (such as those proposed by Clements and Keyser, 1983, Levin, 1985, Milliken, 1991), or prosodic weight theories (such as the frameworks discussed in Hayes 1989, 1995), face problems in accounting for the range of behaviors exhibited by word-initial geminate consonants. This shortcoming is due (at least in part) to the simple fact that these earlier frameworks were initially developed by drawing upon evidence from languages that did not have these segments.

The goal of this chapter is to illustrate the implications that word-initial geminates have for prosodic representation and to propose modifications to existing frameworks that allow for an account of all observed patterns, crucially including those exhibited by initial geminates. While the focus is on the patterns exhibited by these segments, the proposed model will also take into account well-known observations regarding geminates and syllables in general. For example, geminates exhibit dual behavior, patterning as two segments for some processes and a single indivisible segment for others (Leben, 1980, Kenstowicz, 1982, Ham, 1998, Schein and Steriade 1986, Tranel 1991, *inter alia*). Furthermore, it is observed that while segments in syllable codas may contribute to the prosodic weight of a segment, the onset segments apparently never do. While traditional prosodic frameworks are adept at accounting for these phenomena, it will be demonstrated that the composite model defended here is equally capable of accounting for them, in addition to the phenomena pertaining specifically to word-initial geminates.

As will be discussed in depth in section 3.1, the proposed model combines elements of both prosodic timing and prosodic weight models (as such, it will be termed the 'Composite Model'). Specifically, it is posited that the universal, underlying representation of geminates consists of a single segmental root node that is linked to two timing positions, following earlier timing models such as those developed in Clements and Keyser 1983 and Levin 1985. Prosodic weight (moras) may be added to the prosodic representation, depending upon language-specific requirements.

The assumptions of the Composite Model differ in important ways from those of the traditional frameworks, specifically in that both prosodic weight and length are assumed, and that geminate consonants do not necessarily contribute prosodic weight to a syllable. This is motivated by empirical observations of languages with initial geminates. First, these segments do not exhibit uniform cross-linguistic behavior with regard to

In some languages, initial geminates participate in prosodic prosodic processes. processes in the same way that vowels do. For example, in Chuukese, both initial geminates as well as vowels help to satisfy a prosodic minimality requirement. In other languages, geminates do not participate in prosodic processes at all. For example in Leti, only syllables with long vowels attract secondary stress, while syllables containing geminates do not. This disparate behavior poses a significant problem for Moraic Theory (MT), which assumes that geminates are always moraic, and thus would be expected to pattern like vowels in prosodic processes (for example, MT would predict that in Leti, both syllables with long vowels as well as those with geminates should attract stress). These observations lead to the conclusion that moraic weight is not obligatory. A second important consideration concerns the observation that initial geminates may pattern with consonant clusters, regardless of whether or not any of the consonants of the cluster are moraic. This suggests that the mora is not available as a means of referring to geminates and consonant clusters as a natural class. Rather, as argued in this dissertation, the two are unified by virtue of their association to timing slots Specifically, consonant clusters comprise two timing slots, and geminates are single segments linked to two timing slots. As a result of this structural similarity, they are predicted to pattern alike. For example, in Cypriot Greek, word-initial geminates and clusters trigger epenthesis when they are preceded by a consonant-final word. As will be demonstrated, accounting for this pattern with the moraic framework necessitates stipulative assumptions, yet is accounted for simply within a timing-slot framework.

Many aspects of the CM are similar to the proposals of Hume, Muller and van Engelenhoven 1997. For example, Hume et al. claim that the inclusion of timing slots in the prosodic representation is crucial to an account of the initial geminates of Leti. They also argue that geminates must be non-moraic in this language, just as is argued in this dissertation. Aside from these fundamental similarities, the model presented here differs substantially from that discussed in Hume et al. For example, the CM predicts languages in which geminates may be moraic in initial position; Hume et al. assume that all initial geminates are non-moraic. Furthermore, the current model includes a small set of constraints on moraic association; in the earlier work, the relationship between prosodic weight and length was not addressed. Essentially, the present discussion builds upon the work of Hume et al. and develops a comprehensive model that provides a unified account of various patterns.

In the following sections, I will outline the basic assumptions of the Composite Model, and demonstrate how evidence from a range of languages supports these assumptions. A brief overview of earlier prosodic frameworks will then be presented, highlighting the challenges posed for these models by initial geminates.

3.1 The Composite Model

As alluded to above, the model that is defended in this work contains elements of earlier prosodic frameworks. For example, in the CM, as in most timing- and weightbased frameworks, it is assumed that geminates comprise single root nodes that are multiply-linked to two prosodic positions (cf. Selkirk 1991). This claim allows for straightforward accounts of phenomena such as geminate integrity and inalterability, as has been discussed at length in earlier works (Leben 1980, Schein and Steriade 1986, etc.).

Similar to skeletal models of representation, including Clements and Keyser (1983) and Levin (1985), it is also assumed that timing relations are explicitly indicated in the representation of segments. As shown in (1), short segments are assumed to be associated to a single timing unit, while long segments (long vowels and geminates) are associated to two.

(1) Association to timing slots in CM (following Levin 1985)¹



As will be presented in more depth in the following sections, evidence supporting the explicit representation of timing relations in the structure of sounds comes from a variety of sources. For example, it allows for an elegant account of Leti, in which nonmoraic geminates and long vowels pattern together. Furthermore, the inclusion of timing slots in the prosodic representation is crucial in predicting the surface syllabification of geminate consonants without relying upon stipulative processes. Additionally, the inclusion of timing slots allows for a direct representation of phonological timing without relying upon unsupported assumptions regarding the role of association lines.

¹ Here, as throughout the dissertation, the root node is indicated with a phonetic symbol.

A second crucial component of the CM is that moraic weight is not an inherent attribute of any segment, but rather is assigned to segments according to languagespecific parameters. Crucially, prosodic weight is a separate attribute of segments which may or may not be present. Geminates may bear prosodic weight regardless of their environment in the word, while the assignment of moras to other segments is dependent upon their place in the syllable. For example, singleton consonants may be assigned weight only in syllable codas. The claim that geminates may bear prosodic weight regardless of word-environment is supported by evidence from Chuukese and Luganda, where it is shown that geminates contribute to prosodic weight, even in word-initial position.

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The assumed representation of prosodic weight is indicated in (2). As can be seen, the mora dominates the timing slot. However, this does not imply that the mora licences the timing unit. Rather, as will be outlined below, the mora is dependent on the characteristics of the segment. For example, the mora associated to the geminate consonant is licenced because of the structure of the geminate; the segment is not a geminate because of the mora.

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Evidence that supports the variable assignment of prosodic weight comes from the comparison of languages such as Chuukese or Luganda, where geminates are demonstrably moraic, with languages such as Leti, where geminates are shown not to contribute prosodic weight. Details of these languages will be discussed in more depth in chapters four and five.

The central claim of this aspect of the CM is that prosodic weight and length are separate attributes. Essentially, it is claimed that length is a universal characteristic of segments: they are either short or long. However, prosodic weight is not universal. Segments which act 'heavy' in one language may act light in another. The assertion that weight and length are different characteristics is supported by observations about how these attributes function with regard to phonological processes, as will be discussed in the following sections.

A final claim of the CM is that mora assignment is regulated by a principled and constrained set of sonority and structure-based requirements. As presented in section 3.4,

 $^{^{2}}$ Note that the mora is associated to the leftmost timing slot. This is not explicitly required by anything in the theory; the mora-assignment constraints simply require that geminates bear a mora. However, due to independent constraints restricting moras from occurring in syllable onsets, it seems that the mora most frequently surfaces in this position.

these requirements are expressed as Optimality Theoretic constraints. Essentially, these constraints ensure that only vowels, syllable coda consonants, and geminates (specifically, multiply-linked consonants) may bear a mora. Similar to the basic claims of moraic theory, onset segments are prohibited from bearing prosodic weight.

It is also claimed that there is a universal, harmonic ranking of these constraints which predicts a limited number of language types. As will be presented in more depth in section 3.4, these harmonically ranked constraints interact with other general wellformedness conditions and predict specific language patterns. These explicit predictions are thus testable against observed language patterns.

In summary, the CM contains many elements of earlier prosodic frameworks yet it is a significant theoretical advance since it is able to account for the patterns exhibited by word-initial geminates in a principled manner. Like previous timing-slot theories, the CM assumes that segments are inherently associated to timing units. In earlier theories such as that proposed in Clements and Keyser (1983), the existence of the mora was assumed but the specific assumptions regarding segmental weight were not articulated. In moraic theory, specific and invariable rules regarding mora assignment were posited. In the current model, these requirements are modified and expanded in order to account for the broader range of evidence typified in languages with initial geminates.

In the following sections the specific components of the CM are discussed in more depth. In section 3.2, evidence supporting the existence of timing slots is presented. In 3.3, the concept of variable moraic assignment is discussed. The interaction of the

posited constraints is presented in section 3.4, and is followed by a brief overview of earlier prosodic models.

3.2 Explicit representation of timing slots

Evidence that supports the inclusion of timing slots in the underlying representation of segments comes from a range of phonological phenomena. First, a process in Leti in which long vowels and geminates pattern alike is accounted for in simple terms under the assumption that these segments form a natural class by virtue of their length; in a framework that does not include explicit timing slots, a unified account of the process is problematic. Additional evidence for the inclusion of timing slots in the underlying representation comes from a language such as Makua, which contrasts short, syllabic nasals with geminates. As will be demonstrated, for such a language, the assumption of timing slots in the input is crucial to predicting the different surface forms. Final suggestive evidence that timing slots are present in the input comes from a process such as that observed in Cypriot Greek, where initial consonant clusters and geminates pattern alike in triggering deletion of a preceding consonant. As will be shown, under the assumption that timing slots are present in the representation of sounds, this process is described in a straightforward manner. If timing slots are not assumed, then stipulative assumptions regarding the role of association lines must be invoked in order to account for the pattern. Each of these examples are presented in the following sections.

3.2.1 Leti and timing slots

The facts of Leti will be presented in more depth in the following chapter; they have previously been discussed in Hume, Muller and van Engelenhoven (1997). For now, it is necessary only to outline the behavior of geminates with regard to two processes, stress assignment and downgrading since it is these processes which indicate that geminates are long and non-moraic.

In Leti, stress is normally assigned to the penultimate syllable:, ,mánu 'bird', tuvúri 'kind of shell'. In the event that the initial 'syllable contains a long vowel, that syllable also receives stress³: r5:nénu 'they eat turtle'. Crucially, if the initial syllable contains a geminate consonant (i.e. it is either closed by a geminate or has a word-initial geminate), that syllable does not receive stress: vappúre, 'wild pig' *váppúre; ppunárta 'nest's edge', *ppúnárta. Crucially, the syllables with geminates do not pattern like the syllables with long vowels, suggesting the geminates are non-moraic. If the basic assumption of moraic theory were maintained, specifically that geminates are inherently moraic, it would be predicted that syllables with geminates should attract stress in the same way that syllables with long vowels do. However, they do not.

In another process, geminates and long vowels pattern alike, indicating that they form a natural class based on their structural similarities. 'Downgrading' is a prosodic process in which the first of two related words is realized as prosodically inferior to the

³ In addition to native speaker intuition, evidence that the long vowels are stressed comes from phonetic observation, where it is found that the initial vowels share durational and pitch differences with other stressed syllables.



second. Words with geminates or long vowels block this downgrading process, suggesting that they form a natural class. The assumed structural representations which lead to this grouping are represented below.

(3) Geminates and long vowels in Leti:



Since a moraic representation of Leti geminates would make incorrect predictions with regard to the stress-assignment patterns, this suggests that geminates and long vowels are unified in another manner. It is argued that the unifying characteristic is one of phonological length, rather than weight. The facts of downgrading can then be described simply: segments that are multiply-linked to two timing positions (i.e., long segments) block the downgrading process. Further discussion of the Leti facts is found in chapter four.

3.2.2 X-slots and multiple linking

In addition to accounting for the behavior of geminates in Leti, the representation of timing association in the underlying forms of words also allows for a non-stipulative explanation of the distinction between geminates and other moraic consonants. Moraic theory does not assume inherent timing associations and thus must resort to stipulation to account for the difference.

A language in which the contrast between geminates and other moraic consonants is crucial is Makua (Cheng and Kisseberth, 1982). This language has geminates, as well as syllabic, short nasal consonants. It is assumed that these segments are moraic, since they may bear tone. Furthermore, it is assumed that the syllabic nasals are underlyingly distinguished from other non-syllabic nasals since both may be found preconsonantally.

In the CM, the contrast between geminates and syllabic consonants may be reflected simply as a difference in timing slot association. Specifically, it is assumed that a geminate consonant is associated to two timing slots while a short consonant is association to one timing slot.

However, this contrast is not as easily expressed in moraic theory. According to Hayes (1989), a geminate is inherently linked to a single mora. Likewise, a syllabic nasal is also linked to a single mora. Thus, at the underlying level these two types of segments have the same structure:

$$\begin{array}{cccc} (4) & \mu & & \mu \\ & &$$

Geminates become multiply-linked via a syllabification algorithm which incorporates the mora into the coda of one syllable, and 'flops' the melody of the segment onto the following syllable (Hayes 1989 pp. 257-258). Crucially, the multiple-linking processes assumed within MT must apply only to geminate consonants, since other moraic segments are not multiply-linked. However, since geminates and syllabic consonants are

represented identically in the underlying form, a general process that targets any moraic segments would inadvertently target short, moraic consonants as well. In order to ensure that only the geminates are multiply-linked, stipulative conditions that target geminates but not other moraic consonants would need to be invoked. However, under the tenets of moraic theory, it is not clear how this could be achieved since the two segment types are otherwise identical.

Naturally, this problem is avoided with the assumption that association to timing slots is inherently present, as in the CM. A geminate surfaces as multiply-linked because it is inherently multiply-linked. A syllabic short consonant is linked to a single timing slot underlyingly and so would not be expected to be multiply-linked on the surface.

3.2.3 Cypriot Greek and timing slots

The representation of timing slots is crucial to the account of Leti. The patterns exhibited by initial geminates in Cypriot Greek, on the other hand, may be accounted for either in the CM or in MT. However, as will be demonstrated, in order to account for the Cypriot facts without the explicit representation of timing slots, it is crucial to assume that association lines have significance which is otherwise unmotivated. Thus, it is concluded that the representation of timing slots allows for a more straightforward, less stipulative account of the facts.

As demonstrated in (5), in Cypriot Greek, word-initial geminates and consonant clusters pattern alike in that they both trigger deletion when following a consonant-final word (further discussion and analysis of this pattern is presented in chapter four): (5) Geminates and clusters triggering deletion:

| | /ton + p:ara/ | [to p:ara] | 'the money | |
|-----|----------------|-------------|-------------|--|
| | /tin + psačin/ | [ti psačin] | 'the fish' | |
| cf. | /ton + tavla/ | [ton tavla] | 'the table' | |

I assume, following Malikouti-Drachman 1987, that prohibitions against complex syllable margins trigger deletion. Essentially, when three consonants come into contact across a word boundary, as in /tin + psačin/, syllabification which incorporates all of the segments would create the ill-formed structures of either a coda with two consonants (*[tinp.sa.čin]) or an onset with two consonants (*[tin.psa.čin]). Likewise, when a short consonant and a geminate come into contact, syllabification would incorrectly create a coda with part of the geminate, or an onset that entirely contains the geminate: *[tonp.para] or *[ton.ppara]. The final nasal is thus deleted in order to avoid these illformed syllabifications.

Since the CM represents consonant clusters and geminates, as two X-slots (as shown below), a complex syllable margin can be described simply as one with two X slots that dominate consonantal features.

(6) Geminates and clusters as a natural class:

| geminate: | Х | Х | cluster: | Х | X |
|-----------|-----|---|----------|---|---|
| • | \ / | | | I | F |
| | (| 2 | | С | С |

Within the moraic framework, initial geminates and clusters are not represented in a uniform manner. As shown in (7), clusters are two separate root nodes while a geminates is a single root node multiply-linked to two prosodic postions (the dotted line indicates that the mora of the initial geminate is linked to a unit higher than the syllable). Since the initial clusters and geminates have different representations in MT, they cannot be referred to as a natural class, unlike in the CM (or any framework that includes explicit timing associations).

(7) Initial clusters and geminates in moraic theory:



When three short consonants come into contact, syllabification creates either a complex coda or complex onset, as shown below. As illustrated in b., deletion allows for non-complex syllable margins.

(8) a. Syllabification and complex margins:

Cluster in coda:

Cluster in onset:

nps

σ *ton psačin n p s

b. Deletion and syllabification:



In order to allow for a parallel account of the patterning of initial geminate consonants, the definition of a 'complex syllable margin' must be expanded.. In the forms with consonant clusters, a complex margin is simply described as one which contains two consonants. However, since geminates are single segments which may be split between two syllables, this definition cannot apply. Rather, it is necessary to state that a complex margin is one that has a single segment and part of another segment (i.e. part of the geminate). As shown below, when the first part of the geminate is syllabilited as part of the coda (a disallowed structure in Cypriot), it cannot be said that the coda contains two segments. Rather, since only part of the geminate is in the coda, the coda contains a single consonant, and *association* to another segment (i.e. part of the geminate). When the geminate is associated to the onset, it cannot be said that the onset contains two segments, again, since the geminate is a single segment. Here, the onset contains multiple association lines⁴ to a single segment.

⁴ Naturally in this representation, the onset also contains a mora. Since there appears to be a crosslinguistic prohibition against moraic onsets, this structure could then be ruled out on those grounds.

(9) Complex syllable margins and geminates



Thus, in order to account for the similar patterning of geminates and clusters in Cypriot Greek while also maintaining the tenets of moraic theory, it is necessary to posit a constraint which prohibits complex syllable margins. Crucially, the definition of 'complex' must include having more than one segment, or more than one *association* to another segment.

The crucial assumption inherent in this type of analysis is that association lines represent segments just as actual root nodes do. In other words, for this account to predict the behavior of both consonant clusters and geminates, a syllable margin that contains two segments (i.e. two root nodes) must be treated identically to a margin that contains association lines to two segments (for example, a singleton consonant and part of a geminate), or to a single segment (for example a geminate).

This reification of the association lines is contrary to the traditional view of these elements in autosegmental phonology. As expressed in Goldsmith (1990) for example, association lines simply reflect coincidence of events on different prosodic tiers, rather than a direct indication of phonological length. Similarly, Clements and Hume (1995) assert that association lines indicate patterns of 'alignment and overlap' of segments and features, not phonological length.

Below are examples suggesting that multiple-linking of association lines does not indicate phonological length nor segmental count. For example, there are single short segments such as flaps or taps which are argued to be ambisyllabic (Kahn, 1976, Clements and Keyser, 1983). As illustrated below, the segment is multiply-linked to both a syllable coda and an onset. Flaps are never analysed as long segments or geminates, despite this proposed multiple linking²

(10) Ambisyllabic flaps (following Clements and Keyser 1983):

σ

In other cases of multiple-linking, there are single segments that are linked to more than one entity: in some accounts affricates are claimed to be single root nodes linked to two feature matrices (e.g. Goldsmith 1990). Similarly, short vowels with contour tones are posited to be linked to more than one tone. However, neither of these segment types are necessarily phonologically long, despite the fact that they are multiplylinked.

In summary, evidence from Leti, in which long vowels and geminates pattern alike, from Makua, in which short syllabic consonants must be crucially distinguished from geminates, and from Cypriot Greek, in which geminates and consonant clusters pattern alike, all provide support for the claim that timing slots are present in the structural representation of sounds.

3.3 Variable mora assignment

A central claim of the CM is that geminates are not inherently moraic. Rather, it is assumed that prosodic weight may be assigned to geminates based on languagespecific parameters. This assumption creates a pleasing parallel between geminates and singleton consonants, which have long been claimed to be assigned prosodic weight on a language-by-language basis (e.g. by 'Weight by Position' within MT). However, unlike singleton consonants that only bear weight when in codas, geminates may be assigned weight regardless of their environment. The claims that moraic assignment is variable and that geminates may be moraic in any environment are supported by evidence from languages with initial geminates, as well as from other languages.

3.3.1 Empirical evidence for variable mora assignment:

There is extensive empirical evidence indicating that prosodic weight is not a universal, uniform characteristic of geminates or coda consonants. For example, as was shown for Leti, syllables with geminates in them do not attract stress, unlike syllables with long vowels: vappúre 'wild pig' *vàppúre, vs. rò:nénu 'they eat turtle' *ro:nénu.

Additional examples of light consonants are found in other languages. For example, Hayes (1995 p. 303) lists over twenty languages that have non-moraic coda consonants. These languages may be accounted for in MT by assuming that the process of Weight-by-Position (which assigns prosodic weight to a coda consonant (Hayes 1989)) does not apply in these languages. More problematic, however, are languages in which geminate consonants do not contribute to prosodic weight, since moraic theory claims that geminates are inherently moraic. For example, as presented in Tranel (1991), languages such as Malayalam and Tubatulabal contain non-moraic geminate consonants⁵; when syllable weight is targeted for processes such as stress, geminates are shown to not contribute weight.

In other languages, 'moraic inconsistency' is observed (Broselow 1995). In these languages, segments which appear to pattern as moraic in some contexts pattern as light in others. For example, in Yawelmani, CVC syllables pattern as light with regard to the bimoraic root requirement, suggesting that the coda is light. However, coda consonants also trigger vowel shortening in surface forms, suggesting that they do contribute prosodic weight; shortening is assumed to be the result of a bimoraic maximum syllable size that prohibits CV:C syllables. In other examples of moraic inconsistencies, it is shown that in Lithuanian, only a sub-class of coda consonants (specifically, the sonorant ones) may bear prosodic weight. As noted by Broselow, these paradoxes pose serious challenges to moraic theory.

⁵ Selkup is also cited as an example of a language which contains light geminates. However, my examination of the data indicates that this conclusion is unwarranted. The data indicate that typical stress assignment is on the initial syllable. Syllables with long vowels attract stress, while syllables closed by geminates do not. However, the form that suggests that geminates don't attract stress also contains a long vowel. The crucial form which would indicate the pattern, one with a geminate and no long vowels, is not given. Nor is it available from the original source of the data (ref). Thus, it is impossible to conclude that geminates in this language pattern as light.

I would suggest that at least some of this variability may be accounted for with the assumption that moraic weight is assigned on a language-by-language basis⁶. Specifically, the observation that geminates seem to pattern as moraic in one language and as non-moraic in another is accounted for simply as the result of different moraassignment parameters in different languages. In Leti or Malayam, geminates are not assigned moras. In other languages, such as those to be described in chapter five, geminates are moraic.

In a language such as Yawelmani, the apparent inconsistency with regard to prosodic weight of codas may be accounted for within the CM under the assumption that shortening is triggered by prosodic length, rather than weight. Thus, a syllable of the form CV:C is prohibited as being too long, rather than too heavy. The claim that phonological length is at issue rather than weight allows for a unified account of the minimality facts (i.e. that CVC is treated as light) and the shortening facts. In each case, the coda is non-moraic; the alleged moraic inconsistency is non-existent.

In an alternative account of moraic inconsistencies, Hayes (1995) posits a 'duallayer' model in which segments that pattern as moraic for all processes bear two levels of moras, while others may bear only one. An example of this is illustrated in (11). In this type of representation, the segment bearing two moras counts as moraic for some processes to the exclusion of the segments that only bear one mora (such as the coda which is part of an intervocalic geminate).

⁶ The observations regarding languages such as <u>Lithuanian</u> are treated comprehensively in Zec (1995); the focus of the current discussion is exclusively on the variable moraic status of geminate consonants.

(11) Two-layer moraic representation (following Hayes 1995)



While this type of representation is able to distinguish between two classes of moraic segments, it is nonetheless problematic. First, as noted in Broselow (1995), the assignment of an extra mora to the vowel is 'reminiscent of' the distinction made in earlier syllable theories between nucleus and rhyme consituents; this may lead to a situation that is at odds with the fundamental claims of moraic theory, that such syllable constituents are unnecessary in syllable structure.

Second, positing that vowels bear two 'mora layers' while a light geminate bears just one is functionally equivalent to claiming that vowels bear a single mora while geminates bear none; essentially, the point is that the vowels act more prominent than the consonants do. However, there is no evidence to suggest that the geminates in Leti function as moraic for any process. To claim that they are moraic but not 'as moraic' as vowels in order maintain the claims of moraic theory is excessively stipulative. A more straightforward explanation of their 'light' behavior is to posit simply that they are 'light' or non-moraic.

In another approach to moraic inconsistency, Hyman 1992 proposes a contrast between 'strong' and 'weak' moras in order to account for the fact that in some Bantu languages, preconsonantal nasals pattern as moraic for some processes and as non-moraic for others. It is proposed that these segments are dominated by 'weak' moras that only participate in some processes. Like Hayes' (1995) approach, this mora division essentially encodes a nucleus/rhyme distinction which appears to contradict the minimalist intent of moraic theory.

In a different approach to the moraic inconsistency problem, de Lacy (1997) claims that processes which appear to treat geminates as non-moraic are in fact targetting the association between different prosodic elements. For example, in a language which targets long vowels as heavy for purposes of stress assignment, to the exclusion of geminate consonants, de Lacy claims that the long vowel is identified as being a more salient target since it consists of one root node that is associated to two moras; presumably a constraint identifies this representation as superior to that of a geminate which consists of a single root node associated to a single mora.

De Lacy's approach also assumes that moras are present for segments which otherwise exhibit no moraic behavior. Furthermore, it is imbueing the role of the association line with meaning. In this case, it is claimed that the number of associations between different prosodic elements serve to distinguish those elements. However, as was outlined above, the role of the association line is simply to reflect correlation between different prosodic elements, rather than identify different classes of sounds based on length or prominence. Thus, the fundamental assumption in de Lacy's work crucially hinges on questionable assumptions regarding the role of the association line in the representational framework.

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3.3.2 The assignment of moras to initial geminates

A subsidiary claim regarding mora assignment is that moras may be assigned to geminates, regardless of their environment in the word. Specifically, it is claimed that in some languages, geminates bear prosodic weight even in syllable- or word-initial position.

This claim is supported by evidence from languages such as Chuukese and Luganda. These facts will be detailed in chapter five, but it is sufficient for the present discussion to outline the evidence that suggests the word-initial geminates are moraic in these languages. In Chuukese, nouns are required to be minimally bimoraic. Thus, any stem which would surface as a CV syllable exhibits vowel lengthening, surfacing as CVV. In a similar vein, a CVC root surfaces as CVVC, suggesting that the coda consonant does not contribute prosodic weight. However, forms with initial geminates and short vowels do not exhibit lengthening, suggesting that the geminate contributes prosodic weight to the word and thus helps to satisfy the minimality requirement. In Luganda, a pattern of tone assignment suggests that initial geminates are moraic, under the well-motivated assumption that the mora is the tone bearing unit (Clements 1986). In one tone class, nouns bear a low tone on an initial short vowel, with all of the remaining vowels being high. Forms with initial geminates bear high tones on all of their vowels. Under the assumption that high tones are assigned to all but the first mora, this pattern is accounted for: in CVCVCV words, the first vowel bears the first mora, and so surfaces with the default low tone. In CCVCV words, the initial geminate bears the first mora, and so the remaining vowels have high tones.

The representation of word-initial geminates such as those in Chuukese or Luganda is somewhat problematic in MT, since it is assumed that the 'typical' geminate is intervocalic. As presented in Davis 1999, it is proposed that the mora associated to the initial geminates in Chuukese is best represented as extraprosodic, with the mora being associated to the foot rather than to the syllable. This representation does not conflict with the observation that onsets are not moraic, and it also does not interfere with an account of the facts. The representation of an extraprosodic initial mora within the Composite Model is demonstrated in (12), and is compared to a moraic onset representation.







b.

Moraic geminate onsets in Composite Model:



There is nothing in the CM that rules out the representation of (12b). While onset segments do not typically contribute prosodic weight to the syllable, evidence from Pattani Malay and Mina suggests that moras can be in the syllable onset.

A recent analysis of Pattani Malay (Hajek and Goedemans, ms.) suggests that onset geminates are moraic. As demonstrated in the examples below in (a), stress is typically assigned to the final syllable of the word. However, in words with initial geminate consonants, stress is assigned to the first syllable, as shown in (b).

(13) a. Typical stress pattern in Pattani Malay

[di: xi:]'self'[pɛ 2dóh]'usefulness'[sIpInóh]'perfect; complete'[ki: xeŋmɛ́:]'sending'

b. Stress and initial geminates:

[b:ú:woh] 'to bear fruit' [m:á:to:] 'jewelry' [d:á:du:] 'police'

Hajek and Goedemans argue that stress assignment in Pattani Malay is quantity sensitive and that since words with initial geminates exhibit stress on the initial syllable, these onset consonants must be moraic. While I am presently unaware of independent evidence supporting this analysis, it does nonetheless provide strong suggestive evidence for the moraicity of onset geminates.

Additional suggestive evidence that onsets can be moraic comes from the Gen language Mina (Odden, p.c.). In this language, falling tones are restricted to syllables that are closed by a consonant (e.g. akpôm 'fish hook') or have complex onsets in which the second consonant is a sonorant (e.g. fetrî 'okra'). Although the evidence for moraic onsets in this language does not come from geminates, the tone assignment pattern as it relates to sonorant singleton onsets is suggestive.

While the status of moraic onsets remains an empirical issue, the claim that wordinitial geminates may bear prosodic weight is strongly supported by evidence from languages including Chuukese and Luganda.

3.3.3 The difference between weight and length

A final assumption implicit in the claim that moraic weight may be assigned on a language-by-language basis is that weight and length are not equivalent. This position is contrary to that of Hayes (1995), where is assumed that 'a syllable is heavy because it is long'. However, as presented in the previous section, there are various examples of syllables that contain geminates that are not heavy, suggesting that length and weight are not in a bidirectional corresponding relationship. Rather, it is claimed here that length is a property of the segment, while weight is a property of the syllable.

Evidence supporting the distinct nature of weight and length comes from the observation that phonological weight does not imply phonological length. A monomoraic segment may be either long or short: a vowel with a single mora is short, while a consonant with a single mora can be long. There is no one-to-one correlation

between weight and length (a claim which will be discussed further following the introduction of the mora-assignment constraints).

The claim that weight and length are distinct is also supported by the observation that phonological processes that target these characteristics are confined to different levels of representation. That is, processes referring to weight (moras) are syllable-based, while those referring to length (X-slots) target segments. For example, syllables which are light (monomoraic) may be targeted for lengthening (due, for example, to a minimality requirement as in Chuukese nouns, as presented in chapter five). However, there are no processes that target segments based on their moraic affiliation (e.g. 'only moraic consonants devoice word-finally'). On the other hand, long segments may be immune to lenition processes (such as the process observed in Moroccan Arabic, described in chapter one), but there are no processes that target syllables which contain long segments (e.g. 'the template for reduplication is a syllable with a long segment'⁷). To claim that weight and length are equivalent is to conflate the processes that target two different prosodic layers. Thus, the concept of weight and length as distinct is supported by their behavior in different environments, and supports the inclusion in the formalism of both moras and X-slots.

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⁷ Naturally, if a template is bimoraic, this may encompasses syllables with long segments if geminates are moraic, since a syllable with a long vowel and one with a geminate are both bimoraic. However, there is no process that targets just syllables with long segments independent of prosodic weight.

3.4 A constrained theory of mora assignment

A final crucial component of the CM is that there is a small, principled set of constraints that dictate which segments may contribute prosodic weight to a syllable. The concept of variable constraint ranking within Optimality Theory (Prince and Smolensky 1993) is utilized to demonstrate language-specific variations of mora contribution, along with the crucial claim that there are universal harmonic rankings within these constraints.

The constraints proposed in this section evaluate segments based on their position in the syllable, as well as their structural characteristics. Crucially, it is assumed that these constraints function within a language's grammar and interact with other constraints. It is also assumed that the mora-assignment constraints work in conjunction with independent syllable-structure constraints to yield the surface forms⁸. A complete discussion of syllable structure constraints for individual languages is beyond the scope of the current discussion. However, the syllable types evident in the different languages reflect many common cross-linguistic tendencies. For example, in general the most sonorous element in a string of segments serves as a syllable peak; a VCV sequence is syllabified as V.CV, etc.

Along with general syllable structure requirements which may differ between languages, it is evident that language-specific requirements regarding mora assignment may also interact with the universal constraints proposed here. For example, in Lithuanian, only sonorant codas may bear moras (Zec, 1995). Although a general,

 $g_{1,1} = g_{1,1} = \theta_{2,1} \dots = \theta_{n,n-1} \dots = g_{n,n-1} \dots = \theta_{n-1} \dots = \theta_{n-1}$

⁸ Naturally, it is also possible that syllable structure is present in the input rather than being derived by constraint. In either case, the point remains that the mora assignment constraints are framed in the context of existing syllable structure.

universal constraint allows coda consonants to contribute moras (as will be presented below), it is evident that in Lithuanian, there is a higher-ranking constraint which prevents this constraint from applying across the board. Again, the universal constraints proposed here are assumed to work in conjunction with other constraints.

In addition to language-specific constraints, it is also claimed that the mora sponsorship constraints introduced below are dominated by universal principles of prosodic organization. Specifically, it is assumed that moras must be licenced by X-slots; a mora cannot exist in a surface representation unless it is associated to a timing slot⁹. A second universal principle is that there is a one-to-one correlation between moras and X-slots. This means that for any segment which projects a mora, there can only be as many moras as there are timing slots. Specific examples of mora to timing-slot association are provided throughout the following discussion.

The constraints which enforce the mora assignment requirements, along with the universal principles regulating mora assignment are listed in (14):

(14) Constraints:

| Nucµ | 'Each X slot in a syllable nucleus sponsors a mora' | |
|------------|---|--|
| Codaµ | 'Each X in a syllable coda sponsors a mora' | |
| Gemµ | 'Each geminate sponsors a mora' | |
| μ * | 'Moras are prohibited' | |

⁹ In some languages, a morpheme can be a single mora underlyingly, without segmental content (for example, one type of reduplicative affix in Chuukese appears to fit this pattern, as discussed in Muller 1997). This universal principle does not rule out these morphemes. Rather, it simply requires that the mora be associated to a timing slot in the surface representation.

Universal Principles (inviolable):

μ-licensing: 'Each mora must be licensed by an X-slot'
X=μ 'There is a one-to-one correlation between moras and X-slots'

The first constraint in the proposed set, Nucµ, states that any segment in the syllable nucleus will contribute prosodic weight. If the nucleus (as identified by independent syllable structure constraints, as outlined earlier) is short, it is monomoraic. If the nucleus consists of more than one X-slot (as in the case of long vowels or diphthongs), it will contribute two moras, due to the universal principle of one-to-one mora and X-slot association. Due to the violable nature of constraints, a language in which syllable nuclei are not moraic can be predicted. However, as will be presented below, the constraint that requires syllable nuclei to be moraic is claimed to be harmonically ranked above the other constraints. This reflects the assumption that syllable nuclei are typically moraic.

The second constraint, Codaµ, requires that coda consonants contribute prosodic weight. Again, since there is a one-to-one correspondence between X-slots and moras, there can only be as many moras as there are X-slots. Naturally, this predicts a situation in which a syllable closed by multiple consonants may have many moras. However, as was outlined above, the mora assignment constraints operate in conjunction with independent constraints. Thus, while the coda constraint ensures that each coda consonant bears a mora, the effects of this constraint may be tempered by an independent constraint on maximal syllable weight.

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. Boli sugar finanto conquesto de antes en primero de la constante de la constante de la constante de la constan The third constraint, Gemµ, requires geminates to contribute prosodic weight. This constraint crucially targets single root nodes that are multiply-linked to two X-slots. Additionally, it also crucially targets these segments independent of syllable position. Essentially, it requires that a geminate contribute to prosodic weight regardless of whether it is intervocalic or word-initial. Since a geminate comprises two timing slots, a form in which both timing slot contribute moras to a syllable or word is predicted (although none of the languages discussed in this dissertation appear to have this structure) due to the one-to-one principle.

As with the other constraints, it is evident that the Gemµ constraint may be affected by independent requirements. For example, there appears to be a general crosslinguistic dispreference for moras in syllable onsets. Thus, when a geminate is intervocalic, with part of the geminate as a coda and the other part as the onset of the following syllable, it is possible that a constraint against moraic onsets will prevent the mora from surfacing in the onset. As mentioned above, geminates may also bear two moras; however, it is possible that this type of structure is restricted in some languages due to maximal weight restrictions on syllables, as was the case with other super-heavy codas.

The constraints requiring syllable codas and geminates to be moraic are claimed to be lower-ranked than the syllable nuclei constraint, as will be presented in the discussion of universal harmonic ranking. This reflects the general observation that by default, consonants are inherently not moraic but rather are assigned prosodic weight on a language-by-language basis. The constraint *µ prevents unmotivated mora assignment. As suggested above, it is assumed that the default state of consonants is non-moraic; a mora is only assigned if there are overriding requirements that demand it. Thus, this constraint prevents unwarranted assignment of prosodic weight.

As presented above, the universal principle $X=\mu$ restricts the relationship between X-slots and moras so that at most, an X-slot may bear a single mora. Naturally, though, any given segment will only bear a mora if it is targeted by a mora assignment constraint. It is assumed that this constraint is undominated (in the absence of evidence for e.g. mono-moraic long vowels, or poly-moraic short segments), and so will not be discussed further in the following analyses.

The group of constraints proposed here describes the assumed correspondence between phonological length (as expressed via X slots) and prosodic weight (moras). Crucially, for each segment or X slot which is targeted by a constraint for mora assignment, the one-to-one principle ($X=\mu$) ensures that at most, a single mora is assigned. Furthermore, the fundamental claim of these constraints is that moras are dependent upon X-slots. All of the constraints assign moras based on different X-slot structures; and there is no constraint which inserts a mora independent of an X-slot.

An interesting result of these two claims pertains to glide formation and subsequent vowel lengthening, a longstanding problem for timing-based models. In such a process, /ua/ surfaces as [waa], as occurs in Kimatuumbi (Odden, 1996). Since timing based frameworks assume that each segment is associated to an X slot, glide formation (as illustrated below) necessitates the creation of an additional X slot, which is not

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present in the underlying form. However, within moraic theory, such a process merely entails the reassociation of the mora; the features of the glide simply associate to the syllable.

(15) Glide formation in X-slot and moraic frameworks



Within the timing-slot approach, the insertion of the additional X-slot does not follow from anything in the theory. However, within the CM, it is driven by the basic claims regarding weight and length. Specifically, a mora is dependent upon the existence of an X-slot, and crucially, there is a one-to-one association between X-slots and moras, as illustrated in the following example. Thus, when a vowel loses its association to a mora and thus becomes a glide, an X-slot must be inserted due to other requirements, as shown in (16 a). Specifically, the mora cannot exist independently of an X-slot, as in the incorrect form in (b). Nor can the mora simply associate to one of the remaining X-slots, since this violates the one-to-one principle, as shown in (c). Thus, the creation of the additional X-slot is motivated by the basic structural relationship between timing slots and moras.



b. Form in which mora is unassociated to X-slot, violating mora licensing principle:



c. Form in which X-slot is associated to two moras, violating one-to-one principle:


While there is language-specific variation regarding what may be moraic, it is claimed that there are universal rankings which cannot be altered. The posited harmonic ranking of these constraints is shown below:

(17) Nucμ >> *μ, Codaμ, Gemμ

 $Coda\mu \gg Gem\mu$

All moraic constraints >> Faith μ constraints

The dominance of the nucleus constraint over all other constraints (crucially $*\mu$) indicates that the syllable nucleus is always moraic, in every language. This assumption is in keeping with the accepted view that a syllable nucleus is always moraic, as suggested earlier. Additionally, the fact that this constraint dominates $*\mu$ implies that no process can eliminate the mora that is contributed by the nucleus (although, of course, independent processes may alter what is in a syllable nucleus, such as vowel shortening that is driven by syllable size requirements). Furthermore, the dominance of this constraint reflects the fact that there is no attested language in which coda consonants and geminates are moraic, while nuclei are not.

The claim that the coda constraint dominates the geminate constraint reflects the observation that there is no attested language in which geminates are moraic while singleton codas are not. If a free ranking were assumed between these two constraints, such a language would be predicted. As in the case with the undominated status of Nucµ, this remains an empirical issue.

Finally, the claim that all of the moraic sponsorship constraints dominate the faithfulness constraints reflects the assumption that restrictions on prosodic structure are based on surface requirements that may differ along language-specific parameters. Essentially, although it is assumed that there are inherent timing structures in the input, it is also assumed that surface moraic structure is the result of language-specific patterns.

Due to the harmonic rankings, there are relatively few permutations of these constraints, yet they yield dramatically different results. The permutations are listed below.

(18) i. Nucµ >> * μ >> Coda μ >> Gem μ

- ii. Nuc $\mu \gg Coda\mu \gg Gem\mu \gg *\mu$
- iii. Nucμ >> Codaμ >> *μ >> Gemμ

Each permutation will be demonstrated in section 3.4.2. However, to briefly summarize the effects of these rankings, in permutation (i), the μ constraint dominates the coda and geminate constraints, predicting a language in which only vowels pattern as moraic, regardless of the input. This is precisely the pattern exhibited in Leti, as well as in Cypriot Greek. In permutation (ii), μ is dominated by the constraints which enforce mora contribution. Thus, both coda consonants and geminates are predicted to act moraic, regardless of input. This is the pattern exhibited by Luganda and Chuukese. In permutation (ii), the ranking is such that coda consonants contribute moras, while geminates do not (unless they happen to be part of a coda). This pattern is exhibited by Thurgovian Swiss.

3.4.1 Constraint permutations

In this section, the permutations of the constraint rankings are demonstrated. Since the constraints which dictate mora sponsorship are restrictions on surface structure, it is posited that they always dominate constraints which dictate faithful correspondence to underlying forms.

As mentioned, one permutation of the proposed constraints predicts a language in which only vowels may contribute moras to a syllable. Following are tableaux that indicate how these constraints obtain this result, regardless of input form.

In (19), it is assumed that there are no moras in the input. Candidate a. is disqualified because it also has no moras in the output, violating the undominated constraint requiring nuclei to contribute moras. The second candidate incurs a violation of $*\mu$, since a mora is present in the output. It also incurs violations of the geminate and coda constraints, since neither of these contribute a mora. However, these violations are driven by the $*\mu$ constraint. Despite the two violations this candidate wins. Candidate c. contains two moras- one from the nucleus and one from the geminate. It also incurs two violations of the $*\mu$ constraint (the same results would obtain if the coda consonant contributed a mora; an additional violation of $*\mu$ would rule the candidate out). The final candidate contains moras contributed by the vowel, the coda consonant and the geminate. Thus it incurs three violations of $*\mu$ and is discarded, even though it violates no other constraint. (Note that while syllable structure is represented in the input, the inclusion of syllable structure constraints would yield the same results.)

an an Arrana an Arrana an Arrana an Arrana an Arrana an Arrana an Arrana an Arrana an Arrana an Arrana an Arran

- 동생 수 있는 동 동 동안 있는 것이 가지 않는 것이 있는 것이 있는 것이 있는 것이 없는 것이 없다.

(19) Non-moraic input

| | Nucµ | *µ | Codaµ | Gemµ |
|--|------|------|-------|------|
| $\begin{array}{c} \mathbf{x} \mathbf{x} \mathbf{x} \mathbf{x} \mathbf{x} \mathbf{x} \mathbf{x} x$ | | | | |
| a o x x x x p a p | *! | | * | * |
| | | * | * | * |
| $\begin{array}{c} r & \mu \\ \mu & \mu \\ x & x & x \\ p & a & p \end{array}$ | | *i* | * | |
| $ \begin{array}{c} d. \\ \mu \\ x \\ x \\ p \\ a \\ b \\ a \\ b \\ c$ | | *i** | | |

Following the claims of Richness of Base (see e.g. Smolensky 1996), which assumes that any input is possible, it is possible to claim that in a language where only vowels are moraic in surface forms, any segment may be moraic in the input. Again, since the moraic-sponsorship constraints are restrictions on surface structure, and constraints which dictate faithfulness to input form is lowly ranked, the correct surface form is predicted. In the following tableau, it is assumed that the input contains moras from the vowel, the geminate and the coda consonant. As before, the non-moraic output violates the highly ranked Nuc constraint., and the candidate which bears a single mora is selected as optimal. Despite the fact that the input contains various moras, the high ranking of $*\mu$ prevents anything other than a single mora from surfacing. In each case, any mora beyond that which minimally satisfies the high-ranking Nucµ constraint incurs an additional, fatal violation.



(20) Moraic input:

| | Nucµ | *μ | Codaµ | Gemµ |
|--|-------|--------------|-------|------|
| µ́/µµ x x x x ∨ p a p | | - | | |
| a. x x x x p a p | *i | | * | * |
| x x x x p a p | | * | * | * |
| $ \begin{array}{c} c. \\ \mu \\ x \\ x \\ y \\ z \\ p \\ a \\ a \\ a \\ a \\ a \\ a \\ a \\ a \\ a \\ a$ | | * i * | | * |
| $ \begin{array}{c} d. \\ \mu \\ x \\ x \\ y \\ a \\ p \\ a \\ p \end{array} $ | € | *[** | | |

To summarize, the preceding ranking predicts a language in which only vowels contribute moras to a syllable, regardless of the input. This is the pattern exhibited by Leti. As presented earlier, and as will be illustrated in more depth in chapter 4, neither the geminates (both initial and medial), nor coda consonants in this language contribute to prosodic weight.

The preceding tableaux illustrate a crucial aspect of this model: moraic structure is dependent upon the realization of X-slots (i.e. whether an X-slot is in a certain environment in the syllable, or whether a segment has a multiply-linked X-slot structure). As was demonstrated, the same surface structure was obtained regardless of the moraic structure of the input. It is posited that timing structure is inherent and invariable, while moraic structure is language-specific (within the boundaries of the structural constraints). As was discussed in section 3.2.2 (in regard to the contrast between geminates and short syllabic segments), this assumption is crucial, since it is impossible to derive the timing structure of a segment from its moraic structure alone, without relying upon stipulative syllabification rules.

In the second possible ranking permutation, $(Nuc\mu \gg Coda\mu \gg Gem\mu \gg *\mu)$, * μ is very lowly ranked, predicting a language in which geminates and coda consonants are moraic. This is demonstrated in the following tableau. Since it has already been established that the constraints are capable of predicting the correct result regardless of the input, only one type of input (in this case, moraic) will be illustrated.

(21)

| | Nucµ | Codaµ | Gemµ | *μ |
|---|------|-------|------|-----|
| рар | 1 | | | |
| a. x x x x p a p | *! | * | * | |
| b. x x x x p a p | | *ī | * | * |
| $ \begin{array}{c} \mathbf{c} \\ \mathbf{\mu} \\ \mathbf{x} \\ \mathbf{x} \\ \mathbf{x} \\ \mathbf{x} \\ \mathbf{x} \\ \mathbf{x} \\ \mathbf{p} \\ \mathbf{a} \\ \mathbf{p} \\ \mathbf{p} \\ \mathbf{a} \\ \mathbf{p} \\ \mathbf{x} \\ \mathbf{p} \\ \mathbf{x} \\ \mathbf{p} \\ \mathbf{x} \\ \mathbf{p} \\ \mathbf{x} \\ \mathbf$ | | *1 | | ** |
| Ф. щ щ щ х х х х р а р | | | | *** |

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As in the previous examples, the candidate which does not contain any moras fatally violates Nucµ. Candidate b. contains a single mora contributed by the nucleus, yet it violates the constraints which require the coda and the geminate to contribute moras.

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Candidate c. contains two moras, one contributed by the vowel and the other by the geminate. Candidate d incurs three violations of $*\mu$, yet these violations are driven by the more highly ranked constraints requiring the nucleus, the coda consonant, and the geminate to contribute moras to the syllable.

The ranking illustrated in (21) predicts a language in which coda consonants and geminates are moraic, as found in Luganda and Chuukese. Crucially, geminates contribute moras regardless of their position in the word. Detailed discussion of these languages is found in chapter five.

In the final permutation, the contraint * μ is ranked between the coda and geminate constraints. This predicts a language in which codas are moraic, while initial geminates are not, a pattern exhibited by Thurgovian Swiss (Kraehenmann 2001, forthcoming). In this language, words must be minimally bimoraic; stems which are subminimal exhibit vowel lengthening. Since absolute word-final consonants are extrametrical, stems of the shape CVC exhibit lengthening, as shown in (22). Forms with final geminates and consonant clusters do not exhibit lengthening, indicating that these consonants help contribute to the minimal weight requirement. Crucially, forms with initial geminates exhibit lengthening (as indicated in the final example in (22)), suggesting that initial geminates are non-moraic. Thus, in this language, vowels and coda consonants (including final geminates) are moraic, while initial geminates are not.

ಪ್ರೊಂಗ್ ಲೇಖ್ ಎಂಗ್ ಮಾತ್ರಿಯಲ್ಲಿ



(22) Thurgovian Swiss

| | root | singula | i r | plural | | |
|-----------------------|------------------|--------------|------------------|----------------|---------|-------------------|
| lengthening: | /has/ | ha:s | | hase | *ha:se | 'hare' |
| no lengthening: | /fɛtt/ /walt/ | fett walt | *fɛ:tt *wa:lt | fette walte | | 'fat' 'forest' |
| cf. initial geminate: | /ttak/ | tta:k | | ttake | *tta:ke | 'day' |

The constraint ranking which predicts this pattern is demonstrated in the following tableau. The first candidate does not contain a mora contributed by the syllable nucleus. Candidate b. does, but it does not have an additional mora contributed by the coda and so is rejected. Candidate c, which has a mora contributed by the initial geminate, is also rejected since it violates Codaµ. Candidate d. contains the same number of moras. However, in this case the second mora is contributed by the coda and not the geminate. Thus, it obeys Codaµ and emerges as optimal. The final candidate, which contains moras contributed by all of the segments, is rejected since it incurs too many violations of $*\mu$.



(23)

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| | Νисμ | Codaµ | *µ | Gemµ |
|---|------|-------|------|------|
| x x x x y p a p | | | | |
| a. x x x x p a p | *i | * | | * |
| b. x x x x y = 1 x = 1 y = | | *i | * | * |
| с. <u>г</u> | | *! | ** | |
| | | | | |
| $ \begin{array}{c} $ | | | ** | * |
| | | | **[* | |
| ṕ a ṕ | | | | |

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In summary, a central claim of the CM is that constraints requiring mora contribution, coupled with a universal harmonic ranking, predict three distinct language types. In the first type, only vowels are moraic, while coda consonants and geminates are not. As was shown, this pattern is attested by Leti. In the second type, vowels, coda consonants and initial geminates are moraic, a pattern found in Luganda. In the final type, vowels and codas are moraic, while initial geminates are not. This pattern is attested by Thurgovian. An empirically interesting issue pertaining to this language type is the fact that a geminate has a 'split personality', in that it is moraic in one context and non-moraic in another. While short consonants also exhibit this pattern (e.g. since a short consonant may be moraic when in a syllable coda and is non-moraic in an onset), it directly conflicts with the well-supported view of MT that geminates are consistently moraic. Future empirical research will provide further evidence for these variable geminates (e.g. Kraehenmann, forthcoming).

3.5 Earlier prosodic models

In this section, the basic claims of earlier prosodic models, especially as they relate to the characterization of initial geminates will be outlined.

3.5.1 Timing-based models

Clements and Keyser (1983) posit that a 'timing tier' of C and V slots (representing non-peaks and peaks of syllables, respectively) functions independently of segmental features. Furthermore, they claim that the timing tier is phonological in nature,

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and functions independently of morphological templates, expanding upon the proposal presented in McCarthy (1979). Under their proposal, a geminate consonant is represented as a single segment multiply-linked to two C slots, while short consonants are linked to one. Consonant clusters are simply two adjacent C slots.

(24) Clements and Keyser (1983) representation of consonants:

| short consonant: | consonant cluster: | geminate consonant: | |
|------------------|--------------------|---------------------|---------------|
| С | СС | Č C | ← timing tier |
| ł | | λ / | _ |
| [root] | [root] [root] | [root] | 🗲 root tier |

Further expanding upon the concept of autonomous timing slots, Levin (1985) proposes that units on the timing tier are not specified as V or C slots, but rather that all segments are represented with generic 'X' slots. While Clements and Keyser claim that the specified slots indicate functional positions within the syllable, Levin claims that syllable structure is predictable from the feature specifications of individual segments. Specifically, she argues that the segment with the highest sonority in a string will be designated as a syllable nucleus; neighboring segments are affiliated to the syllable as onsets or codas according to language specific syllabification rules.

To support the generic status of timing slots, Levin cites evidence from Mokilese reduplication in which the progressive form of verbs is indicated by the prefixation of a tri-segmental reduplicant. For example, the progressive form of [podok] 'to plant' is [podpodok], with a CVC reduplicant; the progressive form of [andip] 'to spit' is [andandip], with a VCC reduplicant; and the progressive form of [wia] 'to do' is [wiiwia], with a CVV reduplicant. Under Levin's proposal, the reduplicant in each of these cases can be accurately described as consisting of three X slots to which material from the base morpheme is copied (as demonstrated below). The generalization regarding the shape of the reduplicant is not easily captured in the CV framework. In order to account for the three reduplicants illustrated above, three different templates are necessary (CVC, VCC, CVV), and thus the descriptive generalization afforded by the X theory is lost.

(25) X-slots in Mokilese reduplication (Levin, 1985)

| XXX | XXX | XXX | ← timing tier |
|-----|-----|-----|---------------|
| | | | - |
| pod | and | wII | 🗲 root tier |

Within X slot theory, a geminate consonant is represented as a single feature matrix which is multiply linked to two timing slots, similar to the CV approach.

(26) Geminate in X-slot theory (Levin, 1985)

Although both CV and X-slot theory focus primarily on segmental timing, they do recognize the concept of segment weight. Under Clements and Keyser's approach, it is claimed that any item on the CV tier that is dominated by the nucleus constituent of the syllable bears a mora (p. 80), while Levin proposes that syllables with branching rhymes are heavy, implying that each segment in the rhyme contributes a mora. By recognizing the contribution that codas make to the prosodic structure of the word, both Clements and Keyser and Levin essentially predict the coda/onset asymmetry.

As discussed earlier in the presentation of the Composite Model, any framework that recognizes the autonomy of the prosodic and melodic units allows for an account of the dichotomous behavior of geminates.

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(27) Autonomous tiers and geminate duality:



single consonant and geminate identical on root node tier

A second significant advantage of the timing-tier model is that segmental timing can be explicitly characterized in the underlying representation. As argued in the presentation of the Composite Model, the presence of underlying prosodic association is crucial to deriving the surface structure of words, since the absence of explicit association requires stipulative syllabification rules to derive the correct surface form. In a framework where timing slot association is specified, stipulation to differentiate geminates from other consonants is unnecessary. An additional benefit of explicit timing associations, as also mentioned earlier, is the fact that it allows geminates and consonant clusters to be treated as a natural class since they both comprise two X-slots.

Timing-based frameworks are uniquely capable of representing geminates in any phonological environment. This is because there are no stipulations or restrictions within

the theory regarding where certain sequences of timing slots may surface. Thus, as demonstrated below, timing-based models are able to represent geminate consonants in word-initial position, as well as word-medially and word-finally:

(28) geminates in various phonological environments:

| XXXX | #[XXX 🕴 🖾 🛠 XX]# |
|--------------|---|
| | $\nabla [1] = \nabla \left[\left[\left[\left[\left[\left[\left[\left[\left[\left[\left[\left[\left[$ |
| a ka | ka ja k |
| intervocalic | word-initially |

To summarize, within a timing-tier model, geminates are represented in a similar manner to consonant clusters. Furthermore, geminates can be represented in any phonological environment in the word. Both of these facts appear to be beneficial, considering the empirical observations regarding geminates: they pattern like clusters, and they are found word-initially, word-medially, and word-finally.

Both CV and X-slot frameworks recognize the coda/onset asymmetry by identifying segments in syllable rhymes and nuclei as fundamentally different from those in the onset. This indirect indication of prosodic weight accounts for facts such as those of compensatory lengthening. However, it cannot account for two different phenomena related to moraic structure.

First, since only segments in syllable nuclei and rhymes are recognized as contributing prosodic weight to a word, there can be no elegant account of a language such as Chuukese, in which word-initial geminates are moraic. In order to account for the fact that initial geminates contribute prosodic weight (and thus help satisfy the minimality requirement), and conform to the concept of prosodic weight in these frameworks, a null syllable would have to be posited to permit the realization of the geminate's mora, as demonstrated below. However, there is no evidence in this language to support such a stipulative structure:

(29) Problems with assuming prosodic weight is only in syllable rhyme:



Also problematic for timing-based models are rhymal segments which do not contribute prosodic weight. The implied assumption that rhymes consistently contribute prosodic weight thus create difficulty in accounting for a quantity-insensitive language, or in a language such as Leti where vowels but not geminates contribute to prosodic weight.

In summary, while X-slot and CV models have significant advantages, including the fact that they are able to represent geminates in any environment, they are unable to capture the variable moraic quality of different segments.

3.5.2 Moraic framework

The observation that consonants in syllable codas may play special roles with regard to prosodic processes led to the innovation of a prosodic framework based on prosodic weight, called Moraic Theory (MT). Building upon proposals in Hyman (1985), McCarthy and Prince (1986), and presented definitively in Hayes (1989), MT claims that

segments may be associated to prosodic weight, depending upon their features as well as their phonological environment.

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Within MT, segments may bear inherent prosodic weight, or have it assigned via the Weight-by-Position rule (which applies only to coda consonants). With regard to inherent weight, it is assumed that short vowels bear a single mora, and long vowels bear two. Short consonants are non-moraic (except for syllabic consonants, as discussed in 3.2), and geminates bear a single mora.

(30) Moraic representation (Hayes 1989):

| short vowel: | long vowel: | short consonant: | geminate consonant: |
|--------------|-------------|------------------|---------------------|
| μ | μμ | | μ |
| | V | | |
| a [a] | a [a:] | t [t] | [t:] |

Within MT, no timing slots are included in the representation, as it is assumed that syllabification patterns will create structures that implicitly represent timing relations. For example, with regard to geminate consonants, is assumed that the mora is adjoined to the coda of the preceding syllable and the melodic content of an intervocalic geminate is 'flopped' onto the onset of the following syllable, yielding an ambisyllabic structure. It is posited that this multiple-linking represents the length of a geminate consonant.

(31) Syllabification of geminates in MT (Hayes 1989):



na na hara kara dinga sa sa sa Sa sa

While geminates bear prosodic weight inherently, singleton consonants may acquire prosodic weight via 'Weight by Position' (WBP). In this process, underlyingly weightless consonants are assigned moraic structure. Crucially, it is only coda consonants that may receive prosodic weight. Onsets are prohibited from bearing moras. WBP applies on a language-by-language basis, reflecting the fact that not all languages treat CVC syllables as heavy (e.g. bimoraic).

(32) Weight-by-position (WBP)



Within MT, compensatory lengthening is accounted for as the reassociation of a 'free' or unassociated mora. As demonstrated in the following example, deletion of a moraic coda consonant leaves an unassociated mora behind. The vowel reassociates to this mora, resulting in a bimoraic, long vowel.

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e de la companya de la companya de la companya de la companya de la companya de la companya de la companya de l Nome de la companya de la companya de la companya de la companya de la companya de la companya de la companya d Nome de la companya de la companya de la companya de la companya de la companya de la companya de la companya d



Due to the assumption that onset consonants can never be moraic, compensatory lengthening is not predicted to occur following onset loss. Since onset loss cannot result in a free mora, lengthening of the following vowel is not possible:

(34) No compensatory lengthening following onset loss:



The version of MT presented in Hayes (1989) allows for a principled account of a variety of phenomena. First, the fact that CVC syllables may act as heavy in one language, but light in another is accounted for as the result of language specific WBP rules. If a language creates moraic codas, CVC is heavy. Otherwise, it is light. MT also predicts the onset/coda asymmetry. Since singleton consonants are not inherently moraic, and there is no process which derives weight-bearing onsets (unlike WBP which derives moraic coda consonants), onsets can never receive weight. Thus, compensatory

lengthening is predicted to be resticted only to cases where codas are deleted. Thus, MT presents a straightforward account of compensatory lengthening facts.

MT is able to supplant timing-based prosodic models in many cases, since it represents geminates and clusters similarly in the word-medial environment. Intervocalic consonant clusters are assumed to comprise the code of one syllable and the onset of another; likewise, geminates are assumed to be split between two syllables. Since geminates are assumed to be inherently moraic, and coda consonants are assigned moras via WBP, they both contribute moraic weight to a preceding syllable:

(35) Geminates and codas creating heavy syllables (word medially):



This representational parallel allows for a coherent description of processes in which geminates and consonant clusters pattern together. For example, a process such as vowel reduction in Yawelmani (as be described in 3.3.1) may thus be accounted for as occurring in heavy syllables¹⁰. Although timing-based models are also capable of providing an account of this process (i.e. vowel reduction is blocked before two X's that dominate consonants), the moraic model has the additional advantage of distinguishing the prosodic role of onset and coda consonants.

¹⁰ However, independent evidence supporting moraic structure in this language is unavailable, and as will be presented below, it is thus maintained that length triggers shortening in this language, not weight. However, the point remains, that accounting for the process in MT is equally viable.

Although MT is able to account for many processes in a principled manner, it has some shortcomings. As was demonstrated earlier, the lack of explicit association in the underlying form of geminate consonants is problematic if the language has a contrast between geminates and other moraic segments (as was the case in Makua); it is impossible to ensure that geminates become multiply-linked on the surface without also targetting non-geminate moraic segments, such as syllabic consonants. Furthermore, the central claim of MT, that geminates are inherently moraic is countered by evidence from languages such as Leti.

3.6 Summary

In conclusion, the Composite Model contains elements that are integral to various earlier models. However, there are significant differences between the current framework and earlier models. Similar to timing-slot frameworks (Clements and Keyser 1983 and Levin 1985), the CM assumes explicit timing slot association. Similar to the moraic framework (Hayes 1989), the CM assumes a restricted set of environments and structures that can bear prosodic weight. Crucially though, the CM assumes that prosodic weight is assigned to geminates on a language specific basis, unlike in moraic theory, which assumes consistently moraic geminates. Unlike the skeletal theories which posited that only segments in the rhyme of the syllable may be moraic, the CM claims that geminates may be moraic regardless of their environment. Finally, as presented in section 3.3, the different moraic patterns observed in different languages are predicted by a small set of harmonically ranked constraints; the assertion that similar segments may have different moraic status in different languages (i.e. light geminates in Leti; heavy geminates in Chuukese) diverges from earlier models which did not address variable weight assignment.

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The central assumptions of the CM are listed in the following table, along with the crucial predictions of each assumption. As can be seen, each prediction is attested by the languages discussed here.

| Assumption: | Prediction: | Attested in: |
|---|--|---------------------------------------|
| Timing slots are present in representation | - geminates and long vowels pattern alike regardless of moraic status | - Leti (chapter four) |
| | - geminates and other moraic segments contrast | - Makua (this chapter) |
| | - geminates and clusters pattern as a natural class | - Cypriot Greek (chapter four) |
| Variable assignment of | - some languages have | - comparison of Leti |
| prosodic weight | moraic geminates, others | (chapter four) with |
| | have light geminates | Luganda and Chuukese |
| Cominatos may bo | gominatos will contributo to | (chapter five) |
| moraic regardless of | - genimales will contribute to | - Chuukese (chapter iive) |
| position in word | word-initial or syllable-initial position | - Luganda (chapter five) |
| Harmonic ranking of universal constraints | - a language where only vowels are moraic is predicted | - Leti (chapter four) |
| | - a language where vowels and codas are moraic, but not initial geminates is predicted | - Thurgovian Swiss (this chapter) |
| | - a language where vowels, codas, and initial geminates are moraic is predicted | - Luganda, Chuukese (chapter five) |

 Table 3.1
 Assumptions and predictions of the Composite Model

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CHAPTER 4

INITIAL GEMINATES AND TIMING SLOTS

In this chapter, data from Leti and Cypriot Greek will be presented in order to highlight how the direct encoding of phonological length (via timing-slots) in the Composite Model allows for a coherent and straightforward account of the observed patterns. In Leti, geminates are shown to be non-moraic, yet they pattern with long vowels for a prosodic process called downgrading. Thus, it is concluded that the Leti geminates are best represented as long segments rather than moraic ones. In a discussion of alternative accounts of the Leti facts, it is shown that the assumption that the geminates are moraic presents intractable problems. In Cypriot Greek, it is shown that initial geminates pattern like consonant clusters in triggering deletion of a preceding word-final nasal. It is demonstrated that the assumption that geminates and clusters are alike in that they both comprise two timing slots provides the most straightforward account of the pattern. In a discussion of alternative accounts, it is shown that while the facts of Cypriot Greek may be accounted for within the moraic framework, this necessitates unfounded assumptions regarding the role of the association line. The Leti facts indicate that timing slots are crucial to an account of the observed patterns, and the Cypriot Greek facts demonstrate that timing slots allow for a more elegant, less stipulative account. Thus, these two languages support a central claim of the Composite Model: that timing association is explicitly represented in the prosodic structure. These languages, when compared with Luganda and Chuukese (in chapter five) also support a second claim of the CM: that prosodic weight is not universal but rather is assigned on a language-specific basis.

As will be shown for Leti, unlike syllables with long vowels, syllables with geminates do not attract stress, suggesting that they are not moraic. In Cypriot Greek, there is no evidence supporting the presence of the mora in the representation of the geminate; it is therefore assumed that it is absent. This reflects the implicit claim of the Composite Model, that geminates are non-moraic by default, and that only positive evidence can motivate the inclusion of moras. As will be shown for Chuukese and Luganda, the assumption that the geminates in those languages are moraic is crucial to an account of the facts. Thus, in comparing these two groups of languages (Leti and Cypriot vs. Chuukese and Luganda), it is evident that prosodic weight is not uniformly present in all of them, supporting the second claim of the composite model.

The facts of Leti and Cypriot Greek are presented in each of the following sections. For each language, the proposed representation will be presented followed by data that support that analysis. Each section concludes with a discussion of alternative analyses of the observed patterns. The chapter concludes with a brief overview of the facts and discussion.

The Leti facts indicate that timing slots are crucial to an account of the observed patterns, and the Cypriot Greek facts demonstrate that timing slots allow for a more elegant, less stipulative account. Thus, these two languages support a central claim of the Composite Model: that timing association is explicitly represented in the prosodic structure. These languages, when compared with Luganda and Chuukese (in chapter five) also support a second claim of the CM: that prosodic weight is not universal but rather is assigned on a language-specific basis.

As will be shown for Leti, unlike syllables with long vowels, syllables with geminates do not attract stress, suggesting that they are not moraic. In Cypriot Greek, there is no evidence supporting the presence of the mora in the representation of the geminate; it is therefore assumed that it is absent. This reflects the implicit claim of the Composite Model, that geminates are non-moraic by default, and that only positive evidence can motivate the inclusion of moras. As will be shown for Chuukese and Luganda, the assumption that the geminates in those languages are moraic is crucial to an account of the facts. Thus, in comparing these two groups of languages (Leti and Cypriot vs. Chuukese and Luganda), it is evident that prosodic weight is not uniformly present in all of them, supporting the second claim of the composite model.

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4.1 Leti

Leti is an Austronesian language, spoken on the island of Leti situated off the coast of East Timor. The data presented in this discussion come primarily from a descriptive grammar of the language (van Engelenhoven 1995) as well as from consultation with a native speaker of the language.

Various phonological processes found in Leti have been the focus of recent research and analysis. For example, the language has productive reduplication processes, discussed in Muller (1997 and 2001) and van der Hulst and Klamer (1996). Leti also exhibits pervasive metathesis, as presented in Hume (1997 a, b) and van der Hulst and van Engelenhoven (1995). Although these processes are relevant for the representation of geminate consonants in this language (as will be presented in the data section), the reduplication and metathesis studies did not focus specifically on the initial geminates.

In subsequent work, Hume, Muller and van Engelenhoven 1997 investigate the behavior of the word-initial geminates in Leti. They demonstrate that in some regards, the geminates pattern typically, acting as single segments for some processes and as sequences of segments for others. At the same time, the Leti geminates do not contribute to the weight of a syllable for purposes of stress assignment, unlike syllables with long vowels. Hume et al. conclude that the geminates in Leti are non-moraic and thus are best represented as single segments that are multiply-linked to two prosodic positions (contra moraic theory, which posits that geminates are inherently moraic). Furthermore, they also assume the existence of moras in order to account for the pattern of secondary stress assignment, in which long vowels (i.e. bimoraic ones) attract stress, while short

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(monomoraic) vowels do not. This 'mixed' representation (illustrated in (1)), which assumes the simultaneous existence of length units and weight units serves as the basis for the Composite Model which is defended in this dissertation. Thus, the data that is presented in the following sections reflects closely the disscussion presented in Hume et al.

(1) Representation of Leti geminate (as compared to long vowels and clusters)



4.1.1 Background facts

The consonant inventory of Leti is shown in (2). All of the segments may surface as geminates, with the exception of the voiced bilabial fricative β .



(2) Consonant inventory of Leti

| | Bilabial | Alveolar | Velar |
|-----------|----------|----------|-------|
| Stop | р | td | k |
| | p: | t: | k: |
| Fricative | ß | S | |
| | | S: | |
| Nasal | m | n | |
| | m: | n: | |
| Lateral | | I | |
| | | l: | |
| Retroflex | | r | |
| | | r: | |

Geminates are found only in word-initial position in underlying forms, similar to consonant clusters, as demonstrated in (3).

(3)

| Initial gemin | lates | Initial cluster | S |
|---------------|-----------------------|---------------------|---------------|
| ppikan | 'plate' | ptuna | 'star' |
| ppuna | 'nest' | pninu | 'fool' |
| ttui | 'genre of literature' | kd ^y eli | 'ring' |
| kkusal | 'to be small' | vroan | 'axe' |
| kkoi | 'child'. | sraki | 'gong' |
| ssoran | 'cough'- | vlira | 'weaving rod' |
| mmei | 'table' | snuran | 'thread' |
| mmanan | 'food' | mniniru | 'soft' |
| nnei | 'sign' | | |
| llai | 'shore/beach' | • | |
| llilin | 'candle/wax' | | |
| rraa | 'again' | | |

Initial geminates and clusters may also be derived from morpheme concatenation.

(4)

| r-rusa | |
|--------|--|
| n-neu | |

'they nail' 'he creeps' t-kari n-mori 'we (incl.) work' 'he lives'

Word-medial geminates and clusters may be derived via morpheme concatenation, or as the result of metathesis, which brings consonants into contact. Metathesis will be presented in more depth later, as it is crucial to the examination of word-initial geminates.

(5)

| pen-ne | 'his pen' | pen-ku | 'my pen' |
|--------|-----------------------|--------|-------------------------|
| anni | 'wind (metathesized)' | anin | 'wind (unmetathesized)' |
| kunsi | 'key (metathesized)' | kunis | 'key (unmetathesized)' |

Geminates may also arise via assimilation when metathesis or vowel deletion causes homorganic coronal or labial consonants to come into contact, as demonstrated below.

(6)

| /d+n/ → [nn] | /lodan/ | [lonna] | 'rattan' |
|--------------|-----------------|--------------------------|------------------|
| /d+l/ → [ll] | /dudal/ | [dulla] | 'horn' |
| /l+n/ → [ll] | /vulan/ | [vulla] | 'moon' |
| /v+p/ → [pp] | /vavi + pure/ | [vappure] | 'wild pig' |
| /v+m/ → [mm] | /vavi + mu/ | [vammu] | 'young wild pig' |
| /t+d/ → [ss] | /puata + seran/ | [p ^w asseran] | 'Seranese woman' |

Preliminary phonetic investigation of the initial geminates in Leti indicate that they differ consistently from their singleton counterparts. A native speaker of Leti was recorded saying words with target segments in word-initial position, both in isolation and in phrases. Six tokens of each word were digitized and the acoustic features of each target sounds was measured. For the sounds /m/ and /m:/, the closure duration was measured. It was found that the mean duration of the short consonant is 51 ms., while that of the geminate is 315 ms. For the sounds /k/ and /k:/, VOT, F0, and RMS amplitude were measured (these features were selected based on results of Abramson 1999, as well as those reported in chapter two). It was found that VOT values were similar: the mean value for /k/ is 34 ms., while that of /k:/ is 27 ms. Although the VOT values do not exhibit the extreme differences such as those found in Cypriot Greek (as in chapter two), the results of the other measurements were intriguing. First, the FO value at the release of /k/ is 144 Hz, while that of /k:/ is 200 Hz. As discussed in Abramson 1999, pitch differences following the release of singletons versus geminates may aid in their identification in Pattani Malay; the differences observed in Leti may also serve as a phonetic cue to the phonological length contrast. The RMS value following consonant release for /k/ was found to be 33 dB, while that of /k:/ is 38 dB. Although this is a difference of just 5 dB, Abramson 1987 found that a difference of less than 2 dB proved statistically significant for initial geminate and singleton stops in Pattani Malay. While there is presently insufficient data to determine if these differences are statistically significant in Leti, the preliminary results suggest that initial geminates are substantially distinct from their counterpart singletons.

4.1.2 Leti geminates as non-moraic

Compelling evidence that indicates the non-moraic status of geminates in Leti comes from stress assignment. As shown in (7), primary stress in Leti is always assigned to the penultimate syllable.

(7) Primary stress in Leti

bisyllabic forms

| spóu | 'kind of boat' | pdudúklu | 'bubbling' |
|-------|----------------|-----------------------|-----------------|
| ppúna | 'nest' | tuvúri | 'kind of shell' |
| kúnsi | 'key' | marsina | 'machine' |
| lópu | 'dolphin' | kars ^y óna | 'pumpkin' |
| má:nu | 'bird' | poli:sa | 'police' |

- trisyllabic forms

In forms with more than two syllables, the initial syllable also receives stress if it contains a long vowel, as shown in (8). In these forms, as in previous examples, the long vowel is derived from metathesis and subsequent lengthening of the vowel. Crucially, the initial syllable is stressed only if the initial vowel is long.

(8) Stress assignment and long vowels:

| má:n ^w or ^y óri | 'crow' | /maun + oriori/ | ('bird + buffalo') |
|---------------------------------------|-------------------|-----------------|--------------------|
| ró:nénu | 'they eat turtle' | /roan + enu/ | ('eat + turtle') |
| má:n ^w á:na | 'chick' | /maun + aan/ | ('bird + child') |
| cf. rimóta | 'sp. turtle' | *rímóta | |
| tuvúri | 'kind of shell' | *túvúri | |

This pattern shows that stress is assigned to heavy initial syllables. Interestingly, syllables that are closed by geminates or other consonant clusters are not assigned stress, as indicated in (9). It is important to note that like many languages, Leti syllabifies intervocalic geminates and consonant clusters as coda/onset sequences. Thus, in a form such as *mat.rúma* 'master of the house' or *kus.sérna* 'Seranese horse', the initial syllable

is closed (see Hume 1997 a, b for evidence regarding syllabification in Leti). However, as shown below, this does not make the syllable heavy for purposes of stress assignment:

(9) Initial CVC syllables and stress

| CVC (closed by geminate) | | CVC (closed by single segment) | |
|--------------------------|------------------|---------------------------------------|-----------------------|
| peppérta | 'heavy' | nvalt ^y áni * pyóltýchi | 'he digs' |
| vappúre | 'wild pig' | * livalt ani matrúma | 'master of the house' |
| *váppúre | | *mátrúma | / ••• • |
| kussérna | 'Seranese horse' | marsina | 'machine' |
| *kússérna | | másina | |

Additionally, segments that have initial geminates also do not receive stress on their initial syllable, indicating that an initial geminate does not make a syllable heavy for purposes of stress assignment, similar to the medial geminates.

| (10) | ppunárta | 'nest's edge' | *ppúnárta |
|------|------------------------|---------------|--------------------------|
| | nnem ^y ása | 'golden sign' | * nném ^y ása |
| | kkant ^y áni | 'earthenware' | * kkánt ^y áni |

Essentially, the preceding examples in (9) and (10) illustrate that syllables with geminates (whether the geminate is at the beginning or end of the syllable) pattern like like light syllables for purposes of stress assignment. Thus, it is concluded that the geminates are not moraic.

Additional evidence that suggests that the Leti geminates are non-moraic comes from a minimal lexical word requirement. In Leti, all words have at least two short vowels in them. However, there are no words of the shape *[ppa] (cf. acceptable forms such as *ai* 'wood', or *kei* 'archipelago'), indicating that geminates do not contribute to the minimality requirement¹. If the minimality requirement is expressed as a bimoraic minimum, then it is apparent that the geminates are non-moraic. Naturally, if the minimality requirement is expressed as a bisyllabic minimum, then a form such as *ppa can be rejected based on its monosyllabic shape (again, cf. a.i and kc.i) which are both bisyllabic).

The facts of stress assignment and minimality indicate that the Leti geminates do not contribute prosodic weight to a syllable, indicating that they are not moraic. Additionally, the facts of stress assignment do recognize a difference between long vowels and short vowels; the former may receive stress while the latter cannot. Thus, the concept of mora count does appear to play a role in this language. However, it is restricted to the vowels.

As shown in (11), there is a contrast between the short vowel and the long vowel with regard to moraic count. However, since the geminate is non-moraic, it is not expected to pattern with any process that counts moras.

¹ As will be demonstrated in Chapter 5, evidence from a similar minimality requirement in Chuukese suggests that initial geminates do contribute prosodic weight; indicating that this pattern is not universal. These conflicting facts reflect one of the basic claims of the Composite Model: prosodic weight is not an inherent characteristic of geminates, but rather is assigned depending upon language-specific requirements.



The facts of non-penultimate stress assignment are accounted for in Hume et al. (1997) as the result of a Weight-to-Stress constraint². This constraint identifies heavy syllables as those which will receive stress. Naturally, since geminates are non-moraic, they will never make a syllable heavy, and so will be unaffected by this constraint.

As shown in the following tableaux, the long initial vowel of the form $r \circ n e n u$ 'they eat turtle' is stressed, since the long vowel makes the initial syllable heavy; if the long vowel is not stressed, the Weight-to-Stress constraint is violated. In the form *kussérna* 'Seranese horse', the initial syllable is not stressed. This does not incur a violation of the Weight-to-Stress constraint, since it does not comprise a heavy syllable. It is assumed that the candidate which contains the initial stressed syllable is penalized as violating a constraint which prohibits unnecessary stress assignment.

 $^{^{2}}$ Recall that regular stress is assigned to the penultimate syllable of the word. Hume et al. account for this unproblematic pattern as the result of a constraint requiring trochaic feet to be aligned to the right edge of a word.

(12) Stress assignment:

WEIGHT TO STRESS: If heavy, then stressed

STRESS PENULT: the penultimate syllable is stressed

| /rɔan + enu/ | Weight-to-Stess | Stress penult |
|--------------|-----------------|---------------|
| 🖝 ró:nénu | | |
| * ro:nénu | *! | |

| /kuda + serna/ | Weight-to-Stess | (no unnecessary stress) |
|----------------|-----------------|-------------------------|
| 🖝 kussérna | | |
| * kússérna | | *i |

4.1.3 Downgrading

An optional prosodic process called downgrading (van Engelenhoven 1995; Hume, Muller and van Engelenhoven 1997) affects a sequence of two syntactically related lexical words, such as verb-object, or possessor-possessed. In this process, the first word is realized without stress and at a faster rate than the second. Furthermore, in a downgraded word, the high vowel [i] is realized as [I]. Finally, in downgraded forms, phonological processes such as vowel reduction (outlined above) are not observed, and the semantic meaning of the utterance is changed. This is accounted for in Hume et al. under the assumption that the words are in separate phonological phrases. Examples of downgrading are shown in (13). The downgraded forms are underlined.
(13) Downgrading

| Underlying form ' /sivi + terranu/ | Downgraded <u>sIvI</u> térannu | Not downgraded sivt ^y érannu |
|---------------------------------------|---------------------------------------|--|
| /spou + ttenanne/ | 'egg of the chicken' spou tténanne | 'his chicken egg' spóu tténanne |
| /ntutnu + wai/ | 'keel of the boat' ntutnu wái | 'his keel' ntútnu wái |
| | 'he lights the fire' | 'he kind of lights the fire |

Interestingly, forms containing long vowels or geminate consonants block downgrading, as demonstrated in (14). Recall that long vowels are derived via metathesis and subsequent lengthening, as described earlier.

(14) Downgrading blocked by long vowels and geminates:

| Underlying form | Surface realization | the cost of the sector |
|-----------------------------------|-------------------------------|--|
| /nvaul + vatu/ | nva:lu vatu | * <u>nva:iu</u> vatu |
| | 'he flings the stone' | |
| /lo + vuer + nain/ | lo vú:re ná:ni | *lo <u>vu:re</u> na:ni |
| | 'under the mountain' | |
| /lo mmei vavan/ | lo mméi vávna | *lo <u>mmel</u> vavna |
| | 'under the table' | |
| /kkani + sn ^y aktuvun/ | kkáni sn ^y aktúvnu | * <u>kkanI</u> sn ^y aktuvnu |
| | 'story of the golden plate' | |

As can be seen in the preceding examples, single consonants, consonant clusters, and short vowels all participate in downgrading. It is only the geminates and long vowels which pattern together as a natural class in blocking the process. This pattern thus suggests that the geminates and vowels have similar phonological structure. Specifically,

this pattern can be accounted for with the assumption that both geminates and long vowels are single root nodes that are multiply-linked to two timing slots, as in (15).

(15) Geminates and long vowels in Leti



Hume et al. (1997) propose a constraint which requires long segments (vowels or geminates) to be in prosodically prominent environments, a restriction which may have its roots in perception. It is speculated that if phonologically long segments were realized in a downgraded word (i.e. at a faster rate) the realization of the contrast would be in danger.

Regardless of the motivation of the constraint, the fact that geminates and long vowels have identical structure with regard to the melodic and timing tiers enables an acccount of downgrading in which the segments which block it are a natural class.

4.1.4 Geminates patterning like consonant clusters

Geminates and consonant clusters pattern as a natural class in that they trigger metathesis and block a vowel reduction process. This patterning is observed in a variety of processes, as will be outlined in the following sub-sections.

4.1.4.1 Metathesis

As discussed in Hume (1997 a, b), metathesis in Leti is observed in two different environments. As shown in (16), words that are underlyingly consonant final switch the position of the final vowel and consonant when they are in absolute phrase-final position (the phrase boundary is marked by curly brackets):

(16) Consonant-final forms in phrase-final position:

| kunis/ | {kunsi} | 'key' |
|---------|---------|---------------------|
| /ulit/ | {ulti} | 'skin' |
| 'lodan/ | {lonna} | 'rattan' |
| ma.un/ | {ma:nu} | 'bird' ³ |
| lo.ut/ | {lo:tu} | 'servant' |

Consonant-final forms also exhibit metathesis when they are phrase-medial and

precede forms that have initial consonant clusters, as shown in (17).

(17) Consonant-final words before CCV- forms:

| /kunis + vnutan/ | {kunsi vnutna} | 'iron key' |
|------------------|----------------|---------------------------|
| /ulit + prai/ | {ulti prai} | 'skin of prai (creature)' |
| /lodan + mderi/ | {lonna mderi} | 'rattan from Muderi' |
| /ma.un + tpunan/ | {ma:nu tpunan} | 'bird throat' |
| /lo.ut + mderi/ | {lo:tu mderi} | 'servant from Mderi' |
| | | |

Crucially, consonant-final forms also exhibit metathesis when they precede forms

that have initial geminates:

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³ The subsequent lengthening of the initial vowel is observed in forms that are underlyingly /cvvc/. This process is independent of the final methathesis discussed here. See Hume (1997 a,b) for further discussion.

(18) Consonant-final words before forms with initial geminates

| /ukar + ppalu/ | {ukra ppalu} | 'index finger' |
|------------------|----------------|----------------|
| /maun + ppuna/ | {ma:nu ppuna} | 'bird's nest' |
| /kapal + ttenan/ | {kapla ttenan} | 'keel' |

Consonant-final forms only surface in an unmetathesized form when they are phrase medial and preceed a word or morpheme with a simple onset, as shown in (19).

(19) Consonant-final words before simple onsets:

| /kunis + lavan/ | {kunis lavna} 'big key' |
|-----------------|--|
| /lodan + mɔa/ | {lodan moa } 'rattan from Moa' |
| /ma.un + lavan/ | {ma.un lavna} 'big bird' |
| /lo.ut + de/ | {lo.ut de} 'servant (deictic morpheme) |

Although these forms exhibit both vowel-final and consonant-final surface forms, it is crucially assumed that they are underlyingly consonant-final. As presented in Hume (1997 a, b), there are a number of reasons to assume this underlying form. First, assuming these forms are underlyingly consonant-final allows for a coherent account of metathesis: simply put, only consonant final forms are subject to this process. If it is assumed that these forms are underlyingly vowel-final, there would be no explanation for why only some forms undergo this process, as shown below.

(20) If forms are assumed to be V-final, no coherent account of metathesis:

 $lo:tu \rightarrow lo.ut or lo:tu$ 'servant'

cf. /lopu/ \rightarrow lopu but not *lo.up

'dolphin'

Second, the distribution of long vowels in Leti is restricted, and entirely predictable. If it is assumed that the vowel-final forms of these words are underlying, it must also be assumed that the long vowel is underlying. If long vowels can be underlying rather than derived, it remains unexplained as to why their distribution is so limited. If it is assumed they are derived, the distribution is expected.

Finally, as noted earlier, metathesis may lead to assimilation of coronals. If the vowel-final form were posited to be underlying, there would be no principled explanation as to the identity of the consonants in the metathesized form. For example, in 'horn', the medial /ll/ alternates with [d..1] in the alternative form. In 'moon', medial /ll/ alternates with [l..n]. If the vowel-final forms were posited to be underlying, there would be no account for why underlying /ll/ surfaces as [d..1] in one form and [d..n] in another. Thus, it is concluded that these forms are consonant final underlyingly.

(21) Unpredictable nature of unassimilated coronals

/dudal/→ [dudal] ~ [dulla] 'horn'/vulan/→ [vulan] ~ [vulla] 'moon'

cf. */dulla/ →[dulla], [dudal] */vulla/ → [vulla], [vulan]

4.1.4.2 Vowel reduction

Geminates and clusters also pattern alike for other phrase-based processes. For example, Hume (1997 a, b) demonstrates that there is a prohibition in Leti against the realization of morpheme-final vowels in open syllables. As a result of this restriction, final vowels are frequently deleted, or are 'merged' to a following sound, resulting in the creation of secondary articulations. However, geminates and clusters pattern together in blocking these vowel-reduction processes, as shown below.

Typical cases of vowel reduction are shown in (22). As can be seen in (a.), when a final low vowel is followed by a word with a simple onset, the vowel is deleted in the phrase. As shown in (b.), when a morpheme-final vowel is high, the vowel is realized as a secondary articulation on the following consonant, again a simple onset. In each case, the final vowel of the first word (morpheme) is prevented from being realized in an open syllable. In one case, the vowel is deleted entirely, and in the other, the vowel is reduced and only realized as features on a consonant.

(22) Vowel reduction

a. Deletion

| /ruma + lavan/ | {rum lavna} | 'big house' |
|------------------|---------------|--------------|
| /samela +*lavan/ | {samel lavna} | 'big mouse' |
| /rimota + lavan/ | {rimot lavna} | 'big turtle' |

b. Secondary articulation formation

| /lopu + lavan/ | {lop l ^w avna} | 'big dolphin' |
|----------------|---------------------------|---------------|
| /a.i + lavan/ | {a l ^y avna} | 'big wood' |

As shown in the following examples, when underlyingly vowel-final words precede words with complex onsets, vowel reduction is not observed. For example, the second word of each phrase in (23a) begins with a consonant cluster. In each case, the final vowel of the first word surfaces unaffected. As is shown by the examples in (b), words with initial consonant clusters pattern in the same way: they block vowel reduction.

(23)

a.

Vowel reduction blocked before consonant cluster:

| /ruma + pruvat/ | {ruma pruvta} | 'small house' |
|--------------------|-----------------|-------------------|
| / samela + tpunan/ | {samela tpunna} | 'mouse's throat' |
| /lopu + pruvat/ | {lopu pruvta} | 'small dolphin' |
| /a.i + vlakar/ | {a.i vlakra} | 'wooden cross' |
| /rimota + tpunan/ | {rimota tpunna} | 'turtle's throat' |

b. Vowel reduction blocked before geminate:

| /samela + ttenan/ | {samela ttenna} | 'mouse's spine' |
|-------------------|-----------------|-----------------------|
| /sivi + ttęi/ | {sivi ttei} | 'female chicken (hen) |
| /loi + llatutun/ | {loi.llatutnu} | 'Laitutunese proa' |

The previous examples have demonstrated that geminates pattern like consonant clusters in that they trigger metathesis in a preceding word that is consonant final, and they also block vowel reduction processes in words that are vowel final. This similar patterning of geminates and clusters is typical of that found in many languages (see e.g. Ham 1998, and references therein for further examples).

Following the analyses presented in Hume (1997a, b), it is argued that there is a general phonotactic constraint against sequences of three consonants in Leti. This constraint triggers metathesis in consonant-final forms when they precede forms with initial consonant clusters. The constraint against three consonants leads to metathesis, as shown in the following tableau; as can be seen, this constraint dominates the LINEARITY constraint against metathesis:

(24) *CCC Sequences of three consonants are disallowed⁴ LINEARITY S₁ is consistent with the precedence structure of S₂, and vice versa ('no metathesis')

/kunis + vnutan/ 'iron key'

| /kunis + vnutan/ | *CCC | LINEARITY |
|------------------|----------------|-----------|
| {kunsi vnutna} | | * |
| {kunis vnutna} | *L. کر بر ا | |

Metathesis is also observed before forms that have initial geminates. Under the assumption that geminates and clusters both comprise two timing slots, this like patterning is to be expected. As shown below, both geminates and clusters exhibit the triggering environment, regardless of the fact that one is comprised of a single segment while the other is two segments:

(25) cluster:

geminate:



⁴ In the constraint *CCC, the symbol C is taken to mean 'timing slot which dominates consonantal features'

Again, due to the basic claim of the Composite Model, that geminates comprise two timing slots, the similar patterning of the Leti geminates and consonant clusters with regard to phrasal processes is entirely expected and predicted.

4.1.5 Geminates as single segments

Compelling evidence that the Leti geminates are single monolithic segments comes from reduplication. As presented in Muller (1997, 2001), there are a variety of different reduplication patterns in this language. In one pattern, a mono-moraic reduplicant is prefixed to a bisyllabic prosodic foot which occurs at the end of the word, as shown in group (26a) below. In these examples, the edge of the prosodic foot is indicated with a bracket, while the reduplicative affix is underlined.

In group (b), it is shown that the reduplicant surfaces between the segments of the initial cluster. As indicated by the starred examples to the right, if the reduplicant were simply prefixed to the word, it would be 'misaligned', meaning that the rightmost edge of the affix does not coincide with the leftmost edge of the prosodic foot, but rather are separated by a single segment⁵.

In group (c), forms that have initial geminates underlyingly are shown. As can be seen, the reduplicant is prefixed to the word, rather than to the foot.

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⁵ It is assumed that the edge of the prosodic foot coincides with the syllable edge. Since a word-internal cluster is syllabified as a coda+onset sequence (ur.pu), the foot boundary falls between the two consonants: kpur[puri 'to become short' Thus, in this form, the reduplicant is not prefixed directly to the edge of the prosodic foot, but rather is misaligned by one segment: kpur[puri. A similar argument is presented for geminates. Since they are posited to comprise a coda and an onset when intervocalic, the foot boundary falls between the two halves of the geminate: pep.pe.rat \rightarrow pep[pe.rat 'heavy'

(26) a.

Ç.

reduplicant is prefixed to prosodic foot

| 1 | taboo (adi) | 1.1: | 'taboo' | |
|--|--|--|--|---|
| | tabuu (auj) | lull | (10000 (10.000) | |
| Kalkakir | TO SOD | Kakir | | |
| <u>til</u> titu | 'eagle' | titu | to shriek' | |
| <u>ta[</u> ta.an | 'for a while' | ta.an | 'to hold' | |
| <u>lu[</u> lu.uv | 'remaining' | lu.uv | 'remnant' | |
| <u>rum[</u> ruma | 'shelter' | ruma | 'house' | |
| <u>sop[</u> sopan | 'messenger' | sopan | 'to order' | |
| <u>mas[</u> masa | 'gilt' | masa | 'gold' | |
| laslasar | 'untruthfulness' | lasar | 'lie' | |
| kapan(panas | 'feverish' | kapanas | 'to be feverisl | h' |
| kaso[s ^v o.i | 'to wiggle' | kaso.i | 'to jerk' | |
| na. <u>ut[</u> utun | 'many (adj)' | na.utun | 'many' | |
| h redun | licant enlite un initial | cluster | | |
| 0. 1004 | пеайгэрцгэ пр шппаг | eracier | | |
| o. teanb | | | | |
| k <u>ri[</u> riat | 'slow' | kriat | 'to be slow' | * <u>r</u> ik[riat |
| k <u>ri[</u> riat k <u>pur[</u> puri | 'slow' 'to become short' | kriat kpuri | 'to be slow' 'to be short' | * <u>ri</u> k[riat * <u>pur</u> k[puri |
| k <u>ri[</u> riat k <u>pur[</u> puri mni[nina | 'slow' 'to become short' 'calm' | kriat kpuri mnina | 'to be slow' 'to be short' 'to be calm' | * <u>ri</u> k[riat * <u>pur</u> k[puri * <u>ni</u> m[nina |
| k <u>ri[</u> riat k <u>pur[</u> puri m <u>ni[</u> nina m <u>nap[</u> napan | 'slow' 'to become short' 'calm' 'softly' | kriat kpuri mnina mnapan | 'to be slow' 'to be short' 'to be calm' 'to be soft' | * <u>ri</u> k[riat * <u>pur</u> k[puri * <u>ni</u> m[nina |
| k <u>ri[</u> riat k <u>pur[</u> puri m <u>ni[</u> nina m <u>nap[</u> napan | <pre>'slow' 'to become short' 'calm' 'softly'</pre> | kriat kpuri mnina mnapan | 'to be slow' 'to be short' 'to be calm' 'to be soft' | * <u>ri</u> k[riat * <u>pur</u> k[puri * <u>ni</u> m[nina |
| k <u>ri[</u> riat k <u>pur[puri</u> m <u>ni[</u> nina m <u>nap[</u> napan reduplicant d | 'slow' 'to become short' 'calm' 'softly' oes not split up gemin | kriat kpuri mnina mnapan aate | 'to be slow' 'to be short' 'to be calm' 'to be soft' | * <u>ri</u> k[riat * <u>pur</u> k[puri * <u>ni</u> m[nina |
| k <u>ri[</u> riat k <u>pur[</u> puri m <u>ni[</u> nina m <u>nap[</u> napan reduplicant d <u>pe</u> pperat | 'slow' 'to become short' 'calm' 'softly' oes not split up gemin 'heavy' | kriat kpuri mnina mnapan ate pperat | 'to be slow' 'to be short' 'to be calm' 'to be soft' 'to be heavy' | * <u>ri</u> k[riat * <u>pur</u> k[puri * <u>ni</u> m[nina *p <u>pe</u> perat |
| k <u>ri[</u> riat k <u>pur[</u> puri m <u>ni[</u> nina m <u>nap[</u> napan reduplicant d <u>pe</u> pperat <u>ko</u> kkoi | <pre>'slow' 'to become short' 'calm' 'softly' oes not split up gemin 'heavy' 'child'</pre> | kriat kpuri mnina mnapan aate pperat kkoi | 'to be slow' 'to be short' 'to be calm' 'to be soft' 'to be heavy' 'kid' | * <u>ri</u> k[riat * <u>pur</u> k[puri * <u>ni</u> m[nina *p <u>pe</u> perat *k <u>ko</u> koi |
| k <u>ri[</u> riat k <u>pur[</u> puri m <u>ni[</u> nina m <u>nap[</u> napan reduplicant d <u>pe</u> pperat <u>ko</u> kkoi <u>me</u> mmeran | 'slow' 'to become short' 'calm' 'softly' oes not split up gemin 'heavy' 'child' 'swiftly' | kriat kpuri mnina mnapan ate ppɛrat kkɔi mmɛran | 'to be slow' 'to be short' 'to be calm' 'to be soft' 'to be heavy' 'kid' 'to be swift' | * <u>ri</u> k[riat * <u>pur</u> k[puri * <u>ni</u> m[nina *p <u>pe</u> perat *k <u>ko</u> koi |

It is argued that the pattern of reduplicant affixation can be accounted for under the assumption that geminates are single, indivisible segments. If they were simply sequences of identical segments, it would be expected that the reduplicant would split these 'clusters' just as it does with the other clusters, such as those shown in (26b). However, they do not. Thus, it is claimed that geminates are single multiply-linked segments.

Muller (2001) proposes an alignment constraint which accounts for this pattern:

ALIGN (RED R, FOOT L)

(27)

Align the right edge of the reduplicant to the left edge of a foot

The inclusion of this constraint accounts for the location of the reduplicant in forms both with and without consonant clusters, as demonstrated in the following tableau. In (28), a form with an initial consonant cluster is evaluated. Here, the optimal form is selected since the reduplicant is aligned correctly⁶, to the left edge of the foot. Candidate (b), which contains a prefixed reduplicant, is rejected since the affix is not aligned to the foot. As shown in Hume 1997b the syllabification patterns of Leti cause initial segments of clusters to become codas when preceded by a vowel. Thus, underlying /cv + ccv/ is syllabified as [cvc.cv]. Since the initial segment of the base cluster is preceded by a vowel, it is a coda consonant. As such, it is not a part of the prosodic foot, the boundary of which coincides with the syllable boundary. Thus, the reduplicant in candidate (b) and the prosodic foot are separated by a segment, rather than being adjacent.

(28) kpurpuri 'to become short'

| /RED + kpuri/ | ALIGN RED |
|-------------------------|-----------|
| a. 🕶 k <u>pur[</u> puri | |
| b. <u>kpu</u> k[puri | *! |

In forms with initial geminates, the reduplicant is prefixed to the word, as demonstrated below, even though this results in a violation of the alignment constraint.

⁶ Naturally, there are other constraints involved in selecting the optimal form, and the reader is referred to Muller 2001 for indepth discussion and analysis of the Leti reduplication facts. The current discussion is intended only to show the alignment of the reduplicant, and in particular its disparate treatment of clusters and geminates.

(29) Misalignment and initial geminates

| /RED + pperat/ | ALIGN RED |
|------------------------|-----------|
| a. 🕶 <u>pe</u> p[perat | *! |

As argued in Muller (1997), this misalignment is forced by a universal prohibition against crossing association lines. This prohibition, which has long been recognized as a central tenet of autosegmental theory (see e.g. Goldsmith 1990) states that no process may result in crossed association lines. With regard to Leti reduplication, it is shown that attempting to prefix the reduplicant to the prosodic foot results in the association lines of the geminate being crossed.

As demonstrated, the boundary of the prosodic foot lies between the two segments of a consonant cluster, and between the two halves of the geminate (again, this follows from the syllabification patterns in Leti as well as the assumption that the foot boundary coincides with the syllable boundary). If the reduplicant in the geminate-initial form is perfectly aligned to the foot, association lines are crossed. However, in the form with an initial cluster, affixing the reduplicant to the foot does not result in crossed association lines, since the cluster is made up of two separate entities. (30)

Form with cluster:

. .

X <u>X X [</u>X X X X | | | | | | | k <u>p u</u> p u r i Form with geminate:

<u>X X X[X X X X X X</u> | | \/ | | | | <u>p ε</u> p ε r a t

cf. perfect alignment: $X \times X [X \times X \times X \times] = [ppeperat]$ $p \in p \in r \ a \ t$ crossed association lines

Thus, the No Crossing Constraint, as outlined in (31), drives the misalignment of the geminate-initial forms. As can be seen, the form with the perfectly aligned reduplicant fatally violates this constraint. If geminates in Leti were posited to be consonant clusters instead of single, multiply linked segments, the disparate patterning with regard to reduplication would be unexplained.

(31) NCC 'No crossing constraint': association lines may not be crossed

| /RED + pperat/ | NCC | ALIGN RED |
|------------------------|-----|-----------|
| a. 🖝 <u>pe</u> p[perat | | *! |
| b. p <u>pe[</u> perat | *! | |

4.1.6 Alternative accounts of Leti

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Kiparsky (1999) posits that a possible representation of initial geminates in Leti is one in which the mora is associated to a higher prosodic level (in this case, the phrase), as demonstrated in (32). In this type of extrametrical representation, the basic claim of moraic theory, that geminates are inherently moraic, is maintained. Additionally, the observation that initial geminates do not contribute to prosodic weight for purposes of word minimality or stress assignment are also accounted for. Specifically, the mora is not a part of the word and thus does not contribute prosodic weight to the word.

(32) Extrametrical, moraic representation of initial geminate following Kiparsky (1999)

Phrase Word Foot ۲ م [ppe]

While this representation accounts for the fact that initial geminates do not contribute to the minimality requirement in Leti, problems with the extrametrical representation become evident when medial geminates are considered, as will be outlined below.

In Leti, medial geminates, like their word-initial counterparts, do not contribute to prosodic weight to the syllable or the word (as was shown in 4.1.2). Thus, the mora which is claimed to be associated to a medial geminate must be extraprosodic under Kiparsky's proposal, just like that of the initial geminate. This is the assumed structure illustrated in (33). Crucially, since the mora is associated to the phrase, the geminate is not associated to the initial syllable in any way. Thus, the syllabification of a sequence with the following structure would be [a.ppa].

(33) Extrametrical medial geminate (following Kiparsky 1999)



There is convincing evidence that a medial geminate is associated to a preceding syllable, suggesting that the representation in (33) is incorrect. As discussed in Hume 1997b, morpheme final vowels are not permitted in open syllables (unless they are absolutely phrase-final). As a result, a morpheme final vowel may be deleted or surface as a secondary articulation on a following consonant, as demonstrated by the examples in (34). Crucially, when a morpheme final vowel is followed by a consonant cluster or a geminate, the vowel is not deleted or changed to a secondary articulation, as shown by the examples in (b).

(34)a. Morpheme final vowel deletion/secondary articulation formation:

b.

/samela + ttenan/

| /samela + nura/ | samelnura | 'sp. rodent' | *samelanura |
|----------------------|------------------------|----------------------|-------------|
| /kkani + tani/ | kkant ^y ani | 'earthenware plate' | *kkanitani |
| Blocked before const | onant clusters a | and geminates: | |
| /koni + mderi/ | konimderi | 'Mderian grasshopper | ' *konmderi |

samelattenan 'spine of mouse'

*samelttenan

In Hume's analysis, this pattern is accounted for by the interaction of two competing constraints: one that deletes morpheme final vowels, crucially, in open syllables, and another that prohibits consonant clusters of more than two segments. If geminates are not associated to a preceding syllable, as under the extraprosodic representation being discussed here, this pattern cannot be accounted for.

An additional issue that becomes apparent when discussing the representation of medial geminates relates to extraprosodicity. As presented in Zec (1988), and Inkelas (1989), extraprosodicity is restricted to word edges; these observations are summarized in Hayes (1995) as the Peripherality Condition which limits extraprosodic elements to edges, and that extraprosodic elements disappear or are otherwise made to be prosodic when affixation causes them to be medial rather than at an edge.

To assume that medial geminates in Leti are moraic and also extraprosodic (in the effort to maintain the tenets of moraic theory, as represented in (33)) is to propose a previously unattested type of extrametricality, i.e. word-medial extrametricality. While word-edge extrametricality is observed in various languages, word-medial extrametricality such as that which must be assumed for Leti, is not. For example, Cairene Arabic generally allows syllables that are maximally CVC, yet allows 'superheavy' CVCC syllables word-finally. McCarthy (1979) proposes that the final C in the superheavy syllable is extraprosodic. If extrametricality were allowed in medial position, one would expect to find a language similar to Cairene Arabic that allows superheavy syllables as in this hypothetical example, but recall that Cairene Arabic is assumed to have CVC syllable structure with CVCC syllables having special status). Such a claim seems unwarranted at this time. Thus, the claim that the tenets of moraic theory can be maintained in accounting for Leti is rejected.

4.2 Cypriot Greek

Cypriot Greek is a variety of the Greek language spoken on the island of Cyprus. Due to the long history of geographical and cultural isolation from Mainland Greece, this variety exhibits significant differences as compared to other varieties of Modern Greek. The data presented in this discussion come from written descriptions of the language (primarily Newton 1972), as well as from consultation with a native Cypriot speaker. The phonological and phonetic characteristics of geminates in Cypriot Greek have been investigated in various works (Hamp, 1961; Newton, 1967, 1972; Malikouti-Drachman 1987; Arvaniti & Tserdanelis 2000; Tserdanelis & Arvaniti 2001). Malikouti-Drachman (1987) showed that the Cypriot geminates are best represented as single melodic units which are multiply-linked to two prosodic positions, findings that are mirrored in the present discussion. However, at the time of Malikouti-Drachman's analysis, moraic theory had not yet been presented as a framework that could supplant the timing-based model, and so the implications that the Cypriot geminates hold for the different representational frameworks could not be explored. In the current discussion, this topic is addressed, and it is shown that a model which includes the explicit representation of timing slots allows for a more elegant account of the facts.

In a more recent analysis of the Cypriot geminates and their implications for phonological representation (Arvaniti, in press), phonetic data is cited as evidence that geminates in this language are represented via timing slots and not moraic structure. Although Arvaniti supports the same conclusion as that of the present analysis, there are fundamental differences in how this conclusion is reached which are worth noting.

Specifically, it is posited in Arvaniti analysis that since geminates do not cause any significant shortening of a preceding vowel, they cannot be associated to a mora. Crucially, it is assumed that there is a direct relationship between the mora and the actual manifestation of phonetic duration, an assumption which, while shared by various researchers (e.g. Broselow et al. 1997), is not uncontroversial. As presented in Chapter 2, while there may be a relationship between the abstract concept of weight and phonetic manifestation, this relationship is not direct.

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In the present analysis, the evidence that Cypriot geminates are best represented with a representation that includes timing slots rather than solely moras comes primarily from the phonological patterns exhibited by these sounds. Specifically, while they act like single, monolithic segments, they also pattern like consonant clusters for some processes. Further support that this type of representation is appropriate for Cypriot is based in more general considerations. It is argued that a representation which includes timing slots is superior to one which assumes only moras, since only the timing-slot model treats initial geminates and consonant clusters as a natural class. Since geminates and clusters are observed to pattern alike in many languages, this aspect of timing-slot models is argued to be a theoretical advantage- not only for Cypriot Greek, but for any language in which initial geminates and consonant clusters pattern alike.

(35) Geminates in Cypriot Greek (as compared to consonant clusters)



4.2.1 Background facts

The segmental inventory of Cypriot is presented below.

(36)

| _ | Bilabial | Labiodental | Interdental | Alveolar | Alveopalatal | Palatal | Velar |
|-----------|----------|--|-------------|----------|--------------|---------|-----------|
| Stop | р | | | t | ķ | | k |
| | p: | | | t: | ķ: | | k: |
| Fricative | | fv | θð | S Z | | šž | хх |
| | | f: v: | θ: | S: Z: | | š: ž: | x: |
| Affricate | | | | | | č | |
| | | | | | | č: | |
| Nasal | m | | | n | | | |
| | m: | | | n: | | | |
| Lateral | | ÷ | | 1 | | | |
| | · | | | 1: | | | |
| Retroflex | | | | r | | | |
| | | - 14 | | r: | | | |
| Glide | | 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1 | | | | у | |
| | | | | | | | |

Geminates are common in Cypriot Greek and are found throughout the language, in both native and borrowed words. These segments are found in both word-medial and word-initial position, as shown below:

| (37) | a. wor | a. word-medial consonant length contrast | | | | |
|------|---------|--|----------|----------|--|--|
| | xapárin | 'piece of news' | apparín | 'horse' | | |
| | túti | 'this girl' | mútti | 'nose' | | |
| | pléki | 'she knits' | purékkin | 'pastry' | | |
| | kaká | 'bad' | kakká | 'feces' | | |
| | | | | | | |

b. word-initial consonant length contrast

| péfti | 'Thursday' | ppéfti | 'he falls' |
|----------|------------|----------------|-------------|
| távla | 'table' | ttávlin | 'backgammon |
| ķiria | 'Mrs.' | <u>k</u> ķirás | 'rent' |
| kullúrka | 'rolls' | kkuláfka | 'flattery' |

4.2.2 Final nasal deletion

Evidence that demonstrates that geminates and consonant clusters pattern alike in Cypriot Greek comes from a process of nasal deletion. As demonstrated in the examples below, the final nasal consonant of the definite articles /tin/ (fem) and /ton/ (masc.) surfaces unaffected when followed by a word that begins with a vowel or a single consonant⁷. As illustrated in (b), when the second word has an initial geminate consonant, the nasal is deleted. Similarly, when the second word begins with an onset cluster, the nasal may also be deleted, as shown in (c). However, as demonstrated by the examples in (d), the nasal is not deleted before all types of word-initial consonant clusters. Specifically, the clusters that do not trigger deletion consist of stops followed by liquids.

(38) Nasal deletion

a. ton ápparon ton tixon tin petterán 'the horse'*to ápparon'the wall'*to tixon'the mother-in-law'*ti petterán

 $^{^{7}}$ Coda nasals undergo place assimilation, a process that is independent of the deletion process to be described here. The point remains that the nasal is not deleted.

| b. | ti <u>k</u> kellén | 'the head' | *tin kkellén |
|----|--------------------|--------------------|------------------|
| | to pparán | 'the money' | *ton pparán |
| | to ttaván | 'the stew' | *ton ttaván |
| c. | ti psačín | 'the poison' | *tin psačín |
| | ti ksilopaúran | 'the cold weather' | *tin ksilopaúran |
| | to flókkon | 'the mop' | *ton flókkon |
| | ti ðromolakšán | 'the ditch' | *tin ðromolakšán |
| d. | tin krémman | 'the cream' | *ti krémman |
| | tin klátsan | 'the sock' | *ti klátsan |
| | ton tráullon | 'the billy goat' | *to tráullon |
| | ton prúnzon | 'the bronze' | *to prúnzon |
| | ton platánon | 'the plane tree' | *to platánon |

The behavior of geminate consonants with regard to nasal deletion is accounted for in a straightforward manner within the CM framework of representation. It is posited that deletion before geminates and consonant clusters is driven by a restriction on threeconsonant clusters that applies across word boundaries as well as within words.

As shown below, there are groups of three consonants that are permitted in Cypriot words, and are found both in words and across a word boundary (such as when the nasal final article time precedes a word such as 'cream': tin + kremman \rightarrow tin kremman). In the second group are three-consonant clusters that are never observed in Cypriot, either within words or across word boundaries. It is argued that final nasal deletion occurs in order to avoid the creation of these disallowed clusters (such as in tin + psačin → ti psačin, not *tin psačin).

(39) Three-consonant clusters in Cypriot Greek

a. Allowed: spr, str, skl, mpl, mpr, ntr, nkl, nkr

Disallowed: nps, nfl, nks, nðr

While the division between the class of acceptable consonant clusters and the unacceptable ones may appear arbitrary, the pattern becomes apparent when the concept of relative sonority is taken into account. Presented below is a modified sonority scale, based on concepts first presented in Selkirk (1984). Each segment class is assigned a number indicating their relative sonority value: stops have a value of 1, as they are less sonorous than fricatives (with a value of 2), nasals (with a value of 3), and liquids (with a sonority value of 4).

(40) Relative sonority scale (following Zec 1995 inter alia)
 less sonorous ← → more sonorous
 Sonority value: 1 2 3 4
 stops fricatives nasals liquids

Quantifying relative sonority values permits a clear, descriptive generalization of the three-consonant cluster patterns. Specifically, in the permitted clusters, the relative values of C2 and C3 are always 1:4. In the disallowed sequences, C2 and C3 have less sonority 'distance' between them. With regard to the nasal deletion process outlined earlier, it can be seen that in each cluster that triggers deletion, the sonority values are not 1:4; conversely, the clusters that do not trigger deletion exhibit that exact ratio:

(41) Sonority ratio for clusters:

| Examples of no deletion: | Examples of deletion ⁸ : | |
|-----------------------------|-------------------------------------|--------------|
| tin + kremman [tin kremman] | tin + psacin | [ti psačin] |
| tin + klatsan [tin klatsan] | ton + flokkon | [to flokkon] |

| Cluster type: | ratio | Cluster type: | ratio |
|---------------|-------|---------------|-------|
| kr | 1:4 | ps | 1:2 |
| kl | 1:4 | fl | 2:4 |

Under the assumption that geminates consist of two timing slots, the fact that they pattern like some consonant clusters in triggering deletion is entirely expected: the two timing slots have the same sonority value (since they are linked to the same root node), as illustrated below.

(42) Sonority ratio for geminates:

X X sonority value of X1= 1; sonority value of X2= 1 \ / [p:] ratio: 1:1

⁸ Naturally, deletion of any one of the segments in the sequence would result in an acceptable form, since two-consonant clusters are subject to few restrictions: the /np/ of the possible form [tin pačin] is not disallowed. However, evidence from other languages (Beckman 1997) indicates that there is a crosslinguistic tendency to preserve segments that occur at the beginnings of words. It is posited that in Cypriot, the deletion of the word-final nasal, instead of the word-initial segment, reflects this tendency.

Since the two timing slots associated to the geminate have a sonority ratio value of less than 1:4, they are expected to trigger deletion. As shown below, if the nasal is not deleted, a three-consonant cluster with an unacceptable sonority contour would result:

(43) ton + pparan [to pparan] (sonority of cluster: 1:1)
* [ton pparan] (sonority of X2 and X3 in resulting cluster 1:1)

A constraint that captures the generalization about relative sonority values and phonotactic restrictions is shown in (44). Essentially, this constraint prohibits sequences of three consonants in which the relative sonority value of C2 and C3 do not fit the allowable 1:4 ratio. Since this constraint results in deletion of the final nasal of the articles /tin/*and /ton/, it is apparent that it dominates the universal MAX constraint which penalizes segment deletion⁹.

(44) *CCC Sequences of three consonants in which the relative sonority values of C2 and C3 are not 1:4 are not permitted.

MAX No deletion

As demonstrated in the following tableaux, the combination of these constraints leads to final nasal deletion before all consonant clusters except those consisting of a stop + liquid combination (i.e. those that have the 1:4 ratio). In tableau 20 (i), a form with a stop + liquid cluster is evaluated. The winning candidate does not incur any violations. Candidate (b) incurs a violation of the MAX constraint since the nasal has been deleted. In tableau (ii), a word with a deletion-triggering onset is evaluated. The winning

⁹ In this constraint, the symbol 'C' is used to represent timing slots which dominate consonantal features.

candidate (a) incurs a violation of the MAX constraint, since the nasal has been deleted. However, this is a necessary violation, since otherwise, a three-consonant sequence with a disallowable sonority contour would result, as in candidate (b). Tableau (iii) evaluates a form with an initial geminate. The winning candidate incurs a violation of MAX, since again, the nasal is deleted. As in the previous tableau, if the segment were not deleted, a sequence of three consonants with an undesirable sonority contour would result.

(45) i. no deletion

| /tin + klatsan/ | *CCC | MAX |
|------------------|------|-----|
| a. 🖝 tin klatsan | | |
| b. ti klatsan | | *i |

ii. deletion before cluster with unacceptable sonority ratio

| /tin + psačin/ | *CCC | MAX |
|----------------|------|-----|
| 🖝 a. ti psačin | | * |
| b. tin psačin | *[| |

iii. deletion before geminate

| /ton + pparan/ | *CCC | MAX | |
|----------------|------|-----|--|
| 🕶 a. to pparan | | * | |
| b. ton pparan | *! | _ | |
| 3 4 | | | |

The preceding analysis demonstrates that in the CM framework, as in other theories that assume timing slots, the facts of nasal deletion can be described in a unified manner. This is because both consonant clusters and geminates are treated as a natural class within this framework: they each consist of two timing slots that dominate consonantal features. Thus, nasal deletion can be described simply as a process that is triggered by two consonants that have a certain sonority ratio.

4.2.3 Geminates as singletons

Evidence that suggests Cypriot Greek geminates are single segments, rather than sequences of two identical segments, comes from a variety of sources. One type of evidence comes from a palatalization process. In Cypriot Greek, segments may be realized as palatals before the front vowel /i/. As shown in (a) below, the velar stop and fricative are realized as palatals in this environment. As shown in (b), when a geminate is in this environment, the entire segment undergoes palatalization. In contrast, when a consonant cluster precedes a high vowel, as in the final example, only the second segment is subject to palatalization; the first segment in the cluster is unaffected¹⁰.

(46) Palatalization¹¹

| a. | kakós | 'bad (masc. s | sg.)' k | ači 't | oad (fem. sg.)' |
|----|-------|---------------|---------|--------|-----------------|
|----|-------|---------------|---------|--------|-----------------|

| tixos | 'wall | (nom. sg.)' | tíši | 'walls (nom pl.) | , |
|-------|-------|-------------|------|------------------|---|
|-------|-------|-------------|------|------------------|---|

b. sákkos 'jacket (nom. sg.)' sáčči 'jacket (nom.pl.)' *sakči

c. marankós 'carpenter (nom. sg.)' maranči 'carpenter (nom. pl.) *maranči

If geminates were sequences of two identical segments rather than a single monolithic segment, their behavior with regard to palatalization would be difficult to explain. Specifically, in the preceding examples, a form in which only the second 'half'

¹⁰ Unfortunately, examples which demonstrate this alternation are in short supply, due to the constrained environment: there must be a root-final CC sequence in which both segments are prone to palatalization before *lil*. However, only velars and coronal nasals are prone to palatalization before *lil*, while coronal stop palatalizes before *lial*. Thus, only words with clusters such as *l*kn/, *lnk* etc. in root-final position demonstrate the fact that the second member of the cluster is affected by the process.

¹¹ The phonetic extent of the palatalization may vary between speakers; some produce a segment closer in articulation to the palatal-alveolar affricate $l \mathcal{E} l$, while others produce a fronted velar segment $l \mathcal{K} l$. Regardless of the realization, the point remains the same: only the segment preceding the vowel l i l is subject to palatalization.

of the geminate is palatalized would be expected if these segments were really sequences. However, if geminates are posited to be single units, the observed pattern is unsurprising.

Additional suggestive evidence that geminates are single segments in Cypriot Greek comes from phonotactic restrictions in the language. First, the distribution of stop clusters within words is severely restricted: only /pk/ and /pt/ are observed out of all possible stop combinations (/pt/, /pk/, /tp/, /tk/, /kp/, /kt/). The stop clusters that are observed are also very rare. For example, review of a Cypriot dictionary (Giagoulles, 1994) reveals only about a dozen examples of the /pk/ cluster, and less than a half-dozen examples of the /pt/ cluster. Furthermore, /pt/ is restricted to the word-medial environment. In contrast, the geminate stops of Cypriot are not subject to such restrictions: all are observed in word-medial and word-initial position, in dozens of examples. If the geminates of Cypriot were posited to be sequences of identical stops, their wide distribution would be difficult to account for in light of the restrictions on the other stop clusters. "Conversely, if the geminates are taken as single segments, their distributional patterns are unproblematic.

Patterns exhibited in morpheme concatenation also indicate that stop clusters are dispreferred in Cypriot Greek¹². Specifically, when stems with final stops precede the perfective past suffix /-tin/, the stop is lenited, as demonstrated in (47). If the stem-final segment were unaltered, a stop cluster would result as indicated in the starred examples. The lenition process only occurs in this environment and thus it is assumed that it is the result of a general prohibition against clusters of this type.

¹² See also Tserdanelis 2001 for further discussion regarding consonant dissimilation in Greek.

(47) Stem-final consonant alternation¹³

| Proposed stem(No | ewton 1972) | Perfective past passive /-tin/ | | | |
|------------------|-------------|--------------------------------|-----------|--|--|
| /vľap/ | 'hurt' | efláftin | *efláptin | | |
| /pemp/ | 'send' | epéftin | *epéptin | | |
| /sfank/ | 'slaughter' | esfáxtin | *esfáktin | | |

cf. $/sfank/ + perfective past active suffix /sen/ \rightarrow esfaksin *esfaxsin$

It is crucial to note that there are no processes which lenite the initial part of a geminate consonant, demonstrating that geminates do exhibit behavior unlike clusters:

| (48) | /mutti/ → [mútti] | 'nose' | *muθti |
|------|-------------------|---------|---------|
| | /ppara/→ [pparás] | 'money' | *fparas |

If geminates were taken to be sequences of identical segments, the patterns described above would be difficult to explain, since a 'cluster' of stops such as /pp/ would be allowed, while a cluster such as /pt/ would not be. However, if it is assumed that geminates are single segments, these patterns become clear. Stop clusters are avoided; geminates are unaffected by this prohibition because they are single segments and not real clusters.

In summary, evidence from palatalization as well as distribution indicate that the geminates in Cypriot Greek are single segments. An account of the palatalization process is straightforward in the CM framework, as in any framework that assumes geminates are single multiply-linked segments. Recall that single and geminate segments are palatalized

¹³ The second and third examples also illustrate the deletion of nasals in tri-consonantal clusters, a process which is independent of lenition but which will be described in more depth later in the paper.

before the vowel /i/, while only the second member of a consonant cluster is affected, as repeated below, from (2a).

| (49) | kakós 'bad (masc. sg.)' | kači | 'bad (fem. sg.)' |
|------|---------------------------|---------|------------------------------|
| | sákkos 'jacket (nom.sg.)' | sáčči | 'jacket (nom. pl.)' |
| cf. | marankós 'carpenter (nom. | sg)' ma | ranči 'carpenter (nom. pl.)' |

Since geminates have a single root node and thus are single segments, the process can be described as the palatalization of the segment immediately preceding the vowel /i/, as demonstrated below.

(50) Palatalization:



This generalization can be expressed as below. It is assumed that this prohibition against sequences of velars and front vowels operates on the root node level; crucially, since geminates and singletons are both single root nodes, they are expected to pattern in the same manner.

(51) *[Ki] Root node sequences of velars and /i/ are prohibited¹⁴

It is assumed that the requirement reflected by this constraint is fairly important in this language since the observed pattern of palatalization is so prevalent; thus, the constraint *[Ki] is posited to be undominated. Additionally, since an underlying non-palatal consonant may surface as a palatal, it is also safe to assume that a constraint such as FAITH, which prohibits featural changes, is lowly ranked. This is demonstrated in the following tableau. Here, the winning candidate (a) is selected because it only violates the relatively low-ranked FAITH constraint. This violation is incurred because the underlying segment /k/ is realized as [č] on the surface. Candidate (b) does not incur a violation of FAITH because there have been no changes to the underlying segments. However, this form violates the more highly ranked constraint against sequences of [k] and [i]. Thus, it is rejected.

| | KI FAITH | *[Ki] | /kak + i/ |
|---|----------|-------|-----------|
| - | * | | 🕶 a. kači |
| | | *! | b. kaki |
| | | *i | b. kaki |

| (52) | Palatalization | input: | /kak-/ 'bad (root)' + | /-i/ 'fem. | sg. adj. | suffix' | →[kačí] |
|------|----------------|--------|-----------------------|------------|----------|---------|---------|
|------|----------------|--------|-----------------------|------------|----------|---------|---------|

¹⁴ Palatalization of segments before *lil* is not limited to velars; alveolars are also targeted when they are followed by a sequence of *lil* followed by another more sonorous vowel. This constraint is intended to reflect one component of this general pattern.

A form with a geminate consonant is evaluated in exactly the same manner as a singleton, as shown below. Recall that since a geminate consists of a single root node, it is entirely affected by the palatalization process. Since the root node cannot be split, there is no candidate in which the geminate is 'half' palatalized, such as *sakči.

| (53) | input: | /sakk-/ | ʻjacket | (root)' | +/-i/ | (nom. | pl. | suffix) | → | sáčči |
|------|--------|---------|---------|---------|-------|-------|-----|---------|---|-------|
|------|--------|---------|---------|---------|-------|-------|-----|---------|---|-------|

| /sakk+ i/ | *[Ki] | FAITH |
|------------|-------|-------|
| 🖝 a. sačči | | * |
| b. sakki | *! | |

The surface form of words with consonant clusters are also correctly predicted by the constraints that have been proposed. As demonstrated below, candidate (a), in which only the segment immediately preceding /i/ is palatalized, is chosen. Candidate (b) violates the constraint against sequences of [Ki]. Candidate (c), in which both of the segments of the cluster have been palatalized, is compared unfavorably to the winning candidate. This is because in (d), two underlying segments have been changed in the surface form, while in (a), only one segment of the cluster has been affected.

(54) input: /marank-/ 'carpenter' + /-i/ (nom. pl. suffix) → maranči (*maranči)

| /pefk + i/ | *[Ki] | FAITH |
|----------------|-----------|-------|
| 👁 a. maranči ț | . | * |
| b. maranki 🕣 | *! | |
| c. maranči | | *[* |

4.2.4 Alternative analyses

Moraic theory (Hayes 1989, *inter alia*) cannot account for the facts of Cypriot Greek in as elegant a manner because under this framework, word-initial geminates and consonant clusters are represented differently: geminates are single root nodes that are multiply linked to two prosodic positions while consonant clusters are two root nodes:

(55) Initial consonant clusters and geminates in moraic theory:



As discussed in chapter three, in order to account for the similar patterning of geminates and clusters within the moraic framework, it is crucial to posit that the association lines carry significance beyond simply coindexing entities on different prosodic levels. Specifically, within the moraic framework, one possible account of the nasal deletion process is to posit that both geminates and clusters create complex syllable margins which are disallowed. However, to do so, the definition of syllable margin must encompass both those that contain two root nodes, as well as those that contain a single root node and an association to a geminate. The stipulative assumptions that are crucial to an account within the moraic framework are taken as evidence that an account which assumes the explicit representation of timing slots is more elegant and thus superior.

4.2.4.1 Moraicity of Cypriot Greek geminates in the CM

As discussed in the previous section, assuming that geminates are represented only via moraic structure (i.e. a representation that assumes moras but not timing slots, as in the conventional model of moraic theory) does not allow for an elegant account of the Cypriot Greek facts. However, it is crucial to point out that this does not imply moras are ruled out in the representation of Cypriot Greek.

Recall that a basic assumption of the Composite Model is that geminates are always represented via multiple association to timing slots, and that in some languages they may also bear a mora. As was demonstrated, the assumption that timing slots are present allows for an account of Cypriot Greek. However, there is currently no evidence supporting the presence of the mora in Cypriot Greek. As stated in Arvaniti (1991), all syllables in Greek are of the same phonological weight, regardless of their structure. Essentially, there are no processes that suggest contrastive prosodic weight, such as a quantity-sensitive stress assignment process. Based on this fact, it seems acceptable to conclude that geminates in this language are non-moraic.

However, there is also no evidence indicating that the geminates of Cypriot are not moraic. Recall that in Leti, evidence from secondary stress assignment indicated that long vowels were prosodically heavier than short vowels. Interestingly, the geminates did not contribute prosodic weight for this process, indicating they are not moraic. There is no such evidence indicating the non-moraic status of geminates in Cypriot Greek. Thus, it may be equally acceptable to conclude that the geminates are moraic. However, a basic claim of the CM is that consonants are by default non-moraic. Thus, it is maintained that in the absence of evidence supporting moraic consonants in Greek, that the geminates of this language are light.

4.3. Conclusion

As presented in the previous discussions, data from the Austronesian langauge Leti and the Indo-European language Cypriot Greek reflect a variety of different behaviors. It is argued that the initial geminates in these languages are best represented as single, multiply-linked, non-moraic segments. Support for this type of representation is found in arguments for simplicity as well as necessity.

First, in these languages, initial geminates and consonant clusters pattern alike. As illustrated in Chapter three, it is only in frameworks that contain explicit representation of timing relationships (such as in the Composite Model) that the parallel between clusters and geminates is reflected structurally. Under moraic theory, initial geminates and clusters cannot have similar structure, and so it is difficult to refer to them as a natural class with regard to phonological processes. However, if geminates and clusters are represented similarly (crucially, if geminates are represented as associated to two timing slots), then their similar patterning is accounted for in a straightforward manner.

Second, it was also shown that the claim that geminates are non-moraic in some languages is crucial for the account of Leti. The Leti geminates were shown to be nonmoraic, based on evidence from stress assignment and minimality. Only under an account where the geminates are non-moraic can these patterns be accounted for. As was

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demonstrated, any alternative account that attempts to maintain the claims of moraic theory (i.e. that geminates are always moraic) necessarily must contain some unsupported and otherwise unattested claims about extraprosodicity. Thus, the claim that the Leti geminates are long but not moraic is crucial to the account of the facts.

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CHAPTER 5

INITIAL MORAIC GEMINATES

A central claim of the Composite Model is that geminates may bear prosodic weight (moras), regardless of where the geminates surface. In this chapter, data from Chuukese and Luganda will be presented in order to demonstrate that word-initial geminates (like many of their word-medial counterparts) pattern as moraic segments.

The discussion of these languages also provides support for the claim that prosodic weight is language-specific. As was demonstrated in the previous chapter, the facts of Leti can only be accounted for in such as simple manner under the assumption that geminates are non-moraic; furthermore, there is no support for the moraic geminate in Cypriot Greek. As will be demonstrated in this chapter, the facts of Chuukese and Luganda are best accounted for under the assumption that geminates are moraic. In the comparison of these two sets of languages, it is must be concluded that while initial geminates are moraic in some languages, they are not moraic in all languages. Thus, prosodic weight assignment is not universal.

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The background facts and relevant processes of each language will be presented in the following sections. For each language, it will be demonstrated how the patterns are accounted for within the Composite Model. Specifically, it is shown how the assumption of assigned prosodic weight (via the structural requirement constraints) correctly designates the geminates of Chuukese and Luganda as moraic. Additionally, it is demonstrated how the assumption of moraic structure provides a straightforward account of the observed patterns. The chapter closes with a conclusion and discussion of the facts and analyses presented here.

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5.1. Chuukese

Chuukese is an Austronesian language spoken in Chuuk State, Federated States of Micronesia. It is also known as Trukese. The data discussed in this section come from written descriptions of the language (primarily Goodenough and Sugita 1980, 1990), as well as from my own fieldwork with native Chuukese speakers, conducted on Moen Island in Chuuk lagoon during the summer of 1998.

Chuukese exhibits a pattern of geminate alternation which has been the focus of various studies (Churchyard 1991, Hart 1991, Davis and Torretta 1997, Muller 1998). In this process, some words surface with medial geminates when suffixed while when unsuffixed they surface with initial geminates, resulting in alternations such as *fittan* 'package of' versus *ffit* 'package'. This alternation has been referred to by many researchers in the literature as 'geminate throwback', reflecting the assumption that the

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medial geminate is 'thrown back' or transferred to the beginning of the word in some realizations (Churchyard, 1991; Hart, 1991; Davis and Torretta, 1997).

More recent analyses of the geminate alternations in Chuukese reveal that gemination is not spontaneously and arbitrarily realized in different positions of the word, but rather is the direct result of phonotactic and syllable structure requirements that affect the surface forms of words (Muller, 1999). Most crucially, it is demonstrated that in the forms that exhibit the alleged 'geminate throwback', the underlying structure contains two geminate consonants. Thus, the form underlying the *fittan – ffit* alternation is /ffitt/.

Although all of the earlier analyses of the Chuukese facts assume that the geminates are inherently moraic, the implications of this assumption are not addressed in depth. In the following sections, the facts of Chuukese are presented, highlighting the evidence that supports the claim that these segments are moraic. An analysis of the facts within Optimality Theory demonstrates that the assumptions of the Composite Model allow for a straightforward account of the Chuukese facts. Most importantly, the analysis supports the claim that geminate consonants may bear prosodic weight even in the word-initial environment. The assumed representation of Chuukese geminates is shown in (1)

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(1) Chuukese geminates.

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5.1.1 Background facts

The consonantal inventory of Chuukese is shown in (2). All consonants may surface as either short or long; glides may not surface as geminates.

(2) Consonant inventory of Chuukese

| | Bilabial | Labiovelar | Labiodentall | Alveolar | Palatal | Velar |
|-----------|----------|------------------|--------------|----------|---------|-------|
| Stop | р | p | | t | | k |
| | р | p ^w : | | t: | | k: |
| Fricative | | | f | S | | |
| | | | f: | S: | | |
| Affricate | | 1 1 | | | č | |
| | | et se | | | č: | |
| Nasal | m | m ^w | | n | | ŋ |
| | m: | m ^w : | | n: | | ŋ: |
| Lateral | | | | 1 | | |
| | | | | I: | | |
| Retroflex | | | | r | | |
| | | | | r: | | |
| Glide | w | | | | j | |

As demonstrated in (3), consonants may contrast for length in both word-medial and word-initial position. Geminates are never observed in word-final position. Consonant clusters are never observed in any position.

(3) Initial and medial geminates

| sto | ns: |
|-----|------|
| 300 | por. |

| - | kak | 'ring (verb)' | kkak | 'ring (noun)' | *kakk |
|----------|---------------------|-----------------|------------------------------------|---|-------|
| | ika | ʻif | ikkair | 'here they are' | |
| fricativ | ves: | | | | |
| | faat | 'shallow water' | ffaat | 'be strung' | *fatt |
| | afat | 'reveal' | affat | 'be made clear' | |
| affricat | tes: | | | | |
| | čʉ | 'extracted' | ččŧ | 'wooden comb' | *ičč |
| | ačawa | 'sp. fish' | aččawa | 'make slow' | |
| nasals: | | | | | |
| | m ^w ææn | 'man' | m ^w m ^w ææn | 'to err' *mæm ^w m ^w | |
| | om ^w usa | 'release him' | om ^w m ^w usa | 'make him vomit' | |
| | | | | | |

Preliminary phonetic investigation of the initial geminates in Chuukese indicate that they differ consistently from their singleton counterparts. A native speaker of Chuukese was recorded saying words with target segments in word-initial position, both in isolation and in phrases. Six tokens of each target sounds were digitized and the acoustic information was measured. For the sounds /m/ and /m:/, the closure duration was measured. It was found that the mean duration of the short consonant is 181 ms., while that of the geminate is 613 ms. For the sounds /k/ and /k:/, VOT, F0, and RMS amplitude were measured (these features were selected based on results of Abramson 1999, as well as those reported in chapter two). It was found that VOT values were similar: the mean value for /k/ is 112 ms., while that of /k:/ is 126 ms. Although the VOT values do not exhibit the extreme differences such as those found in Cypriot Greek, the results of the other measurements were intriguing. First, the F0 value for /k/ is 132 Hz, while that of /k:/ is 148 Hz. As discussed in Abramson 1999, pitch differences following the release of singletons versus geminates may aid in their identification; the differences observed in Chuukese may also serve as a phonetic cue to the phonological length contrast. The RMS value following consonant release for /k/ was found to be 19 dB, while that of /k:/ is 25 dB. Although this is a difference of just 6 dB, Abramson 1987 found that a difference of less than 2 dB proved statistically significant for initial geminate and singleton stops in Pattani Malay. While there is presently insufficient data to determine if these differences are statistically significant in Chuukese, the preliminary results suggest that initial geminates are distinct from their counterpart singletons.

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5.1.2 Geminates as moraic

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Evidence that geminate consonants in Chuukese are moraic comes from a compensatory vowel lengthening process that is driven by a word-minimality requirement (see e.g. Davis and Torretta 1997). Essentially, this process reveals that nouns which would not otherwise satisfy the bimoraic word-minimality requirement exhibit vowel lengthening; forms with geminates do not exhibit lengthening and thus are posited to be moraic.

The vowel lengthening is triggered by a process of final mora deletion observed throughout the language¹. As shown in the representative examples in (3) a final monomoraic vowel is deleted (as in 'shore'), while a final bimoraic vowel is shortened (as in 'taro') when they would be in absolute final position. When the vowel is followed by the genitive suffix /-n/, the final vowel is protected from deletion. Since the quality and length of the final vowel which surfaces in the suffixed forms is unpredictable, it is assumed that they are part of the underlying material in the root; thus, these forms are all underlyingly vowel-final. In fact, it is posited that all lexical roots are underlyingly vowel-final (Dyen 1949 inter alia).

States in

| (4) | orosseti-n /orosseti/ | 'shore of' | orosset | 'shore |
|-----|--|---------------------|---------------------|-------------------|
| | sawaa-n /sawaa/ | 'taro of' | sawa | 'taro' |
| | mororofi-n /mororofi/ | 'medicinal plant of | mororof | 'medicinal plant' |
| | p ^w ereka-n /p ^w ereka/ | 'sp. yam of' | p ^w erek | 'sp. yam' |

In some nouns, vowel lengthening accompanies final mora deletion. As represented by the first example in (5), such nouns surface with short vowels when suffixed. When they are unsuffixed, the final mora from the root is deleted, as expected. However, the remaining vowel of the root surfaces as long. As indicated by the starred forms on the right, a noun may never surface with just a single short vowel. This fact suggests that there is a bimoraic minimality requirement imposed on nouns; evidence

¹ Recall that Leti, another Austronesian language exhibits a similar reduction process involving morphemefinal vowels. It has been suggested (Lassettre, p.c.) that this reflects a general tendency within this language family.

from the language shows that nouns may not be smaller than the following shapes: CVV, C_iC_iV . The vowel lengthening observed in the unsuffixed nouns is posited to be a lengthening effect which enables the noun to satify the minimality requirement. As a syllable closed by a consonant does not satisfy the minimality requirement, it is assumed that word-final coda consonants are extraprosodic and thus cannot contribute to word-minimality requirements.

(5) Evidence for word minimality: vowel lengthening in nouns

| f a sa-n | 'nest of' | faas | 'nest' | *fas |
|-----------------|---------------|--------------------------|------------|------|
| fæne-n | 'building of' | fææn | 'building' | *fæn |
| m aa- n | 'behavior of' | m aa ² | 'behavior' | *ma |
| 00- 11 | 'omen of' | 00 | 'omen' | *0 |

The following examples demonstrate that this vowel lengthening is observed in noun roots that have medial geminates. As can be seen in the unsuffixed form, when a geminate would surface in word-final position (as the result of the final mora deletion), the segment surfaces as a singleton. This is accounted for in earlier discussions of Chuukese (e.g. Davis and Torretta 1997) as the result of a general prohibition against word-final geminates. Since the short final segment does not contribute to syllable weight, the remaining vowel is lengthened.

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² Naturally, these data could also be described as the non-deletion of the final mora, rather than vowel lengthening. Regardless of the description, the point remains: nouns are minimally bimoraic.

(6) Lengthening in forms with medial geminates

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| tappa-m ^w | 'your coconut' | taap 'coconut' | *tapp, *tap |
|--|--------------------|------------------------------|--|
| sissi-m ^w | 'your spider lily' | süs 'spider lily' | *siss, sis |
| kip ^w p ^w a-m ^w | 'your plant' | kiip ^w 'plant' | *kip ^w p ^w , *kip ^w |
| mænni-m ^w | 'your field' | mæn 'field' | *mænn, *mæn |
| m ^w akka-m ^w | 'your sp. tree' | m ^w aak'sp. tree' | *m ^w akk, *m ^w ak |
| n u ssu-m ^w | 'your left overs' | nuus 'left overs' | *nuss, *nus |

As demonstrated in (7), verb roots are not subject to the bimoraic minimality condition; a verb may surface as a single CV syllable.

(7) No lengthening in verbs

| Sŧ | 'to be calmed' | *s tt |
|-----|-----------------|-------------------|
| fan | 'run aground' | *faan |
| kʉ | 'to catch fire' | * k uu |
| at | 'to arrive' | *aat |

Interestingly, noun roots with initial geminates do not show vowel lengthening when they are unsuffixed, as shown in (7). The forms with initial geminate consonants pattern with noun roots which are sufficiently heavy to satisfy the minimality requirement without vowel lengthening (such as those shown in 4).

(8) No lengthening in nouns with initial geminates

| nn ii -n | 'breadfruit loaf of' | nnii | 'breadfruit loaf' *nni | | |
|---------------------|----------------------|-----------------|------------------------|-------------------|--|
| kkeyi-n | laugh of | kkey | 'laugh' | *kkeey | |
| ččara-n | 'starfish of' | ččar | 'starfish' | *ččaar | |
| kk uu- n | ¥'fingernail of' | kk u | 'fingernail' | *kk uu | |

As will be demonstrated shortly, there is another class of nouns that does not exhibit vowel lengthening. This is unexpected, since an examination of the suffixed forms might suggest that they comprise sub-minimal roots. Instead of vowel lengthening,

these forms surface with initial geminates in the unsuffixed form, as shown in (9). As was demonstrated earlier, forms with short vowels and initial geminates satisfy the minimality requirement, and so these forms are acceptable.

(9) Forms with medial geminates:

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| fitta- kittu | m [™] -m [™] | 'your package' 'your itch' | ffit kk i t | 'package' 'itch' | *fiit, fitt *k#t, k#t |
|--------------------|-----------------------------------|-------------------------------|---------------------------|---------------------|--------------------------|
| kunn | u-m ^w | 'your turning' | kkun | 'turn' | *kuun, kunn |
| čočča | a-m ^w | 'your armful' | ččoč | 'armful' | *čooč, čočč |
| form | s that exh | nibit vowel lengthening | , | | |
| tappa | ı-m ^w | 'your coconut' | taap | 'coconut' | |
| sissi- | ·m ^w | 'your spider lily' | siis | 'spider lily' | |
| kip ^w l | o ^w a-m ^w | 'your plant' | kiip ^w | 'plant' | |

The source of the initial geminate in forms such as 'package' has been the focus of various analyses (Hart 1991, Davis and Torretta 1997, *inter alia*), with most researchers suggesting that the mora associated to the medial geminate is reassigned to the initial segment, resulting in an initial geminate. This process, termed 'geminate throwback' was posited to be a strategy to satisfy the well-attested noun minimality requirement.

However, a recent reanalysis of the Chuukese facts (Muller 1999) suggests an alternative to the geminate throwback account. Specifically, it is posited that the underlying form of words that exhibit the geminate alternation have two geminates, while those that exhibit vowel lengthening have one. Thus, 'package' is /ffitta/, while 'coconut' is /tappa/. A phonotactic constraint prohibits both geminates from occuring simultaneously. When a word such as 'package' is suffixed, the medial geminate

surfaces: [fitta-n]. When final mora deletion thrusts the medial geminate into word-final position, it is degeminated. Thus, the initial geminate may surface, satisfying the minimality requirement: [ffit]. Since a form with a single medial geminate cannot satisfy the minimality requirement, it must lengthen its remaining vowel: [taap].

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Regardless of the underlying form of the different noun types, the surface observations are the same. Nouns are subject to a minimality requirement. Since a word with the form CV: satisfies the requirement as well as CVCV, this requirement is most easily expressed in terms of moraic count (rather than e.g. syllable count or timing slots). Specifically, nouns must be bimoraic or larger in Chuukese. In the event that independent processes such as final mora deletion create a sub-minimal form, vowel lengthening occurs. Crucially, forms that have initial geminates and single short vowels do not exhibit this lengthening. Since a single short vowel is by definition monomoraic, it is concluded (following Davis and Torretta 1997, among others) that the initial geminate is contributing prosodic weight to the word.

The behavior of geminates with regard to the noun minimality requirement in Chuukese are accounted for in a straightforward manner under the assumption that geminates are moraic segments, even in word-initial position. A central claim of the Composite Model is that in some languages, geminates can be moraic regardless of their environment in the word (as compared to e.g. short consonants that are restricted to coda position when moraic). Chuukese provides a clear example of the language type predicted in the CM in which geminates are moraic in all positions, as shown by the facts of word minimality.

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Chunkese lacks syllable-based prosodic processes which would indicate whether the geminate's mora is associated to the syllable node or some higher prosodic category. As was discussed in chapter three, it is assumed that moras are generally prohibited from onset position³. Thus, (following Muller 1999) the mora associated to an initial geminate in Chunkese is assumed to be associated to a prosodic level other than the syllable, as demonstrated below. Crucially, it must be assumed that the mora is part of the phonological word, since it is shown that geminates contribute to the word minimality requirement (thus the mora may be associated to the word, or to the foot).

(10) Extraprosodic moras from initial geminates:



According to the claims of the CM, Chuukese is a language in which geminate consonants (multiply-linked single segments) satisfy the structural requirement for prosodic weight. As demonstrated below, a constraint that requires nouns to be minimally bimoraic is thus satisfied equally well by words with long vowels and those

³ Recall that evidence from stress assignment in Pattani Malay suggests that onset segments may be moraic.

with initial geminates. Crucially, it a form such as 'giant clam' satisfies the minimality requiement because the geminate is moraic, even in word-initial position.

(11) WORD MIN Nouns must be bimoraic

FREE MORA The morpheme final vowel must not be realized in absolute final position (following Davis and Torretta 1997)

| /fasa/ 'nest' | WORD MIN | FREE MORA |
|---------------|----------|-----------|
| 🖝 faas | | |
| fasa | | *! |
| fas | *! | |

| /ttoo/ 'giant clam' | WORD MIN | FREE MORA |
|---------------------|----------|-----------|
| 🕶 tto | | |
| ttoo | | *i |

5.1.3 Geminates as clusters

There is suggestive evidence from the diachronic and synchronic sources of geminates that indicates the Chuukese geminates comprise two timing slots. Diachronically, geminates are derived when consonants come into contact following vowel deletion (Dyen 1949). This is a well-attested process in Oceanic languages and is assumed to result in the preservation of both timing slots. There are no attested cases where vowel deletion results in the deletion of a remaining consonant, thus it is assumed that both are maintained and comprise two timing slots.

(12) Diachronic source of geminates:

 $CVCVCV \rightarrow CCVCV * \rightarrow CVCV$

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Synchronically, the creation of the present participle involves geminating a single consonant. Thus, pairs such as *fotu-ki* 'plant it' and *ffot* 'to be planted' are observed; furthermore, speakers indicate that the initial sounds are contrastive in such pairs. If this morphological processes is analyzed as the affixation of a single timing unit, or as the reduplication of a segment, then the resulting geminates are best treated as comprising two timing slots.

The provenance of geminates in Chuukese may be represented as in (13). Specifically, under the assumption that geminates are comprised of two timing slots, the facts regarding their derivation are easily reflected:

5.1.4 Geminates as single segments

The distribution of geminates and consonant clusters in Chuukese suggests that geminates are single segments. Consonant clusters are prohibited entirely, and when words containing clusters are borrowed from other languages, epenthesis is observed: [takisi] < taxi. If geminates were sequences of identical consonants, similar epenthesis would be expected: *tato, rather than [tto] 'sp. clam'. However, the geminates are treated as single segments for this process. If they were taken to be clusters, their immunity to epenthesis would be difficult to account for.

As in the analyses of geminates in chapter 4, the patterning of the Chuukese geminates with regard to epenthesis is accounted for as the result of their status a single, multiply-linked segment.

5.1.5 Alternative analyses

Naturally, the facts regarding noun minimality in Chuukese would be very difficult to describe in a framework that does not recognize abstract prosodic weight. Words with shapes such as CVV, CVCV, and CCV all pattern as a natural class in satisfying the minimality requirement. Under the assumption that vowels and geminate consonants are moraic, all of the minimal forms can also be described simply as being bimoraic.

However, the strong claims of moraic theory do not provide a sastisfactory account of Chuukese. As discussed in chapter three, under conventional moraic theory the default structure of geminates is an intervocalic, moraic segment, in which the mora is in the syllable coda. Following this claim, it may be concluded that non-coda geminates are not moraic. However, if this is maintained, the behavior of geminates with regard to noun minimality may not be accounted for in a straightforward manner.

Within the claims of the CM, geminates are posited to bear moraic structure regardless of their position in the word. Thus, they do not have to depend upon syllable structure, as implied within moraic theory. Furthermore, as was presented in Chapter 3, the explicit representation of timing slots in the representation of geminate consonants ensures multiple-linking, without relying upon stipulative syllabification rules. In summary, assuming both timing slots and prosodic weight units allows for a straightforward and explicit account of geminates in Chuukese.

5.2 Luganda

Luganda is a Bantu language spoken in Uganda and Tanzania. The data presented in this discussion come from written descriptions and discussion of the language (Ashton et al., 1954; Chesswas, 1963; Cole, 1976; Herbert, 1974; Snoxall, 1976, Clements, 1986; Katamba, 1985; Hubbard 1994), as well as limited consultation with a linguist who is a native Luganda speaker.

In an examination of the phonological timing relations of Luganda, Clements (1986) concludes that the behavior of geminates suggests that geminates are single, multiply-linked units that also bear a mora which serves as the tone-bearing unit (TBU). The evidence that strongly supports the analysis of the geminates as moraic comes from allomorphic variation as well as tone patterns, as will be illustrated in the following discussion. However, in this earlier work, the relationship between the phonological timing structure and the weight structure is merely stipulated rather than developed as a comprehensive model. Additionally, the actual location of the prosodic weight tier within the representation is an issue that is left unexplored.

The basic claims defended in Clements (1986) closely mirrors those defended in the current discussion, crucially that units of prosodic weight and length are simultaneously present in the representation of sounds. The discussion of the Luganda facts presented in this section thus is fundamentally similar to that in the earlier works. However, this discussion focusses primarily on how the facts of Luganda may be accounted for within the Composite Model. Specifically, it is shown that while the geminates may be considered single segments that are multiply-linked to two timing positions, they crucially must also be represented as moraic. The assumed representation of the Luganda geminates is illustrated below:

(14) Luganda geminates:



5.2.1 Background information

The consonant inventory of Luganda is as follows:

(15)

| | Bilabial | Labiodental | Alveolar | Palatal | Velar |
|-----------|--------------|--------------|---------------|--------------|------------|
| Stop | p b p: b: | | t d t: d: | с ј с: ј: | kg k:g: |
| Fricative | | f v f: v: | S Z. S: Z: | | |
| Nasal | m m: | | n n: | ្រ ្ភា: | ព្ ព្: |
| Lateral | | | l | | _ |
| Glide | w | | | У | |

All segments except the glides and the lateral tap /l/ may surface as geminate, in both word-initial and word-medial environment, as demonstrated in (16). As can be seen in group (b), verb step is may surface without any preceding vowel in the imperative form; in this environment, perfect minimal pairs that contrast initial consonant length are most easily identified.

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(17) Consonant length contrast:

| 'to open' | kùgúlá | 'to buy' |
|------------------------|--|---|
| 'to breathe' | kùsá | 'to grind' |
| 'stick' | mùgó | 'rim of a pot' |
| | | |
| 'open (imperative)' | gùlá | 'buy (imperative)' |
| 'breathe (imperative)' | sá | 'grind (imperative)' |
| 'at the back of the | mànjó | 'at the front' |
| house' | | |
| 'garbage dump' | gògóló | 'sledge' |
| | 'to open' 'to breathe' 'stick' 'open (imperative)' 'breathe (imperative)' 'at the back of the house' 'garbage dump' | 'to open'kùgúlá'to breathe'kùsá'stick'mùgó'open (imperative)'gùlá'breathe (imperative)'sá'at the back of themànjóhouse'gògóló |

Luganda does not allow consonant clusters. NC segments are found throughout the language but are commonly accepted as prenasalized consonants rather than sequences of segments, due to their behavior with regard to processes that target individual segments, such as the language game Ludikya, to be discussed below.

5.2.2 Tone processes

Compelling evidence that Luganda geminates bear moras, even in the word-initial environment, comes from tone assignment processes in the language. Essentially, geminate consonants interact in tone processes in the same way that vowels do, suggesting that they are moraic. In order to illustrate these processes, some background information regarding tone assignment in Luganda is warranted.

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Hyman, Katamba, and Walusimbi (1987) argue that words in Luganda are underlyingly marked only for high (H) tones; surface tone patterns may be H, L, or HL. Sandhi processes and phrasal tone assignment may obscure the lexical tone marking, as demonstrated in the examples in (18). In the first pair, the form 'he buys' surfaces in the present indicative form without any lexical H, as compared with the form 'he sees', which surfaces with a H. When same verb stems are prefixed with the first person plural marker /tu/, the tone patterns change. The prefix is H in both forms, indicating that /tu/ is underlyingly marked for H. The root 'to buy' (/gula/ is again toneless. However, the H in the root 'to see' (/lába/) is no longer evident:

(18) agula 'he buys' cf. alába 'he sees'
túgula 'we buy' túlaba 'we see' *túlába

Hyman et al. account for the tonal alternations in the 'buy' paradigm as the result of Meeusen's Rule, which prohibits adjacent H tones. Thus, the underlying H of /tú/, and the underlying H of the root 'to see' /lába/, are prohibited from surfacing simultaneously when the two morphemes are joined: túlaba, *túlába.

In addition to internal sandhi processes such as that described above, there is also a tone-spreading process that applies at the phrasal level. In this process, an intonational H tone spreads from the right edge of a phonological phrase, to any mora that is unmarked for tone, as shown in the illustration below. However, the spread is checked by the presence of a lexically assigned H tone as well as by the left edge of the phonological phrase. Basically, there must be a 'buffer' mora between the phrasal tone and the lexical tone, for between the phrasal tone and the left edge of the phrase, as demonstrated in (19).

(19) Phrasal H spread:



The effects of this phrasal H spread are illustrated in the different 'tone classes' proposed in Cole (1967). As shown below, the first class are ones which under Hyman et al.'s analysis are unmarked for lexical tone. As a result of phrasal H spreading, then, all of the syllables except the initial one are H.

(20) Stems unmarked for lexical tone: LHHH... pattern

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| mùgó | 'rim of pot' 3 | màtá | 'milk' 6 |
|------------|----------------|------------|------------|
| bùyá | 'game pit' 14 | kidé | 'bell' 7 |
| mùlímí | 'farmer' 1 | kimúli | 'flower' 7 |
| kùgúlú | 'leg' 15 | kitábó | 'book' 7 |
| mùlámúzi | 'judge' 1 | lùpápúlá | 'paper' 11 |
| kisánílizó | 'comb' 7 | kisúmúlúzó | 'key' 7 |

As stated, all of the forms in the preceding example are claimed to be underlyingly unmarked for lexical tone. Thus, the phrasal spread process is allowed to spread the H to all of the vowels except the first one, which serves as the 'buffer', as demonstrated below:





Interestingly, forms with initial geminates that are unmarked for lexical tone surface with a H on the initial vowel, as shown below:

(22) Initial geminate forms, unmarked for lexical tone

| bbégá | 'back' 5 | *bbègá |
|---------|--------------|----------|
| ggúlú | 'sky' 5 | *ggùlú |
| ddágálá | 'medicine' 5 | *ddàgálá |
| ssóméló | 'school' 5 | *ssòméló |

Following Hyman et al. (1987), it is assumed that the initial geminate of *bbégá* 'back' plays the same role as the initial vowel of *mulimi* 'farmer'; both block further spread of the phrasal H. As will be demonstrated at the end of this section, this pattern is accounted for in a straightforward manner under the assumption that geminate consonants bear a mora, even in word-initial position.

Medial geminates also act as buffers for tone assignment, illustrated by a verbal tone class in Clements (1986). In this class, the initial mora of the verb stem (actually the second mora in the verb, following the verbal prefix) is lexically marked as H. Thus, the syllable immediately following cannot bear the phrasal H tone, but later syllables may, resulting in a pattern of LHLH.... Examples illustrating this pattern are shown in (23). In each case, the assumed underlying lexical tone assignment is indicated, following various sources, including Snoxall 1967 and Cole 1967.

(23) Verb tone class: LHLHH...

| kùlábiká | 'to be visible' | *kùlábiká |
|------------------|--|-----------------|
| /kulábika/ | • · · · • | - |
| kùkwáàtá | 'to grasp' | *kùkwáátá |
| /kukúata/ | the second second second second second second second second second second second second second second second s | |
| kùlábirízá | to delay' | *kùlábírízá |
| /kulábiriza/ | 12. | |
| kùsitùkásitúká | 'to be restless' | *kùsítúkásítúká |
| /kusitukasituka/ | | |

In these examples, the medial L toned vowel serves as the 'buffer' between the lexical H of the verb root and the phrasal H tone. Interestingly, as shown below, medial geminate segments also serve as a buffer, allowing the lexical H and the phrasal H to surface on adjacent syllables. Again, assumed lexical tone assignments are indicated.

(24) Verbs with geminates:

| kùlinná | 'to climb' | *kùliŋŋà |
|---------------|-----------------|-------------|
| / kulinna/ | | |
| kùcóppá | 'to become | a * kùcóppà |
| /kucóppa/ | pauper' | |
| kùlippirirá | 'to trample on' | kùlíppirírá |
| /kulinnirira/ | | |

Just as with the initial geminates, the medial geminates appear to act as the 'buffer' between the lexical H and the phrasal H.

5.2.3 Morphological processes

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Additional evidence that the Luganda geminates are moraic comes from allomorphic variation that treates bimoraic stems differently than trimoraic (or larger) stems. For example, as presented in Clements (1986), evidence from the creation of the present perfect suggests that geminates are moraic. As shown in (25), in the formation of the perfect stem of the class of verbs in which the final consonant is /l/, roots with two moras or less exhibit one pattern while those with greater than two moras exhibit another. As demonstrated below, the present perfect form of the bimoraic stems surfaces with /ze/, while those with more than two moras, in (b), surface with /dde/. Crucially, the examples in (c) illustrate that a stem containing a geminate and two short vowels patterns with the trimoraic stems, suggesting that the geminate is moraic. In each example, the proposed stem is indicated in brackets.

(25) Creation of the present perfect

| a. bimoraic | stems | | |
|-------------|----------------------------------|-----------|-----------------------------|
| tubala | 'we count' | tubaze | 'we have counted' |
| /-bala/ | | | |
| tugula | 'we buy' | tugaze | 'we have bought' |
| /-gula/ | | - | |
| tweela | 'we sweep' | tweeze | 'we have swept' |
| /-ela/ | - | | - |
| b. trimorai | c stems | | |
| tutuula | 'we sit down' | tutudde | 'we have sat down' |
| /-tuula/ | | | |
| tusasula | 'we pay' | tusasudde | 'we have paid' |
| /-sasula/ | | | |
| tweesela | 'we water cattle' | tweesedde | 'we have watered cattle' |
| /-esela/ | | | |
| c. stems wi | ith geminates | | |
| tuggala | 'we shut' | tuggadde | 'we have shut' |
| /-ggala/ | | | |
| tujjula | 'we become filled up' | tujjudde | 'we have become filled up' |
| /-jjula/ | | | |
| tuttula | 'we beat patterns into mudcloth' | tuttudde | 'we have beat patterns into |
| /-ttula/ | | | mudcloth' |
| | | | |

Observation of reduplication patterns contribute additional support to the claim that Luganda geminates are moraic. As noted in Hyman and Katamba (1990), in verbal reduplication, a bimoraic verb stem exhibits vowel lengthening when reduplicated; those that have more than two moras do not. Crucially, geminates contribute to the prosodic weight of words, such that forms with geminates and short vowels pattern as trimoraic. In each case, the semantic effects of reduplication are to indicate action done repeatedly or frequently, some times with a pejorative connotation.

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(26) Verbal reduplication of bimoraic verb stems:

| kùbálá | 'to count' | kùbáláábálá | *kùbálábálá |
|-------------------|---------------|--------------|-------------|
| /-bala/ kùgúlá | to buy' | kùgúláágúlá | *kùgúlágúlá |
| /-gula/ kùlímá | to cultivate' | kùlimáálimá | |
| /-lima/ kùlábà | 'to see' | kùlábààlábà | |
| /-laba/ | 6 | 1 X # XX # X | |
| kutema /-tema/ | to chop | kutemaatema | |

Verb stems that contain at least three moras do not exhibit this lengthening, as demonstrated in the following examples.

(27) Verbal reduplication of stems with greater than two moras:

| kùlímá | 'to spy on' | kùlíimaliimá |
|-----------|-------------|----------------|
| /-liima/ | | |
| kùsásúlá | 'to pay' | kúsásúlásásúlá |
| /-sasula/ | | |
| kùléètá | 'to bring' | kùléètáléètá |
| /-leeta/ | | |

Crucially, verb stems containing geminates pattern with the trimoraic stems, as shown in (28).

(28) Verbal reduplication of stems with geminates:

| kubbira /bbira/ | 'to steal for' | kubbirabbira | *kubbiraabbira ⁴ |
|---------------------|------------------------------------|--------------|-----------------------------|
| kuddako /-ddako/ | 'to come next' | kuddakoddako | *kuddakooddako |
| kuggala /-ggala/ | 'to shut' | kuggalaggala | *kuggalaaggala |
| kukkuta /-kkuta/ | 'to be satisfied' | kukkutakkuta | |
| kummuka /-mmuka/ | 'to be lively' | kummukammuka | |
| kuttula /-ttula/ | 'to beat patterns into a mudcloth' | kuttulattula | |

Since the verb stems with geminates pattern with the trimoraic stems, and not with the bimoraic stems, it is possible to conclude that a form such as *ttula* is trimoraic. Similar to the creation of the present perfect, the behavior of forms with geminate consonants indicate that geminates are moraic in Luganda.

As was demonstrated by the facts of both tone assignment as well as allomorphic variation, the Luganda geminates behaved uniformly as moraic in both word-initial and word-medial environments. A central claim of the CM is that geminates may be moraic regardless of their environment in the word. Thus, the behavior of the Luganda geminates is accounted for in a straightforward manner within the CM.

For example, assuming a moraic geminate accounts for the 'buffer' effect observed in the interaction of lexical and phrasal high tones, as shown in (29). It is

⁴ One could argue that there is no vowel lengthening exhibited before the second geminate /bb/ in *kubbirabbira* due to a prohibition against long vowels before geminate consonants in this language. While it has often been claimed that vowels are shortened before geminates (see e.g. Clements 1986), there is in fact no phonological contrast between long and short vowels in this environment. Thus, it is unclear whether the observed shortening before geminates is due to low-level phonetic effects or to a phonological restriction.

shown in (a) that the initial vowel of a CVCVCV form provides the mora that serves as the 'buffer' between the spread of the phrasal H and the edge of the word. The second example demonstrates that the mora associated to an initial geminate consonant serves the same purpose. If the geminate were not moraic (as in the starred example), the tone pattern would be expected to be *bbega, instead of bbega. The examples in group (b) demonstrate that the presence of the mora in medial geminates obtains the same results.



(29) a. initial mora serving as buffer in unmarked nouns:



Medial mora serving as buffer in verbs with lexical H:

b.



Assuming that Luganda geminates are moraic also provides a coherent account for the allomorphic variation that is observed. Essentially, if geminates are moraic, the disparate treatment of different stems is accounted for as the result of prosodic weight: bimoraic stems pattern one way, trimoraic another.

(30) Patterning of verb stems for different processes:

| Present perfect suffix: | -ze suffix Bimoraic stems (CVCV) | -dde suffix Trimoraic stems (CVCVCV, CVCCV) |
|-------------------------|--|---|
| Reduplication: | vowel lengthening: Bimoraic stems (CVCV) | no vowel lengthening: Trimoraic stems (CVCVCV, CCVCV) |

5.2.4 Geminates as single segments

Phonological processes that target consonant quality treat geminate and singleton consonants identically, suggesting that geminates are single melodic units, rather than sequences of identical segments. For example, affixation of the present perfective suffix /ye/ results in fusion between the final consonant of the stem and the glide of the suffix. As shown below, the present form of the verb reflects the identity of the final consonant. Fusion with the perfective suffix yields a different segment, as demonstrated by the forms in (a). In the case of a voiced final consonant, the segment that surfaces is /z/, and in the case of a voiceless segment, the fused segment is /s/. Crucially, the forms in (b) illustrate that geminates are treated as single segments with regard to this process:

| (31) | present | present perfec | t | gloss |
|------|----------|----------------|----------|-----------|
| a. | twetaaga | twetaaza | | 'need |
| | tudduka | tuddusa | | 'run' |
| Ь. | tuyigga | tuyizza | *tuyigza | 'hunt' |
| | tukka | tuzza | *tukza | 'descend' |

Another process that illustrates that geminates behave as monolithic entities is palatalization. In this optional process, velar stops are realized as palatals when preceding the high front vowel /i/ or its glide counterpart /y/. Crucially, this process treats geminates and singleton consonants in the same manner:

(32) Palatalization (from Clements 1986) kiintu ~ ciintu 'thing'

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| bwoogi oluggi | ~ | bwooji olujji | 'sharpness' 'door' |
|------------------|-------------|--|-----------------------|
| . 1 8. | ند : میہ | | |
| | دوادید مد | and r an raak national National (¹¹²) | |
| | с. К | 1.2.2. | 191 |

A final process that indicates that geminates are single melodic units comes from the language game Ludikya. In this game, syllables are switched within a word. Thus, the word *kimuli* 'flower' is realized as *limuki*. When a word contains a geminate consonant, the melody of the consonant is switched: jjuba \rightarrow bbaju 'dove'. If the geminate in the target word were a sequence of two identical segments, rather than a single unit, the Ludikya word might be expected to surface as *jbaju, in which the segments have switched places. However, this does not occur.

The treatment of NC sequences in Ludikya indicates that these segments pattern as single units rather than sequences of segments. In this game, a word with NC transposes the nasalized segment without separating the nasal from the stop: bageenda \rightarrow ndageeba 'the are going' *dageemba.

In summary, the geminates in Luganda pattern as single segments rather than sequences of segments with regard to consonant fusion, palatalization and the language game Ludikya. These facts are accounted for under the assumption that the geminates are single segments rather than sequences of identical clusters.

5.2.5 Geminates as clusters

Luganda does not permit consonant clusters; as mentioned earlier, the NC sequences observed in the language are assumed to be prenasalized consonants, rather than consonant clusters. Due to the lack of consonant clusters, it is difficult to find direct evidence that geminates pattern like sequences of consonants rather than as single segments. Since there is no basis for comparison (unlike in Leti or Cypriot Greek) there

is no way to conclude definitively that geminates comprise two timing slots. However, there are observations that are suggestive of the fact that geminates in Luganda comprise more than one timing slot. These observations come from the realms of phonetics, synchronic facts regarding the derivation of some geminates, and reported syllabification patterns.

Although it is maintained in this dissertation that acoustic features do not directly indicate phonological structure (see chapter two; cf. Ham 1998), it is claimed that there exists a relationship between the relative duration of segments and the number of timing slots they are associated to. Very simply, a segment that is associated to two timing slots will be longer in duration than one which is associated to a single timing slot, all things being equal.

In an investigation of the word-medial geminates in Luganda, Herbert (1976) reports that the closure duration of geminate /t:/ and /k:/ is more than twice as long as those of their singleton counterparts (/t/ = 93 ms.; /t:/ = 235 ms.; /k/ = 98 ms.; /k:/ = 226 ms.)⁵. This difference in duration may reflect the phonological structure of the two types of segments: geminates are longer since they are linked to two timing slots, while singletons are relatively shorter since they are linked to one. Again, the absolute durations do not directly indicate phonological structure, but the evidence is suggestive.

The possibility that longer duration is correlated with multiple timing-slot association is also supported by the facts of Cypriot Greek. As was shown in chapter

⁵ Unfortunately, it is impossible to determine if the reported measurements exhibit variation that is statistically significant. Also, it is unclear why the bilabial stops were excluded from this investigation. However, the point still holds: the geminates are longer than the singletons.

two, the Cypriot geminates are significantly longer than the singleton consonants in environments where that feature could be measured (recall that the duration of absolute initial voiceless stops is impossible to discern). As was also shown in chapter four, the similar patterning of geminates and clusters in Cypriot indicates that these segments are best represented as single segments that are multiply-linked to two timing slots; a purely moraic representation did not allow for a coherent account of the facts. Thus, in Cypriot Greek, the geminates are found to be both-longer in terms of duration, as well as multiply-linked in terms of phonological representation. While it is impossible to establish a direct correlation, it is plausible that it exists. Thus, while phonetic evidence alone is insufficient as evidence for a phonological structure, taken together with phonological facts, it provides supporting evidence.

Additional suggestive evidence that the Luganda geminates are associated to two timing slots comes from their synchronic source. As shown in the examples in (33), some initial geminates arise due to assimilation of a root-initial segment to a nasal prefix (either the class 10 prefix or the first person singular subject prefix). When the nasal prefix precedes a word that begins with a nasal, the segment is assimilated, resulting in a geminate consonant, as indicated.

(33) Assimilation leading to geminates:

a. /N-/ (class 10 plural prefix) assimilating to initial nasal of noun root, resulting in geminate (tone markings following Cole 1967):

| lùmúlí | 'reed' 11 | mmúli | 'reeds' 10 |
|---------|------------------|--------|-------------------|
| lùnákù | 'day' 11 | nnáku | 'days' 10 |
| lùnyágó | 'spear shaft' 11 | nnyágó | 'spear shafts' 10 |

b. /N-/ first person sg. subject prefix assimilates with verb-root initial nasals resulting in geminates:

| kùmálá | 'to complete' | mmálá | 'I complete' |
|----------|-----------------|---------|----------------|
| kùnóònyá | 'to seek' | nnóònyá | 'I seek' |
| kùŋóólá | 'to disapprove' | ŋŋóólá | 'I disapprove' |

It is possible to infer that the result of contact between the nasal prefix and a word-initial nasal is a unit that comprises two timing slots (as opposed to a segment which is linked to just one timing unit) by looking at the behavior of words that do not contain initial nasals in the same environment. As demonstrated below, when a nasal prefix is followed by a word with an initial non-nasal segment, an NC sequence results.

(34)

| lùti | 'skewer' 11 | nti - | 'skewers' 10 |
|---------|-------------|--------|--------------|
| lùfúmó | 'legend' 11 | ìfúmó | 'legends' 10 |
| kùvúbá | 'to fish' | nvúbá | 'I fish' |
| kùfúmbá | 'to cook' | ìfúmbá | 'I cook' |

Since an NC sequence is the result of the nasal prefix preceding a non-nasal consonant, it is clear that both consonants involved are being maintained. In other words, a/N + C/ sequence yields [NC] in the surface form, indicating that there is not deletion of one of the units. Thus, it follows that a sequence of /N + N/ is realized as [NN] on the surface, crucially, a sequence that comprises two timing slots.

5.2.6 Alternative analyses

Naturally, the behavior of geminates in Luganda would be difficult to characterize without the theoretical generalizations offered by the moraic model. Similar to the discussion of Chuukese, it is apparent that being able to refer to a class of stems grouped according to their prosodic weight (e.g. calling CVCVCV and CCVCV stems trimoraic) is superior to referring to a class that does not share any characteristics (e.g. referring to a disparate group such as 'trisyllabic, and bisyllabic with geminates'). Furthermore, the assumption that the mora serves as the TBU enjoys a well-supported role in the study of tone languages; the patterning of geminates with regard to tone processes (even word-initial geminates) provides further support for their status as moraic. Under any account that does not allow word-initial moraic geminates, the patterns would be difficult to account for.

As presented in depth in chapter three, as well as in the discussion of Chuukese, the assumption that timing slots are also present in the representation of geminate consonants allows for the explicit syllabification of geminate consonants, a particular advantage with regard to non-intervocalic segments. Thus, although timing slots are not crucially needed in accounting for the patterning of geminates (unlike languages such as Leti or Cypriot Greek), the presence of timing slots does at least allow for a coherent description of some patterns.

5.3 Summary

In conclusion, Chuukese and Luganda both provide compelling evidence that geminate consonants may be moraic even in word-initial position. As was demonstrated, the facts of these languages are accounted for in a straightforward manner in a framework that recognizes the moraic status of initial geminates.

While the initial geminates are shown to be moraic, there is no compelling evidence that the mora of initial geminates is in the syllable onset in either language. However, by drawing upon the concept of extrametricality, the mora may be accomodated within the prosodic structure, without violating the well-supported prohibition against moraic onsets. In the absence of evidence suggesting that onsets are moraic, I assume that the mora associated to the initial geminates in these languages is extrametrical.

As was also shown, both languages provide suggestive but not conclusive evidence that the geminates comprise two timing slots (this is due mainly to the lack of consonant clusters in both languages). While the assumption of explicit timing slots are not crucial to the account of either language, they do allow for non-stipulative assumptions about syllable structure. Since the CM posits that timing slots are present universally, this outcome is thus desireable.

Crucially, the comparison of the languages discussed in the present chapter and those of chapter four provide support for another claim of the CM: prosodic weight is not universally assigned to geminate consonants. The claim that Luganda and Chuukese geminates are moraic is well-supported here; the claim that geminates are light is equally well supported by the facts of Leti, and strongly suggested by the facts of Cypriot Greek. This diverse pattern is best accounted for in a model that does not stringently require that geminates be moraic, but rather acknowledges the diversity of individual languages, such as the Composite Model.
CHAPTER 6

DIRECTIONS FOR FUTURE RESEARCH

6.1 Phonology

An issue that merits, future investigation is the question of whether moraic geminate consonants are syllable-initial. As was presented in chapter three, the assumed representation of word-initial moraic geminates in Chuukese treats the mora as extrasyllabic, in order to avoid a moraic syllable onset. Such a representation is viable since there is no evidence suggesting that the mora must be in the syllable onset in this language (or in Luganda, which was also shown to have moraic word-initial geminates). As was also presented, Pattani Malay is a potential example of a language that gives evidence for moraic onsets. Additional research may confirm this possibility.

The claim that there is a small, restricted set of constraints that dictate mora assignment also predicts various situations that are worthy of future research. As was outlined in chapter three, the harmonic rankings predict languages such as Leti, in which only vowels are moraic, or Luganda in which vowels and geminates may be moraic, even when those geminates are in word-initial position; the other languages included in this study are also predicted within this set of constraints. The final language type that is predicted is attested by Thurgovian Swiss, in which vowels and coda consonants (including geminate codas) contribute to prosodic weight, while initial geminates are non-moraic. Future research on languages with initial geminates may provide further support for the model by providing additional examples of the predicted language types.

There are a-number of language families that appear to be fertile ground for future research. For example, many varieties of Arabic have initial geminates that arise via morpheme concatenation (similar to the pattern illustrated in chapter one for Moroccan Arabic); many varieties of Arabic also have quantity-sensitive stress assignment as well as morphological processes that target templates based on prosodic weight. Thus, it may be possible to further test the hypothesis that moraic geminates can occur in the onset (if, for example, a syllable of the form CCVC is treated as heavy for stress assignment or some other prosodic process). Other language families that are ripe for additional study include Austronesian, and Bantu. Both of these families include languages with initial geminates and are rich with morphophonemic processes that evaluate syllable weight (such as reduplication in Leti) thus providing an ideal testing ground for the claims regarding variable prosodic weight of geminates. Furthermore, tone processes found throughout Bantu languages (such as those of Luganda) also provide opportunities to evaluate the patterning of initial geminates.

There are a number of predications based on the claim that both weight and length are present in prosodic representation, as presented in Hume et al. (1997). Crucially, it is predicted that for any process that targets both weight and length, only segments that are long and contribute a mora will be affected. In a language where consonants are not moraic, only syllables with long vowels are both long and heavy. In a language that allows moraic consonants, a syllable with a long vowel or a geminate is both long and heavy, and so these two syllable types would be expected to pattern alike. While Ossetic is a potential testament to this prediction (de Lacy 1997), future research is needed to verify this claim.

6.2 Phonetics

As demonstrated in chapter two, the investigation of geminates in Cypriot Greek illustrates that geminates are longer than their singleton counterparts, and crucially they also have an additional acoustic cue that identifies them (VOT). As was outlined, these results differ significantly from those found in Pattani Malay, in which other acoustic cues such as RMS amplitude are indicators of geminates, while VOT plays no significant role (Abramson 1999 and references therein). It is concluded that these conflicting results indicate that there is no universal secondary cue for geminates, and it is speculated that segmental inventory may affect the 'availability' of acoustic cues. Future research on other languages with initial geminates will allow for this speculation to be tested. Specifically, a cross-linguistic study of the acoustic features of initial geminates along with the features of the segmental inventory will allow for more accurate statements regarding the role of acoustic cues.

Related to the question of identifying secondary cues in different languages is that of whether listeners are able to utilize these cues to identify consonant length contrasts in languages other than their own. For example, Abramson 1999 (and references therein) claims that Pattani Malay listeners use pitch and amplitude differences to identify geminates in their own language. Although the results reported in chapter two suggest the VOT is the most salient cue of initial geminate stops for Cypriot Greek listeners, pitch and amplitude were not investigated. It is possible that these cues are used along with VOT to help identify initial geminates. If that is true, then it is also possible that a speaker of one language may be able to utilize these cues to identify geminates in another language. Cross-linguistic perception experiments would test this hypothesis.

Another topic for future research pertaining to the articulation of initial geminates relates to duration. As outlined in chapter two, it was shown that medial geminate stops are longer than their singleton counterparts, and geminate fricatives are longer than singleton fricatives in all environments. Due to the lack of vocal cord vibration preceding and during the articulation of a word-initial stop, it is impossible to determine their duration.

Since increased VOT plays such an important role in identifying initial geminates in Cypriot Greek, while duration is indistinguishable, it is possible to speculate that speakers do not 'need' to produce initial geminates with longer duration but rather focus only on the salient VOT difference. Alternatively, it is possible to posit that speakers produce geminates with the same duration of articulation regardless of their environment in the word. To refute or verify either of these claims, future research involving palatograms of actual geminate production will be necessary.

A final issue related to the phonetic characteristics of geminate consonants bears on other types of phonological or phonetic contrast. Specifically, it has been posited that the fortis-lenis phonation type contrast in Korean is actually due to the fact that fortis consonants are geminates, primarily since the fortis consonants are found to be significantly longer than the lenis ones (Han 1992). While phonological evidence demonstrates that this analysis is incorrect (Oh and Odden 1997), the similarity of acoustic features between fortis consonants and geminates is intriguing. Furthermore, the analysis of other languages that are posited to have the fortis-lenis contrast are shown to be better analyzed as having a consonant length or weight contrast (e.g. Carlyle 1988 for Breton). Thus, it seems likely that future investigation of languages that are purported to have this type of phonation contrast may in fact prove to be languages with geminate/singleton contrasts.

The research discussed in this dissertation represents a first attempt towards elucidating the phonological and phonetic nature of geminates in word-initial position, and creating testable hypotheses regarding these segments. It is hoped that additional research on languages with initial geminates will shed light on the topic and thus help to further the basic goal of phonological and phonetic investigation: to understand how contrast is encoded and manifested in human language.

APPENDIX A: SURVEY OF LANGUAGES WITH INITIAL GEMINATES

Included in this appendix are surveys of over two dozen languages which are reported to have word-initial geminates¹. A cursory examination of the languages included here reveal diverse patterns of distribution. For example, in some languages, geminates are restricted to a single class of segments, as in Kiribati which only allows nasal geminates. In other languages, such as Moroccan Arabic, the entire segment inventory (including, obstruents, sonorants, glides, etc.) may be geminated. There are also diverse patterns regarding the environment of geminates in these languages. For example, Sa'ban allows geminates only in word-initial position, while Tamazight Berber allows geminates to surface word-initially, word-finally, intervocalically, and in consonant clusters. In other languages, there are restrictions on geminates in word-initial position, as compared to word-medial position. For example, in Hatoma, voiceless obstruent and nasal geminates are found word-medially. However, only continuants may be geminated in word-initial position.

¹ Bantu languages which only exhibit initial geminate nasals as the result of morpheme concatenation are omitted, since they represent an invariant pattern. Such languages include Kerewe, Runyankore, Zinza, Haya, Jita, Ruri, Nyambo, Hehe, Kimatuumbi, Makonde, Yao, Mwera, Ndengerko, Rufiji, Ngindo, Makua, Lomwe, Echuabo, Efik, Kenyan, Ewe, Ga, and Kono. In each of these languages, the only initial geminates which are observed are those arising from /N + N across morpheme boundaries.

Future research on the typological patterns exhibited by languages with initial geminates may be compared to similar studies of medial geminates (e.g. Thurgood 1993) in order to establish if there are any implicational relationships evident in the patterns. For example, as was claimed in Muller (1999), the presence of a word-initial geminate in a given language implies that medial geminates are also present in that language. However, the evidence from Sa'ban appears to falsify that claim. Further investigation of the geminate inventory of these languages will also reveal if there are any universal preferences with regard to segment type. For example, as claimed in Jaeger (1978), voiceless geminate stops should be preferred over voiced ones, due to aerodynamic concerns. A preliminary survey of the languages included here suggests that this prediction may be borne out, since voiceless geminate stops appear to be more common than their voiced counterparts, even in languages with voiced and voiceless singleton stops. For example, Hatoma has singleton /p, t, k/ and /b, d, g/. However, only the voiceless stops may surface as geminates. Whether this apparent preference represents a universal pattern remains an empirical issue.

The entry for each language is laid out as follows. Explanatory notes are included in italics.

Name (General, specific language families) \leftarrow classification according to Summer Institute of Linguistics Ethnologue.

Consonant inventory: phonemes are indicated; consonants with secondary articulation are noted in the class of their major articulation. Thus, Chuukese /p/ and /p^w/ are both indicated in the bilabial voiceless stop cell.

Classes of geminates observed: types of geminates found in any environment

and the second second

Word-environment distribution: which geminates are found in which environment: word-initially, word-medially, word-finally, or in a consonant cluster

Other:

- Vowel length contrast: does the language exhibit vowel length contrast
- Consonant clusters: does the language allow heterorganic consonant clusters

Notes: any interesting facts or observations related to geminates

References: pertinent references on language.



Atepec Zapotec (Otomanguean, Zapotecan)

Consonant inventory:

| | Bilabial | Labiodental | Interdental | Alveolar | Palatal | Velar | Glottal |
|-----------|----------|------------------|-------------|-----------|-------------|---------------------------|---------|
| Stop | P | * * * * * * * | | t t: | | k k ^w k: | ? |
| Fricative | β | f | θð | | \$\$. \$ | \$ \$ | |
| Affricate | | | | ts ts: | č | | |
| Nasal | | | | n n: | | | |
| Lateral | | | | I I: | | | |
| Retroflex | | | | r | | | |
| Glide | w | | | | У | | |

Classes of geminates observed: stop, affricate, sonorant

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|------------------|-------------|------------|-------------------|
| stops, sonorants | all | no | no |

Other:

- Vowel length contrast: no

- Consonant clusters: restricted to medial position

Notes: initial geminates rare

References: Nellis, Neil and Jane Goodner Nellis. 1983. *Diccionario Zapoteco de Jurez: Ca Titsá Quí Ríu*. Serie de Vocabularios y Diccionarios Indigenas "Mariano Silva y Aceves" Num. 27. Mexico: Summer Institute of Linguistics.

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Bernese Swiss

(Indo-European, Germanic)

Consonant inventory:

| | Bilabial | Labiodental | Alveolar | Palatal | Velar | Glottal |
|-----------|--------------|-------------|--------------|-----------|--------------|---------|
| Stop | թ Ե p: b: | | t d t: d: | | k g k: g: | ? |
| Fricative | | fv f: | SZ S: | š š: | x x: | h |
| Affricate | pf pf: | | ts ts: | tš tš: | kx kx: | |
| Nasal | m m: | | n n: | | ຫຼ ະ | |
| Lateral | | | 1 | | | |
| Retroflex | | | r | | | |
| Glide | w w: | | | j | | |

Classes of geminates observed: stop, fricative, affricate, nasal, glide

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| voiced stops | all | all | none |

Other:

- Vowel length contrast: yes

- Consonant clusters: yes

Notes: Initial geminates are morphologically derived in one verb tense.

References: Ham, W. 1998. *Phonetic and phonological aspects of geminate timing*. PhD. dissertation, Cornell University.

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Breton (Indo-European, Celtic)

ه پ^{ور} در در هو

in the second second second second second second second second second second second second second second second

Consonant inventory:

| | Bilabial | Labiodental | Interdental | Alveolar | Palatal | Velar | Glottal |
|-----------|----------|-------------|-------------|------------------|---------|-------|---------|
| Stop | b | | | đ | | g | |
| | p: b: | | | t: | | k: | |
| Fricative | | v | | z | ž | r | |
| | | f: v: | | S: | š: | x: | |
| Affricate | | | | | | | |
| | | | | | | | |
| Nasal | | | | n | ļ | | |
| | m: | | | n: | л: | | |
| Lateral | | | | I | | | |
| | | | | Ŀ | | | |
| | | | | l ^y : | | | |
| Retroflex | | | | r | | | |
| | | | | r: | | | |
| Glide | | | | | | | |
| | | | 1 | | | | |

Classes of geminates observed: obstruent, sonorant

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| all | all | ? | no |

Other:

- Vowel length contrast: no

- Consonant clusters: yes

Notes: The geminate counterparts of voiced obstruents are voiceless, reflecting the cross-linguistic preference for voiceless geminates; voiced geminates do not have singleton counterparts

References: Carlyle, K. 1988. A syllabic phonology of Breton. PhD. dissertation, University of Toronto.

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Chuukese (a.k.a. Trukese)

(Austronesian, Mirconesian)

Bilabial Labiodentall Alveolar Palatal Velar Stop k ₽ p^w t k: t: p: p^w: Fricative f s f: s: Affricate č č: Nasal m n ŋ m‴ n: ŋ: m: m^w: Lateral I Retroflex r r: Glide w i

Consonant inventory:

Classes of geminates observed: stop, fricative, affricate, nasal, retroflex

-1

Word-environment distribution:

| <u>Word-initial</u> | Word-medial | Word-final | Consonant cluster |
|---------------------|-------------|--------------------|-------------------|
| all | all | no final geminates | No clusters |
| | - | | |

Other:

- Vowel length contrast: yes

- Consonant clusters: no

Notes: Many borrowed words are borrowed with initial geminates e.g. mmak 'writing' from English 'mark'

References: Goodenough, W. and H. Sugita. 1980. *Trukese-English dictionary*. American Philosophical Society. Philadelphia. Muller, J. 1998. Field notes, Chuuk



Circassian (Caucasian, Northwest)

Consonant inventory:

| | Bilabial | Alveolar | Palatal | Velar | Uvular | Pharyngeal | Glottal |
|-----------|---|---|---|---|--------------------------------------|------------|---------|
| Stop | p b p' p ^w p: b: p': | t d t' t ^w t: d: t': | с ј с' | k g k'g ^w k ^w | q q ^w | | ? 2₩ |
| Fricative | ф ф ^w | S Z S' S: S: S': | ž ž ž ž ž ž ž ž ž ž ž ž ž ž ž ž ž | XY | Х _м ^R м Х R | ħ | |
| Affricate | | | čj č' | | | | |
| Nasal | m | n | | | | | |
| Lateral | | t l t ^w | | | | | |
| Retroflex | | r | | | | | |
| Glide | w | | | | | | |

·∼, ne, r

Classes of geminates observed: bilabial stop, alveolar stop and fricative

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| all | all | ? | yes |

Other:

- Vowel length contrast: no

- Consonant clusters: yes

Notes: C' indicates glottalized stops.

References: Smeets, H. 1984. Studies in West Circassian phonology and morphology. The Hakuchi Press, Leiden.

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Cypriot Greek (Indo-European, Greek)

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Consonant inventory:

| - | Bilabial | Labiodental | Interdental | Alveolar | Alveopalatal | Palatal | Velar |
|-----------|----------|-------------------------|-------------|----------|--------------|---------|-------|
| Stop | P. | | | t | Ķ | | k |
| | p: | n and the second second | | t: | ķ: | | k: |
| Fricative | 4 | * f | θð | SZ | | šž | ХŶ |
| | | -f | θ: | s: z: | | š: ž: | x: |
| Affricate | | | | | | č | |
| | | | | | | č: | |
| Nasal | m | | | n | | | |
| | m: | | | n: | | | |
| Lateral | | | | 1 | | | |
| | | | | l: | | | |
| Retroflex | | | | r | | | |
| | | | | r: | | | |
| Glide | | | | | | У | |
| | | | | 1 | | | |

Classes of geminates observed: stop, fricative, affricate, nasal, liquid

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------------|-------------|------------|-------------------|
| stops, nasals, | All | None | None |
| liquids, voiceless | | | |
| fricatives | | | |

Other:

- Vowel length contrast: no

- Consonant clusters: exhibit same distribution as geminates

References: Newton, B. 1972. Cypriot Greek: its phonology and inflections. Mouton, the Hague.

Cypriot Maronite Arabic (Afro-Asiatic, Semitic)

State (Liter),

| | Bilabial | Labiodental | Interdental | Alveolar | Palatal | Velar | Pharyngeal |
|-----------|----------|-------------|-------------|----------|---------|-------|------------|
| Stop | р | | 77 | t | | k | |
| | p: | | | t: d: | | k: | |
| Fricative | | f v | θð | S Z | šž | x | 2 |
| | | f: v: | θ: ð: | S: Z: | š: ž: | x: | |
| Affricate | | | | | | | |
| Nasal | m | | | n | | | |
| | m: | | | n: | | | |
| Lateral | | | | 1 | | | |
| | l | | | l: | | | |
| Retroflex | | | | r | | | |
| | | | | r: | | | |
| Glide | | | | | у | | |
| | | | | ļ | y: | 1 | |

Consonant inventory:

Classes of geminates observed: stop, fricative, nasal, liquid, glide

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| all | all | ? | yes |

Other:

- Vowel length contrast: No

- Consonant clusters: Allowed throughout the language

Notes: The stop voicing opposition has been lost in all cases except for t:/d:.

References: Borg, Alexander. 1985. *Cypriot Arabic*. Abhandlungen fur die kunde des morgenlandes. Kommissionsverlag Franz Steiner Wiesbaden. Stuttgart.



Dobel (Austronesian, Malayo-Polynesian)

Consonant inventory:

| | Bilabial | Labiodental | Interdental | Alveol | ar | Palatal | Velar | Glottal |
|-----------|----------|-------------|-------------|--------|----|-------------|-------|---------|
| Stop | b | | | t | d | | k | ? |
| | b: | | | t: | | - - - | k: | ?: |
| Fricative | ф. | | | S | | | | |
| | | | | S: | | | | |
| Affricate | | | | | | | | |
| Nasal | m | | | 1 | n | | ŋ | |
| | | | | 1 | n: | | | |
| Lateral | | | | | 1 | | | |
| | • | 1 | | | l: | | | |
| Retroflex | | | | | ſ | | | |
| | | | | | _ | | | |
| Glide | w | | | | | у | | |
| 1 | | | | | | y: | | |

Classes of geminates observed: stop, fricative, nasal, glide

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| all | all | none | none |

Other:

- Vowel length contrast: no

- Consonant clusters: yes

References:

Hughes, Jock. 1995. Dobel. Comparative Austronesian Dictionary. Darrell T. Tyron, ed. Mouton de Gruyter. Berlin, New York.

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Hatam (West Papuan)

Consonant inventory:

| | Bilabial | Alveolar | Palatal | Velar | Glottal |
|-----------|--------------|----------|-----------|--------------|---------|
| Stop | p b p: b: | td t: | c j j: | k g k: g: | |
| Fricative | | S | | | h |
| Nasal | m m: | n n: | n | ŋ | |
| Lateral | | | | | |
| Tap/flap | | r l: | | | |
| Glide | w | | У | | |

Classes of geminates observed: stop, nasal, liquid

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| all | all | N/A | preceded by nasal |
| | | | consonant |

Other:

- Vowel length contrast: no

- Consonant clusters: NC clusters, Cr clusters as onsets, limited CC clusters elsewhere

Notes: syllabic nasals occur in word-initial position

References:

Reesnik, Ger P. 1999. A grammar of Hatam Bird's Head Peninsula, Irian Jaya. Pacific Linguistics. Research school of Pacific and Asian Studies. The Australian National University. Canberra.

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Hatoma (Japanese Ryukuan

Consonant inventory:

| | Bilabial | Labiodental | Interdental | Alveolar | Palatal | Velar | Glottal |
|-----------|----------|-------------|-------------|----------|---------|-------|---------|
| Stop | рb | | | t d | | k g | |
| | p: | | | t: | | k: | |
| Fricative | | f | | S Z | | | |
| | | f: | | S: | | | |
| Affricate | | | | | čĭ | | |
| | : | | | | č: | | |
| Nasal | m | | | n | | | |
| | | | | n: | | | |
| Lateral | | | | | | | |
| Retroflex | | | | r | | | |
| Glide | | | | | | | |

Classes of geminates observed: voiceless fricative, nasal, stop, affricate

Word-environment distribution:

Word-initialWord-medialWord-finalConsonant clustervoiceless fricativesvoiceless fricativesnonenonenasalsvoiceless stopsnasalsaffricate

Other:

- Vowel length contrast: Yes

- Consonant clusters: None

Notes: Only continuants can be geminate in initial position.

References:

Lawrence, Wayne. ms. *Hatoma wordlist*. Lawrence, Wayne. pc.

Kiribati (Austronesian, Micronesian)

Consonant inventory:

| | Bilabial | Alveolar | Palatal | Velar |
|-----------|---|----------|----------------|----------|
| Stop | b b [₩] | t | 3.2 . 2 - 2 | k |
| Nasal | m m ^w m: m ^w : | n n: | | ŋ |
| Lateral | | | | |
| Retroflex | | r | | |
| Glide | w | | | |

Classes of geminates observed: nasal

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| all | all | none | none |

Other:

- Vowel length contrast: yes

- Consonant clusters: NC clusters only

Notes: Harrison (1995) notes that evidence from a minimality requirement in the langauge indicates that initial geminates are moraic, similar to Chuukese.

References:

Groves, T., G. Groves, and R. Jacobs. 1985. Kirbatese: an outline description. Pacific Linguistics Series D. #64. Australian National University.

Harrison, S. 1995. Kiribati. Comparative Austronesian Dictionary. Darrell T. Tyron, ed. Mouton de Gruyter. Berlin, New York.

Lak (Caucasian, Northeast)

Consonant inventory:

| | Bilabial | Labiodental | Alveolar | Palatal | Velar | Uvular | Glottal |
|-----------|------------------|-------------|------------|---------------|----------------|------------|---------|
| Stop | p b' p' p: | | t d , t | с с' с: | kg k' k: | q q' q: | ? |
| Fricative | | ÷ | SZ S: | š ž š: | x x: | Х: Х к | h |
| Affricate | | | | č č' č: | | | |
| Nasal | m | | n | | | | |
| Lateral | | | 1 | | | | |
| Retroflex | | | r | | | | |
| Glide | w | | | У | | | |

Classes of geminates observed: stop, fricative, affricate

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| all | all | none | none |

Other:

- Vowel length contrast: No

- Consonant clusters: disallowed in word initial position.

Notes: Geminate sonorants only arise word-medially as the result of assimilation across morpheme boundaries. Borrowed words from Russian exhibit initial geminates. Phonological process of palatalization indicates phonological status as single segment.

References: Anderson, G. 1997. Lak Phonology. In *Phonologies of Asia and Africa* (*including the Caucasus*). Alan S. Key, ed. Eisenbrauns, Winona Lake, Indiana.

Leti (Austronesian, Southwest Maluku)

이 지원 경찰과 비행을 한 것을 것 같을까?

Consonant inventory:

| | Bilabial | Alveolar | Velar |
|-----------|----------|----------|-------|
| Stop | Р | td | k |
| | p: | t: | k: |
| Fricative | β | S | |
| | | s: | |
| Nasal | m | n | |
| | m: | n: | |
| Lateral | | 1 | |
| | | l: | |
| Retroflex | | r | |
| | | r: | |

Classes of geminates observed: stop, nasal, liquid

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|---------------|------------|-------------------|
| all | all (but only | No | No |
| | derived) | | |

Other:

- Vowel length contrast: no; long vowels are only derived

- Consonant clusters: only found word-initially underlyingly; otherwise all derived

References: van Engelenhoven, A. 1995. A description of the Leti language (as spoken in Tutukei). PhD dissertation, Leiden.

Hume, E., J. Muller and A. van Engelenhoven 1997. Non-moraic geminates in Leti. *Phonology 14.*

Logbara (Central Sudanic - Ma'di)

Consonant inventory:

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| | Bilab | ial | Labio | dental | Labiov | velar | Alve | olar | Palatal | Vela | r | Glottal |
|-----------|-------|---------|-------|--------|--------|-------|----------|----------------|---------|------|---|---------|
| Stop | р | b b: | | gb | kp | gb | t | d d: | | k | g | ? |
| Fricative | φ | | f | v | | | S | Z | | | | h |
| Affricate | | | | | | | ts | dz | | | | |
| Nasal | | m | | | mbn | g | n n:² | | ŗ | | ŋ | |
| Lateral | | | | | | | | l <u>l:</u> | | | | |
| Retroflex | | | | | | | | r | | | | |
| Glide | | N | | | | | | | У | | | |

Classes of geminates observed: Voiced stop, nasal, lateral

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|------------------|------------------------|------------|-------------------|
| stops and nasals | stops, nasals, lateral | no | no |

Other:

- Vowel length contrast: yes

• Consonant clusters: NC, labio-velars, stop-liquid, stop-fricative. No stop-stop clusters

Notes: Not included in typological survey due to insufficient data on geminates

References: Crazzolara, J. P. 1960. A study of the Logbara (Ma'di) language; grammar and vocabulary. International African Institute. Oxford University Press.

² It is unclear whether the initial geminate /n/ noted in Crazzolara is a sequence of syllabic nasal plus onset nasal, or a single long segment. Geminate /n/ is not observed elsewhere.

Luganda (Niger-Congo, Bantu)

| | Bilabial | Labiodental | Alveolar | Palatal | Velar |
|-----------|--------------|--------------|--------------|-------------------------|------------|
| Stop | p b p: b: | | t d t: d: | с ј с: ј: | kg k:g: |
| Fricative | | f v f: v: | S Z S: Z: | | |
| Nasal | m m: | | n n: | ர ர: | ŋ ŋ: |
| Lateral | | | I | | |
| Glide | w | | | У | |

Consonant inventory:

Classes of geminates observed: stop, fricative, nasal

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| all | all | none | none |

Other:

- Vowel length contrast: yes

- Consonant clusters: no

Notes: The geminate counterparts of /l/, /w/ and /y/ are obstruentized as /d:/, /g:/ and /j:/

References: Cole, D. 1967. *Some features of Ganda linguistic structure*. Witwatersrand University Press, Johannesburg.

Moroccan Arabic (Afro-Asiatic, Semitic)

Consonant inventory:

| | Bilabial | Alveolar | Palatal | Velar | Uvular | Pharyngeal | Laryngeal |
|-----------|----------|------------------|---------|------------|---------|------------|-----------|
| Stop | b b | t/t d/d t: d: | | kg k:g: | q a: | | |
| Fricative | f | s/ş z/z | š ž | er gr | x y | <u>ከ</u> | h |
| Affricate | | 3. 3. | č. | | х. ү. | ш. т. | |
| Nasal | m m: | n n: | | | | | |
| Lateral | ÷۲ د | - l l: | | | | | |
| Retroflex | | r: | | | | | |
| Glide | w w: | | j j: | | | | |

Classes of geminates observed: Stop, fricative, nasal, liquid, glide.

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| all | all | all | all |

Other:

- Vowel length contrast: no

- Consonant clusters: yes

Notes: Many borrowed words exhibit initial geminates

References: Heath, J. 1987. Ablaut and ambiguity: Phonology of a Moroccan Arabic dialect. State University of New York press. Albany.

Ngada (Austronesian, Malayo-Polynesian)

Consonant inventory:

| | Bilabial | Labiodental | Interdental | Alveolar | Palatal | Velar | Glottal |
|-----------|----------------|---------------------------------------|-------------------------|----------|---------|-------|---------|
| Stop | P b 6 b: | | | t d ď | ť | k g | ? |
| Fricative | | f v | tu ana na statistica | S Z | | r | h |
| Affricate | | i i i i i i i i i i i i i i i i i i i | Fra at | | | | |
| Nasal | m | | | n | | ŋ | |
| | m: | | | n: | | | |
| Lateral | | | | 1 | | | |
| Retroflex | | | | r r: | | | |
| Glide | | | | | | | |

Classes of geminates observed: nasal, stop, retroflex

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| m, n, b, r | ? | no | no |

Other:

- Vowel length contrast: no

- Consonant clusters:

References: Djawanai, S. & C. Grimes. Ngada. Comparative Austronesian Dictionary. Darrell T. Tyron, ed. Mouton de Gruyter. Berlin, New York. Moore, P. 1980. Nga'da phonology. *Austronesian Studies. Papers from the second eastern conference on Austronesian Languages.* P. Naylor, ed. University of Michigan.

Nhaheun (Austro-Asiatic, Mon-Khmer)

Consonant inventory:

| | Bilabial | Labiodental | Interdental | Alveolar | Palatal | Velar | Glottal |
|-----------|--------------|-------------|-------------|--------------|--------------|--------------|---------|
| Stop | p b p: b: | | | t d t: d: | с ј с: ј: | k g k: g: | ? |
| Fricative | | | | S S: , | | | h |
| Affricate | | | | | | | |
| Nasal | m m: | | | n n: | n n: | ព្ ព្រះ | |
| Lateral | | | | l I: | | | |
| Retroflex | | | | r | | | |
| Glide | w w: | | | | j | | |

Classes of geminates observed: stop, fricative, nasal, glide, lateral

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|-----------------|-------------|------------|-------------------|
| all (except j:) | none | no | no |

Other:

- Vowel length contrast: yes

- Consonant clusters: yes

Notes: Geminates are restricted to word-initial position. However, most words are mono-syllabic so it is not possible to see if geminates are allowed elsewhere. /3:/ is excluded from initial position but other voiced obstruent geminates are not prohibited. This may be a gap.

References: Jacq, Pascale. pc. Nhaheun Phonetic/Phonological notes.

Pattani Malay (Austonesian, Malayan)

Consonant inventory:

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| | Bilabial | Alveolar | Palatal | Velar | Glottal |
|-----------|--------------|--------------|----------|------------|---------|
| Stop | p b p: b: | t d t: d: | сј ј: | kg k: | ? |
| Fricative | | S Z | | r | h |
| Nasal | m m: | n | ŗ | ព្ ព្រះ | |
| Lateral | | l l: | | | |
| Retroflex | | r | | | |
| Glide | w w: | | У | | |

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Classes of geminates observed: stop, nasal, sonorant

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| all | none | none | no |

Other:

- Vowel length contrast: no

- Consonant clusters: generally restricted to word-initial position, like geminates

Notes: Stress facts suggest that initial geminates may be moraic (Hajek and Goedmans ms.)

References: Hajek J. and R. Goedemans. 2001. Geminates and stress assignment in Pattani Malay. ms.

Yupho, N. 1989. Consonant clusters and stress rules in Pattani Malay. Mon-Khmer Studies 15.

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Piro (Arawakan, Maipuran)

| • • • • | | | | | |
|-----------|----------|-----------|-----------|-------|---------|
| | Bilabial | Alveolar | , Palatal | Velar | Glottal |
| Stop | p | t | 1 | k | |
| Fricative | | S | š | x | |
| Affricate | | ts | č | kx. | |
| Nasal | m m: | n n n: | | | |
| Lateral | | I | | | |
| Retroflex | | r | | | |
| Glide | w w: | | y y: | | |

Consonant inventory:

Classes of geminates observed: nasal, glide

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| all | all | none | none |

Other:

- Vowel length contrast: yes

- Consonant clusters: yes

References: Matteson, E. 1965. The Piro (Arawakan) Language. University of California Publications in Linguistics, vol. 42.

Ponapean (Austronesian, Micronesian)

Consonant inventory:

| | Bilabial | Alveolar | Palatal | Velar |
|-----------|---|--|---------|-------------------|
| Stop | ₽ ₽ | đ | t | k |
| Fricative | | S | | |
| Nasal . | m m ^w m: m ^w : | n n: | | ָרָ ווי ווי |
| Lateral | 42.4 1.1 | 1 | | |
| Retroflex | | ran a sana an an an an an an an an an an an an | | |

Classes of geminates observed: sonorant

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|---------------|------------|-------------------|
| nasals | all sonorants | none | none |

Other:

- Vowel length contrast: yes
- Consonant clusters: no

References: Regh, K. 1981. *Ponapean reference grammar*. University Press of Hawaii. Honolulu.

Puluwat (Austronesian, Micronesian)

Consonant inventory:

| | Bilabial | Labiodental | Interdental | Alveolar | Palatal | Velar | Glottal |
|-----------|--|---|--|-----------|---------|---------|---------|
| Stop | p p ^w p: | بر المراجع المراجع المراجع المراجع المراجع المراجع المراجع المراجع المراجع المراجع المراجع المراجع المراجع الم مراجع المراجع ا | an an an an an an an an an an an an an a | t t: | C C: | k k: | |
| Fricative | | f f | ng ng san 2 n Saran | S S: · | | | h h: |
| Nasal | m m ^w .m: m ^w : | | er u Sange George | n n: | | ŋ ŋ: | |
| Lateral | | | | 1 1: | | | |
| Retroflex | | | | r | | | |
| Glide | W | | | | У | | |

Classes of geminates observed: stop, fricative, nasal, lateral

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| all | all | none | none |

Other:

- Vowel length contrast: yes

- Consonant clusters: no

References: Elbert, S. 1972. *Puluwat dictionary*. Pacific Linguistics Series C. #24. Australian National University.

Roma (Austronesian, Malayo-Polynesian)

| | Bilabial | Labiodental Interdental | Alveolar | Palatal | Velar | Glottal |
|-----------|----------|-------------------------|----------|---------|-------|---------|
| Stop | р | | t d | | k | |
| | p: | | t: d: | | k: | |
| Fricative | | | S | | | h |
| Affricate | | | | | | |
| Nasal | m | | n | | | |
| | m: | | n: | | | |
| Lateral | | | 1 | | | |
| | | | Ŀ | | | |
| Retroflex | | | r | | | |
| | | | r: | | | |
| Glide | w | | У | | | |

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Consonant inventory:

Classes of geminates observed: stop, nasal, retroflex, lateral

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|------------------------|-------------|------------|-------------------|
| stop, nasal, retroflex | all | no | nasal geminate |
| - | | | followed by glide |

Other:

- Vowel length contrast: no

- Consonant clusters: yes

Notes: exhibits metathesis which results in some medial geminates

References: Hajek, J. and J. Bowden. 1999 Taba and Roma: Clusters and geminates in two Austronesian languages. 14th International Congress of Phonetic Sciences Proceedings. San Fransisco.

Steven, Lee Anthony. 1991. The Phonology of Roma, an Austronesian language of Eastern Indonesia. Doctoral Dissertation, University of Texas at Arlington.

Sa'ban (Austronesian, Borneo)

Consonant inventory:

| | Bilabial | Alveolar | Palatal | Velar | Glottal |
|-----------|--------------|--------------|--------------|-------------|---------|
| Stop | p b p: b: | t d t: d: | | kg k: | ? |
| Fricative | | S S: | | | h |
| Affricate | | | č j č: j: | | |
| Nasal | m m: | n n: | ្រ ្ភាះ | ព្វ ព្រះ | |
| Lateral | | l I: | | | |
| Retroflex | | r r: | | | |
| Glide | w | | У | | |

Classes of geminates observed: Stop, fricative, affricate, nasal, liquid

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| all | few | none | none |

Other:

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- Vowel length contrast: no

- Consonant clusters: yes

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Notes: Geminates are restricted almost exclusively to word-initial position

References: Clayre, I. 1973. The phonemes of Sa'ban: A language of highland Borneo. *Linguistics*, volume 100. 26-46.



Taba (Austronesian, Malayo-Polynesian)

| ٠, | | | ÷ | | |
|-----------|----------|----------------|---------|--------------|---------|
| <u>_</u> | Bilabial | Alveolar | Palatal | Velar | Glottal |
| Stop | pb b: | t v d t; d: | | k g k: g: | |
| Fricative | | S S: | | | h h: |
| Nasal | m m: | n n: | | ព្ ព្រះ | |
| Lateral | | 1 1: | | | |
| Retroflex | | r | | | |
| Glide | w w: | | j | | |

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Consonant inventory:

Classes of geminates observed: stop, fricative, nasal, lateral, glide.

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|--------------------|
| all | all | none | initial and medial |

Other:

| - Vowel length contrast: | No |
|--------------------------|---|
| - Consonant clusters: | Observed in same environment as geminates |

References: Bowden, J. 1998. Taba (Makian Dalam). PhD. dissertation, University of Melbourne.

Tamazight Berber (Afro-Asiatic, Northern Berber)

Consonant inventory:

| | Bila b | Labiod ental | Interdenta 1 | Alveolar | Palatal | Velar | Uvular | Pharyngea 1 | Glottal |
|-----------|-----------|-----------------|-----------------|------------------------------|---------|----------------------------------|--------------|----------------|---------|
| Stop | b b: | | d d: | t t t: t: | | k g kw gw k: g: kw: gw: | q q: | | |
| Fricative | β β: | f f: | θ ð θ: ð: | s z s z s: z: s: z: | ,vs ,ż: | x Y x: Y: | Х: R: Х R | ከ ና ከ: ና: | h h: |
| Affricate | ų i | | | | | | | | |
| Nasal | m m: | | | n n: | | | | | |
| Lateral | | , L | | l I: | | | | | |
| Retroflex | | | , | r r r: r: | | | | | |
| Glide | w | | | | У | | | | |

Classes of geminates observed: stop, fricative, nasal, liquid

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| all | all | all | yes |

Other:

- Vowel length contrast: no

- Consonant clusters: yes

References: Jilali, Saib. 1976. A phonological study of Tamazight Berber: Dialect of the Ayt Ndhir. PhD. Dissertation, University of California, Los Angeles.

Thurgovian Swiss German (Germanic)

| | Bilabial | Labiodental | Alveolar | Palatal | Velar |
|-----------|----------|-------------|--------------|---------|-------|
| Stop | р | | t | | k |
| | p: | | t: | | k: |
| Fricative | | f | S | š | x |
| | | f: | St 🦷 | š: | x: |
| Affricate | pf | | ts | | ks |
| | | 42 | a | | |
| Nasal | m | | n - | | |
| | m: | | n: | | ŋ: |
| Lateral | | | - 1- 1- | | |
| Retroflex | | | jar™a * j | | R |
| Glide | w | | | j | |

Consonant inventory:

Classes of geminates observed: stop, fricative, nasal, lateral

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|----------------------|
| stops | all | all | yes, across morpheme |
| | | | boundaries |

Other:

- Vowel length contrast: yes

- Consonant clusters: yes

Notes: Kraehenmann (2001) reports that the geminate/singleton contrast is phonetically neutralized in initial position.

References: Kraehenmann, A. 2001. Swiss German stops: geminates all over the word. *Phonology* 18. Kraehenmann, A. forthcoming.

Woleaian (Austronesian, Micronesian)

| | Bilabial | Labiodental | Alveolar | Palatal | Velar |
|-----------|---|-----------------------|--------------|---------|-------------|
| Stop | p p: b: | | t t: | C: | k: |
| Fricative | β | f f: | s s s: | | x |
| Nasal | m m ^w m: m ^w : | · un | n: | | ព្វ ព្វះ |
| Lateral | | | 1 | | |
| Retroflex | | | r | | |
| Glide | w | | | У | |

Consonant inventory:

Classes of geminates observed: stop, fricative, nasal

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| all | all | none | none |

Other:

- Vowel length contrast: yes

- Consonant clusters: no

Notes: /b:/ is the geminate of β . Some segments proposed to be geminates do not have singleton counterparts.

References: Harrison, S. 1995. Woleaian. *Comparative Austronesian Dictionary*. Darrell T. Tyron, ed. Mouton de Gruyter. Berlin, New York.

Sohn, H-M. 1975. Woleaian reference grammar. University Press of Hawaii. Honolulu.
Yapese (Austronesian, Malayo-Polynesian)

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Consonant inventory:

250

| | Bilabial | Labiodental | Interdental | Alveolar | Palatal | Velar | Glottal |
|-----------|----------|-------------|-------------|---------------|---------|------------|---------|
| Stop | рb p' | | | tđ ť | сј | kg k'g: | ? |
| Fricative | | f f | θ, θ | | Ş | | h |
| Affricate | | | | | | | |
| Nasal | m m' | | | n n' | | ŋ ŋ' | |
| Lateral | | | | 1 ' : | | | |
| Retroflex | | | | r | | | |
| Glide | | | | | | | |

Classes of geminates observed: 1, g

Word-environment distribution:

| Word-initial | Word-medial | Word-final | Consonant cluster |
|--------------|-------------|------------|-------------------|
| l, g | none | none | yes |

Other:

- Vowel length contrast: yes

Consonant clusters: yes

References: Jensen, J. 1977. Yapese reference grammar. University Press of Hawaii. Honolulu.

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