THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF SPANISH, ITALIAN, AND PORTUGUESE
AND INTERCOLLEGE PROGRAM

THE PHONETIC IMPLEMENTATION OF TONE IN COATZOSPAN MIXTEC

JANALYN A. SHEETZ

Spring 2010

A thesis
submitted in partial fulfillment
of the requirements
for baccalaureate degrees
in Bachelor of Philosophy, Spanish, and International Studies
with interdisciplinary honors in Endangered Languages and Spanish.

Reviewed and approved* by the following:

Chip Gerfen
Associate Professor and Head of Spanish, Italian and Portuguese Department
Thesis Supervisor

Eric White
Executive Director for the Division of Undergraduate Studies
Honors Adviser

John M. Lipski
Edwin Erle Sparks Professor of Spanish and Linguistics
Honors Adviser

* Signatures are on file in the Schreyer Honors College.

ABSTRACT

With fewer than 5000 native speakers remaining, the Mexican indigenous language of Coatzospan Mixtec (CM) faces potential extinction in coming generations. Spoken only in the remote northern mountains of the Mexican state of Oaxaca in San Juan Coatzospan, the language has received relatively little linguistic documentation, though some fundamental work has been conducted by Pike and Small (1974) and Gerfen (1999). The primary goal of this project is to continue the process of describing this endangered language in the hope of gaining a more complete knowledge of the linguistic systems of tone used around the world. Specifically, this thesis is concerned with the description of how lexical tone is implemented phonetically in CM both in words produced in isolation as well as in combination with other words.

Using voice recordings of a selection of single words and two word phrases, the fundamental frequency of the voice was measured and averaged across repetitions to show how the phonological process of terracing downstep influences the fundamental frequencies of an isolated word. The findings show that tone patterns may be affected by adjacent tones when spoken in sentence context. A downstep process phoneme /!/, postulated by Pike and Small (1974), appears to cause downstep when contiguous to an H tone. When adjacent to an L tone it does not show the same downstep effects. The data also show that a shift in H f_0 target placement before a lowered H or a L tone may occur in an attempt to further disperse the articulation of adjacent tone targets. L.H. tones that follow /!/ lose their sharp rise but still resist declination while the L target of a L.L. couplet seems to shift rightward and fall sharply.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

My family has been a constant source of encouragement to me throughout my academic endeavors. Thanks to my dad for teaching me the value of hard work and for providing financial support for my academic career, to my mamita for lovingly investing a countless number of hours into my education, and to my brother, for never giving up on me, even when I did. Also to my fiancé, Timothy Byrne, for listening to my unguided ramblings on topics completely unrelated to his area of study. *Les quiero*.

Thanks to Dr. Eric White and Dr. John Lipski for giving their time to suggest improvements and guidance during this process.

Thank you to the Office of Undergraduate Education for providing the financial support for this project through the Summer Discovery Grant program.

A special thanks to Dr. Chip Gerfen, without whom this project would never have reached its culmination. His academic advice and guidance has proved invaluable throughout my college career.

Last but not least, I would like to thank the members of the San Juan Coatzospan community for extending a warm hand of hospitality and friendship to me during my stays in Mexico. In particular I am grateful to Maria Acosta and her family for their willingness to be my family away from home. They are the true linguists, not I. ^{n}*dađia̰βi* ^{n}*do*.

I dedicate this thesis to the entire San Juan community, with the hope that they come to know how much of a treasure they are and how valuable their language is.

Chapter 1

Introduction

1.1 San Juan Coatzospan

This thesis focuses on the tone system of Coatzospan Mixtec (CM). CM is spoken in the remote northern mountains of the Mexican state of Oaxaca in the village of San Juan Coatzospan. The language is spoken by fewer than 5000 native speakers, and only 500 monolingual speakers remain (Lewis, 2009). This language is indigenous to Mexico and, along with others like it, faces eventual extinction due to the heavy influx of Spanish. CM is a member of the Mixtec language family. The Mixtecs constitute a major Mesoamerican civilization dating back to the pre-Colombian era. Known as "the cloud people," Mixtecan communities have typically settled in the mountainous, lowland, and coastal regions of the Oaxaca, Puebla and Guerrero states. While many of these small villages remain scattered over the region today, most are not in contact with each other, and nearly all use a distinct variety of Mixtec (Josserand, 1982).

Languages like CM that are continually surrounded by a culturally dominant language and who begin to adopt that language into daily interactions are commonly called *minority* or *endangered languages*. Many of these face extinction in coming generations due to the loss of native speakers, and the majority of these small language groups have been left undescribed or under-described by linguists. According to *Ethnologue*, a descriptive compilation of the 6,909 known living languages of the world, 473 languages are classified as being nearly-extinct, having only a few remaining elderly speakers where once the language thrived (Lewis, 2009). The death of a language not only has significant social and cultural implications for those directly connected to the community, but each death is a loss to our knowledge and understanding of the world's languages and the people who speak them.

CM is one such language. While it does not face immediate extinction, the prevalence of the Spanish language and the promotion of western culture above indigenous traditions have taken a toll on the vitality of the community. It has been studied and recorded by very few scholars, the most notable studies being Small (1990), Pike and Small (1974), Gerfen (1999), and Gerfen and Baker (2005). The primary goal of this project is to build on past descriptions of CM, in order to further our knowledge and appreciation for this small yet important language, and also to expand our understanding of human languages around the world. Specifically, this thesis is primarily concerned with the description of how lexical tone is realized phonetically in CM both in words produced in isolation as well as in combination with other words.

1.2 Organization

The general organization of this work is as follows: Chapter 2 contains a review of the relevant literature surrounding the topic of tone and the theories and processes surrounding and acting on it; chapter 3 provides a description of isolated tones in CM, proving a baseline for the description and analysis of chapter 4, where the CM tone process of terracing downstep will be described and discussed. Finally, chapter 5 contains a summary of this body of work, discusses potential limitations of the analysis and points to future work to be investigated in the description of CM tone.

Chapter 2:

Review of relevant literature

2.1 Tone

2.1.1 Fundamental frequency

In order to achieve the goal of understanding how CM tone is phonetically implemented, we must first gain an understanding of what pitch is and how it is realized cross-linguistically. For our purposes here, pitch is defined as the perceptual correlate of the fundamental frequency (hereafter f_0) of vocal fold vibration during voice production. The higher the frequency of vibration of the vocal folds, the higher the pitch of the utterance. Therefore the term *pitch* is used to reference a perceptual feature while *fundamental frequency* refers to the physical phenomenon of rate of vocal fold vibration.

The rate of air flow through the glottis (i.e., the vocal folds and the space between the folds) is a chief determinant of pitch. The larynx acts as a valve and a sound producer, regulating the flow of air as it passes into and out of the lungs. Made of four principal cartilages (the thyroid, cricoid, and two arytenoid cartilages), the larynx houses two ligaments called the vocal folds that stretch between the thyroid and arytenoid cartilages. As Ohala explains, it is the rotation of the arytenoid cartilages controlled by the larynx muscles that allows the vocal folds to be brought together to produce voicing, to close off the lungs completely, or to pull away from each other. Thus control of air flow from the glottis and the cartilage rotation controlled by the larynx's muscles are the primary mechanisms for changing the pitch of the voice (1978:7-8).

2.1.2 Tone v. intonation

All languages use pitch contours in their sound systems, but how pitch is utilized to express meaning differs cross-linguistically. In broad strokes, languages use pitch in two principal ways. The first of these is called intonation, which Ladd describes as "the use of suprasegmental phonetic features to convey 'postlexical' or sentence-level pragmatic meanings in a linguistically structured way" (1978:6). In traditional phonetics, the term *suprasegmental* refers to those phonetic features including fundamental frequency, intensity (psychophysically *loudness*), and duration. Any of these three major features used in a set of particular configurations may be used to denote sentence-level pragmatics (i.e., the meanings encoded to phrases and utterances as a whole). English uses pitch for intonation in order to denote different utterance types, such as yes/no questions v. open-ended questions as well as other pragmatic and emotional cues.

Many languages, by contrast, use pitch to distinguish between words in the lexicon. This is true of CM as well as other languages including the Asian and African languages of Chinese and Yorùbá, respectively. Languages that employ pitch in this fashion are called *tone languages* and are quite common, accounting for 60—70% of the world's spoken languages (Yip, 2002). Importantly, there is no fundamental difference between the physiological implementation of *intonational pitch* and *lexical pitch*. The linear string of tones and transitions between tones is a feature of all languages, but what makes a tone language different from an intonation language is the function and internal organization of the f_0s. Thus, the phonetic difference between the pitch contours of a language like English verses a language like Chinese is the result of their functional difference and represents no fundamental difference in phonotactics (Ladd, 1996:148).

Among tone languages there is great disparity in the number, distribution, and interaction of tones. Tone systems vary along a number of dimensions. For example, the number of tone levels can differ greatly, with some languages distinguishing up to 5 levels of pitch contrast (Yip, 2002). Many systems use only two or three, discriminating between H(igh), L(ow), and sometimes M(id) tones (Maddieson, 2008). Additional tonal contrasts can be created when two or more basic tones are combined on the same vowel, resulting in what is called a "contour tone." Contour tones are called "rising" when the final pitch is higher than the first marked with ˇ or LH) and are called "falling" when the final pitch is lower than the first pitch on the same vowel (marked with ˆ or HL). According to Yip (2002) and Goldsmith (1990), these contour tones are best analyzed in terms of Goldsmith's autosegmental theory of phonology, which allows for many-to-one associations between tiers, connecting multiple level tones to the unit where the tone is realized (in this case, the vowel) on the segmental tier (Goldsmith, 1990:39).

2.2 The phonetics/phonology interface

Much linguistic literature has discussed the nature of the boundary between the concepts of phonology and phonetics, in regard to tone as well as other aspects of spoken language. The study of phonology has traditionally dealt with the discrete symbolic elements, which are to some extent idealizations drawn from speech. Information from the physical signal is grouped into temporal and quantitative dimensions in a *categorical* fashion. On the other hand, phonetics is inherently gradient. The study of phonetics relates the phonology's idealizations to the actual speech signal and deals in real time with continuous dimensions. Instead of dealing with categorical values, phonetics deals with infinitely gradient values from the speech signal (Keating, 1996).

In the past, many researchers believed that phonetic realizations of phonological features were automatic and generally universal (Chomsky and Halle, 1968). However, research has shown that phonetic implementation rules differ cross-linguistically and are explicit for each language. For example, both European and Canadian French have a phonological contrast between nasalized and non-nasal (i.e., oral) vowels. However, the manifestation of vowel nasalization is not identical across these two dialects of French, as van Reenen (1982) reports a systematic difference in the timing of velum lowering between the two dialects. In the same way, both English and Swedish make use of the high back rounded vowel /u/, and both languages exhibit patterns of systematic anticipatory lip rounding. However, English speakers begin to round their lips approximately 100 milliseconds before the vowel, wheras Swedish speakers may begin to anticipate the vowel up to 500 milliseconds beforehand (Lubker and Gay, 1982:437—38). These observations, and others like them, strongly imply that rules of phonetic implementation are not general, but require an explicit model. Therefore, whereas languages may share phonological and phonetic features, their phonetic realization needs to be examined in a language-specific fashion.

For tone languages, tones such as H, M, L are ultimately phonological classifications that refer to abstract, categorical representations of what are gradient, continuous phenomena in speech. However, these abstract phonological representations may not perfectly correspond with the f_0 of the output, due to a number of acoustic processes.

2.3 Processes that affect the realization of tones

The disparity between phonological representation and acoustic output is not uncommon. It is seen in some of the phonetic features found among many tone languages, including CM. These include acoustic phenomena such as declination, downstep, tone terracing, floating tones/process phonemes, final lowering, and tone change due to environment (sandhi). The following sections provide a brief overview of each of these processes, some of which will contribute to the later description of the CM tone system.

2.3.1 Pitch declination

Pitch declination is the process by which f_0 tends to decline over the course of the utterance, even when the tones of the sentence are phonologically constant. Declination is a gradual process that generally occurs evenly as the sentence proceeds and is a universal trait of both lexical tone and non-lexical tone languages (Ladd, 1996:74). It is believed by many to be a physiologically based phenomenon, in which a drop in pressure occurs as the amount of air in the lungs decreases, assuming that the speaker has not stopped to breathe. This lowered pressure slows the rate of vocal fold vibration and thereby lowers the pitch (Yip, 2002:9). Some counter evidence to this explanation also has been recorded (see Ohala, 1978).

2.3.2 Tone sandhi

Tone sandhi refers to phonetically conditioned tonal alternations that occur across word boundaries (Chen, 2000:xi). The word *sandhi* historically originates from a Sanskrit root meaning “junction” or “combination,” referring to the assimilative changes that occur between the final and initial sounds of two adjacent words in Sanskrit (Simpson and Weiner, 1989). In the more current literature, the term is often used to refer to these types of complex tonal alternations occurring specifically in Chinese connected speech, but it may also apply to similar phenomena in other languages. Chen provides an example of these processes in Beijing Mandarin, where a tone sandhi rule converts a falling-rising contour (transcribed in different phonetic transcription systems as MLH or 214) into a high rising (35) contour when it precedes another falling-rising (214) tone (2000:20). (Chinese languages use a number system to categorize different tone levels, so the numbers in parentheses refer to the tone levels that are reached during the production of the word.)

/xiao/ 'small' + /gou/ 'dog' → /xiao gou/
2 1 4 2 1 4 3 5 2 1 4

2.3.3 Downstep and terraced tone

Downstep, however, is a stepwise lowering of pitch at specific pitch accent locations and is commonly found in the languages of sub-Saharan Africa. Descriptively, it is the process by which the f_0 of a second H tone is produced at a lower level than the first H in an H L H… phrase and the lowered H tone acts as a new maximum pitch for the rest of the H tones in the sentence (Ladd, 1996:74—75). As Yip (2002:12) notes, although very similar to declination and although it is likely that the two processes are related, the manner and nature of their relationship is not clearly understood.

More than one type of downstep occurs in the world's tone languages and a range of varieties have been discussed in linguistic literature. One such variety has been linked to many descriptions of Mixtec languages and is called "terrace tone," a downstep phenomenon in which a H is lowered after some type of trigger mechanism, causing a change in pitch key. What makes terrace tone downstep especially difficult to understand is the seemingly unpredictable way in which it manifests itself. For example, not all strings of H tones will implement downstep, but the downstep seems to be triggered by specific morphemes and not by others. The way that some phonologists have accounted for these types of systems is to posit a downstep trigger called a "null process phoneme"

(Pike and Small, 1974). This invisible process phoneme has no specific phonetic content in isolation but is thought to be attached to certain morphemes in the lexicon, causing a phonological pitch key downstep when appearing in the right environment in a spoken string. Thus, it may phonologically trigger downstep, and phonetically cause a lowering of pitch register, but will not have a phonetic realization when there are no other adjacent tones or when the adjacent tones are not H. This process phoneme is considered to be a type of *floating tone* (Yip, 2002:12; Goldsmith, 1990:20) and the presence of the process phoneme is what distinguishes terracing from the regular occurrence of downstep (Pike and Small, 1974).

The manifestations of downdrift and downstep should not be confused with the process of "final lowering" during pitch production. In both tonal and non-tonal languages, final tones and pitches are often realized at a noticeably lower pitch level than otherwise would be expected. In other words, even if a phrase final syllable is phonologically specified for a H tone, its pitch may phonetically drop off drastically in comparison to the pitch that is normally considered "H." This is especially common when the final tone does not sharply contrast with the tone preceding it (Ladd, 1996:77).

2.3.4 Extrinsic factors

The final type of phonetic features that we must be aware of are the extrinsic factors that affect the phonology of a pitch. Each speaker of a language will have idiosyncratic aspects of her or his speech, including overall pitch range, and the implementation of downstep, declination and pitch rising. Pitch range depends highly on the sex of the speaker, as males usually have a larger vocal tracts and larger and heavier larynges than females, resulting in the typically lower f_0 of men in comparison to females.

Range may also be influenced by a person's manner of speaking. A monotonous voice will have a narrower range than a lively, or up-rising voice (Ladd, 1996:269—272).

2.4 The phonetic implementation of tone

The above observations regarding the production of lexical tone all point to the central question to be discussed through the research conducted here. Tone, and the notion of relative tone heights such as high (H), mid (M), low (L), are inherently abstract categories that classify the lexical specifications for tone on given words. An interesting question to investigate is how these categories are implemented by speakers during speech. How, for example, are phonological H and L tones realized phonetically? These are not easy questions to answer, but research examining the processes of phonetic implementation may greatly enhance our understanding of the world's tone languages.

Laniran (1993) calls phonetic implementation "the process by which phonological features are mapped into the phonetic output." Put another way, in tone languages, it is the process by which the features of relevant pitch heights H and L are copied onto the phonetic output in terms of fundamental frequency and are then produced acoustically. Cross-linguistically this process differs greatly, as each system not only has an independent number of tonal contrasts, but also implements the tone differently based on the phonetic and phonological processes of the language. By examining the phonetic implementation of lexical tones, we can begin to understand the way or ways in which H toned items influenced by a process of downstep are acoustically different from H tones not influenced by that process. We can also begin to understand how the phonetic implementation of downdrift may vary in language specific ways. Similarly, processes such as final lowering will cause the phonetic implementation of a phrase-medial L tone to differ from a phrase final L (Ladd:1996), and it is only by careful scrutiny of the actual realization of tones that we can come to understand the ways in which categorical specifications of tones are affected by context. Even phonetic environments influenced by the presence of a particular consonant may influence the f_0 of adjacent tones (Hyman and Schuh, 1974:105).

In simple terms, the phonological status of a tone does not directly predict how that tone will be produced in speech. Thus both the process by which we categorize tones and our ability to distinguish between them empirically can be significantly more complicated than what is initially assumed in the basic notion of tone levels H, M, and L. This separation between the symbolic model of phonology (H, M, L, and other sound categorizations) and the actual phonetic production of the form is clearly demonstrated by Laniran's 1993 research on Yorùbá pitch targets. Laniran found that sequences of identical tones in Yorùbá are phonetically realized differently based on the lexical tone that precedes the sequence and the number of tones in the sequence. In these identical H tone sequences, all of the syllables are thought to link to a commonly shared H tone but that the realization of the H f_0 target is late. When spoken, a gradual rise in pitch appears throughout the phrase, but the f_0 target for H is not produced until late into the sequence (usually the end of the second or the beginning of the third syllable). This occurrence lead Laniran to posit that although all syllables are phonologically specified for lexical tone, the phonetic implementation rules of the language may change the way in which these lexical tones are specified, thus making certain H (and also L) tones appear with a different f_0 than their counterparts.

This is the principle that brings us to the topic of the research conducted here. Laniran's observations and others like it show that the phonology of specified lexical tone often may contrast with the speaker's phonetic production of the tone. This is true of Yorùbá and many other tone languages, and is also true of Coatzospan Mixtec. The following is an investigation of how and to what extent the CM phonetic implementation of tone differs from its abstract phonological structure under specific contextual conditions. Before examining the phonetics of the CM tone, a general discussion of the features shared by branches of the Mixtec family is discussed below.

2.5 The Mixtec language family

The Mixtec language family consists of at least 22 mutually unintelligible dialects originating from one Proto-Mixtecan language (Josserand, 1982). Mixtec as a language family is classified as a member of an even larger branching phylum called Otomanguan, localized throughout Mesoamerica. Besides Mixtec, this group is arguably the historical source for languages like Chinantecan, Zapotecan, and Tlapanecan. The Mixtec branch of this phylum is characterized by the rich and complex lexical tone system found in all varieties spoken today. Yet these varieties contain such large amounts of lexical variation that Macaulay argues that "…'Mixtec' really should be considered a group of related but distinct languages" (1996:6). The distinction between "dialect" and "language" is heavily debated in linguistic circles as no sharp boundary exists on the continuum of intelligibility and unintelligibility. However, for the purposes of this project, the term "language" will be used as there is little mutual intelligibility between Mixtec languages. These broad linguistic differences are likely due in great extent to the patterns of Mixtec territorial expansion (Macaulay, 1996:7).

2.5.1 Shared Mixtec family features

A number of typological features are shared across the Mixtec languages. The disyllabic couplet is the most common structure used for lexical words in all varieties of Mixtec and was first described by Pike's seminal 1948 work on San Miguel el Grande Mixtec. This structure is believed to have originated in Proto-Mixtecan, the mother language from which all current dialects of Mixtec are derived (Rensch, 1976:53). Disyllabic couplets are lexical morphemes comprised of two syllables and are bearers of contrastive tone patterns in CM. They are a set of open class morphemes but are highly restricted in form, being limited to one of two basic shapes in which coda consonants are historically forbidden: CVV, and (C)VCV. All couplets (as seen in Figure 1 below) are "divocalic," with CVV couplets containing either two vowels, or, more commonly, a long vowel (marked with a colon).

Table **2-1**: Examples of basic couplet patterns

/ʃu:/ 'rock'	/tsu:me/ 'candle'
/ʃṵ:/ 'mouth'	/đṵ:ʃe/ 'lazy'

The CVV form exhibits all the same underlying tonal patterns as the (C)VCV form, and is thus traditionally considered to be disyllabic. The syllable, and not the mora, is argued to be the tone bearing unit (TBU) (Pike and Small, 1974), and this theoretical position is assumed in the literature and has remained virtually unchallenged. Gerfen posits that such a view may not be necessary, but that the syllable TBU is nevertheless functional for explaining the commonality of underlying tonal patterns (1999). Monosyllabic words also exist, but in CM these are limited to pure grammatical functions and represent a class of enclitics and affixes that lack distinctive tone (Gerfen, 1999).

Leaving the discussion of the prosodic word and syllable structure, we turn to a description of the Mixtec languages' use of tone. Many incorporate three levels of distinctive tone into their phonological systems, with L, M, and H tones expressing lexical meaning. Others, such as CM, are hypothesized to include only two, making a distinction between H and L. Tone sandhi is prevalent within many of these tone systems, but not all, and sandhi systems are posited by Rensch to be "local developments in each case since they do not systematically occur in the same set, however, they presumably are the result of morphophonemic variation…." (1976:53). Three different Mixtec sandhi systems are detailed here:

Jicaltepec Mixtec exhibits a limited tone sandhi system, with a lower allophone (M or L) of H appearing immediately following a stressed syllable with a low tone. In all other instances, no tone lowering occurs (Bradley, 1970).

In San Miguel el Grande Mixtec of West-Central Oaxaca, only the couplet forms MM, ML, LH, LM change from L to H in certain situations. Brown (1998) posits that these lower register tone patterns carry a floating high tone or process phoneme that is not phonetically produced in speech (as per Autosegmental Theory, Goldsmith 1990). However, if such a morpheme comes into contact with another morpheme of the same type, the floating H tones are associated with the second couplet, changing one of these lower-toned couplets into a high tone bearing couplet (Brown, 1998:29).

Although her analysis does not detail its tone system, Monica Macaulay mentions in passing the presence of tone sandhi in Chalcatongo Mixtec. A large number of words and affixes in this dialect show a floating H tone that may, in certain phonological circumstances, be pronounced on the second syllable of that word (Macaulay, 1996:13).

2.6 CM description

The most noteworthy description of the Coatzospan Mixtec tone system to date is contained in a 1974 article authored by Eunice Pike and Priscilla Small. But in addition to the summary on the processes of terracing-downstep and tone sandhi provided by the article, the authors provide an explanation of the significant non-tonal features of CM, including the disyllabic couplet, vowel laryngealization, nasalization, and an overview of the consonant and vocalic systems of the language. In addition to Pike and Small's research, the work conducted by Gerfen (1999) provides additional insight into the nature of CM laryngealization and nasalization, specifically investigating the phonetic implementation of these phonological processes.

2.6.1 Laryngealization

CM is a laryngeally complex language (Silverman, 1995) in that not only tone contrasts, but also non-modal phonation such as larngyealization and/or breathy voicing, are used to differentiate between lexically contrastive minimal pairs. This combination of two types of laryngeal features creates an environment in which the two features could overlap, adding further complication to the phonetic system In CM, laryngealized vowels behave contrastively:

Table **2-2**: Laryngealization v. modal minimal pairs

/ʃu:/ 'rock'	/ʃṵ:/ 'mouth'
/ʃa:/ 'tongue'	/ʃà̰:/ 'chile'
/u:βi/ 'pain'	/ṵ:βi/ 'two'
/le:ⁿdʲu/ 'dirty'	/lḛ:ⁿdʲu/ 'uncombed, tangled'

There is one instance in which laryngealization is not used in a lexically contrastive way, but is predictable by the phonology, and that is in the case of disyllabic couplets containing a voiceless C_2 (see Gerfen, 1999 and Gerfen and Baker, 2005 for extensive discussion). Here, laryngealized vowels are marked following conventions of the International Phonetic Alphabet (IPA) with a tilde underneath the vowel: /̰ / immediately adjacent to the vowel.

Table **2-3**: Predictable instances of laryngealization

/tʲṵ:tʲu/ 'paper'	/lɨ̰:ʃɨ/ 'chicken'
/βa̰:su/ 'glass'	/βḭ:ko/ 'cloud'

Laryngealization is a process that is applied to vowels by which the vocal folds are held more stiffly than in normal vowel production, causing at the most extreme end of the laryngealization continuum, an audible creak in the voice. However, even when an audible creak is absent, the "echo vowel" effect of laryngealization is common, and the laryngealized vowel is followed by a brief rearticulated vowel identical in features to the pre-laryngealizated vowel. This same phonetic process has been called glottalization or "creaky voicing," but since audible creaks are not a required feature of the laryngealization process in Mixtec, this terminology is avoided for reasons of clarity. Some of the words analyzed in this thesis contain laryngealized vowels and the reader should be aware that the presence of laryngealization may cause subtle f_0 and amplitude lowering and rising (Gerfen and Baker 2005:317). These dips and rises control the aural perception of two vocalic beats.

2.7 CM tone system

2.7.1 Basic tone patterns

As previously discussed, Pike and Small (1974) posit that CM differentiates between two basic tones: H and L. These typically appear on the TBU in a one-to-one fashion, with only one tone being assigned to the nucleus of the syllable (the vowel). In certain phonetic environments, however, up to two tones may be assigned to the same vowel, resulting in the tone cluster contrasts of LH and HL. The LH cluster may only occur when preceding a pause and the HL contour only appears in the first syllable of a couplet when following an H tone. In isolation, there are 5 basic tone patterns: H.H., L.H., L.L., H.LH., L.LH.

Table **2-4**: Five basic isolation couplet patterns (per Pike and Small, 1974:109):

H.H.	/ʃṵ́:vé/	‘thread’
L.H.	/ḛ̀:mí/	‘burned’
L.L.	/đà̰:mà/	‘skirt’
H.LH.	/βá̰:̌ /	‘good’
L.LH.	/tsù:mě/	‘candle’

2.7.2 Phonetic implementation of CM tone

Acoustically, as discussed in §2.3 and §2.4, the phonetic implementation of a tone (H or L) may vary greatly depending on a variety of phonetic and phonological circumstances. In CM the same is true, and Pike and Small's 1974 description of the language's complex rule system of allotones demonstrates this clearly. First, H tones may be produced in a number of ways. The highest version H occurs when it is the first H between Ls, or is the first H after a sequence of Ls (e.g. /tsa̰ká kà:nì/, 'long fish'). The next manifestation of H is slightly lower in pitch than the first and appears between a H and a L (e.g. /tṵ́tú kànì/, 'long paper'). An H with a down-gliding pitch appears when the H is in the initial syllable of a non-laryngealized couplet in nucleus position, and precedes an L or a lowered H (e.g. /kṵ́tsí ʃú:!ʃú/, 'glass pig'). This down-glide is not, however, as deep nor as long as a phonetic HL cluster (e.g. /!vî:đí/, 'warm').

L tones also exhibit a variety of possible acoustic forms. As reported by Pike and Small (1974) a initial syllable L of a pre-pause couplet undergoes a down-glide when it precedes a voiced consonant (e.g. /gà̰tsì vì:đě/, 'wet blanket'). An audible downdrift is reported when a sequence of Ls occurs pre-pause and, when in isolation, a sequence of Ls with no contrasting H tone is raised (e.g. /ʃḭ̀kɨ̀ kà:nì/, 'a long squash' = /díóɲá tʲṵ́:tʲú/ 'they want paper'). In contrast, an isolated sequence of Hs with no contrastive Ls is reported to be lowered in pitch, resulting in an neutralized pitch setting in purely H and L tone sentences. Simply put, isolated L and H tones are claimed to be indistinguishable (Pike and Small, 1974:110).

2.7.3 CM tone sandhi

As discussed in §2.3.3 , tone sandhi is a process that has marked effect on the implementation of tone in a number of the world's tone languages. The effects of tone sandhi in CM are equally marked and complex, as best exemplified in the extensive model and charting developed by Pike and Small (1974). According to Pike and Small, tone sandhi processes may occur among 14 classes and subclasses of couplets and can only be accounted for using 18 derivational rules when five details concerning the involved patterns are known: 1) The presence or absence of /!/ in isolation; 2) the tone class of the second of the two couplets; 3) the isolation tone pattern of the first couplet; 4) the grammatical category of the second couplet; 5) the grammatical category of the first couplet if the isolation variant of that couplet is H.LH. A further description and discussion of the complex sandhi rules used in CM is available in Pike and Small (1974).

2.7.4 Process phoneme /!/ as a downstep trigger

While tone sandhi and other salient phonological features may affect the implementation of tone in CM, an equally notable feature is the presence of terracing downstep, with which this thesis is primarily concerned. A "process phoneme" has been postulated to directly influence the acoustic production of a phrase in certain phonological environments, resulting in pitch downsteps throughout a sentence. According to Pike and Small (1974), CM utilizes this overtly null tone in addition to the basic H and L tone differentiation. Originally postulated by Pike in his 1967 work on San Miguel el Grande Mixtec, this process phoneme is believed to have no specific phonetic content, but causes a form of downstep by exerting a lowering influence when an H immediately follows. The result is a lowered key change between the process phoneme (written as /!/) and a pause or another /!/, with the potential of multiple key changes occurring within a single pause group. During a pause in speech production, a default "key reset" occurs before the speaker continues. This modulation in pitch key is a variety of downstep and has been called "terrace tone." It is a rare linguistic feature in the Americas, as it is most commonly found among African languages (Pike and Small, 1974:106).

As a result of the presence of the process phoneme, a contrast may occur across three levels of tone preceding a pause: H, L, and lowered H. But it is important to note that even when an H is lowered by the process phoneme /!/, the tone still functions as an H and contrasts with following L tones. Likewise, a lowering due to an adjacent process phoneme does not change the lexical semantics of the affected morpheme. Pike and Small offer the following sets demonstrating the contrast between the three tone levels (107):

/kṵ́tsí kạ̰́ní-ǒ/	'we will kill a pig'	(un-lowered H on /ní/)
/kṵ́tsí lṵ́!kú-ǒ/	'our crazy pig'	(lowered H on /kú/ after /!/)
/kṵ́tsí kṵ́ʃì-ǒ/	'we will bury a pig'	(L tone on /ʃì//)

The process phoneme is highly restricted in terms of phonetic actualization as it is only produced between two H tones, even though it is lexically part of the couplet in all environments. In terms of location within the morpheme, it may appear couplet-initially, finally, or on both ends of the couplet (1). It may only occur medially, according to Pike and Small, when a H.H. or !H.H. morpheme precedes a H.H. or H.H! morpheme (2).

(1)	Initially:	/!ⁿdí:vu/	'ancient'
	Finally:	/tʲṵ́:tʲú!/	'paper'

Both: /!skʷí:dú!/ ‘spotted’

(2) Medially: /kṵ́tsí vḭ́!đí/ ‘sweet pig’

Couplets that evidence the presence of a process phoneme during normal speech may take any of the following forms: H.H!, !H.H., !H.H!, L.H!, !HL.H!.

Table **2-5**: Basic process phoneme couplet patterns (per Pike and Small, 1974:109):

H.H!	/í:đú/	‘horse’
!H.H.	/!skʷí:lú!/	‘buzzard’
!H.H!	/!skʷí:!/	‘pinto’
L.H!	/kù:nú!/	‘profound/deep’
!HL.H!	/!î:tsí!/	‘dry’

2.8 Summary

The complexity of the CM tone system is apparent from the descriptive work of Pike and Small, but as of yet, no work has provided a quantitative analysis of the phonetic implementation of CM downstep. Since the implementation of this phonological process likely differs across the phonetic systems of distinct languages, a quantitative analysis should not only provide insight into the language-specific implementation model of CM, but also may afford greater clarity into the tone systems of the world.

A complete investigation of CM tone is far beyond the scope of this project, but in the subsequent chapters I explore a small piece of the puzzle. In the next chapter a baseline is established for the f_0 of basic tone patterns by examining the implementation of isolated couplets. Chapter 4 discusses how these tones are affected by terrace tone downstep when combined into sentences and draw a comparison between the observations of Pike and Small (1974) and the pitch measurements found in recorded data.

Chapter 3

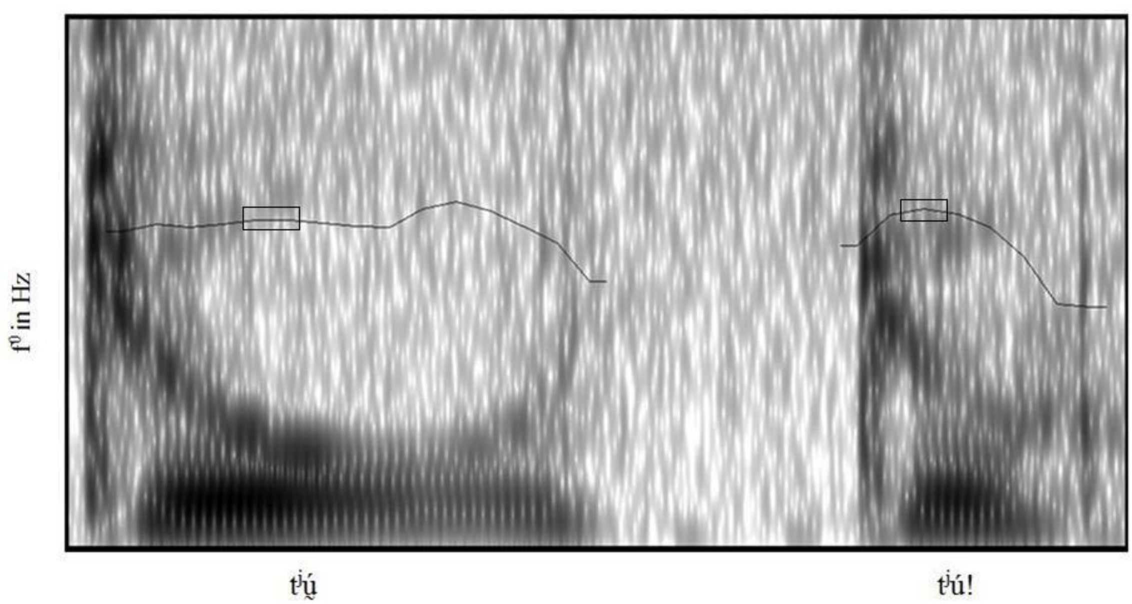
The phonetic implementation of tone in isolated CM words

3.1 Methodology

To investigate the acoustic implementation of tone in CM, a corpora of isolated words and two-word phrases composed of the basic CVCV couplet structure were recorded. All tokens were recorded by native CM speakers using a lapel microphone attached to an iPod voice recorder and a full list is available in Appendix A. Couplets contained both laryngealized and modal vowels. Participants were asked to repeat each token a minimum of 5 times with a pause of several seconds in-between to prevent speakers from falling into a list intonation.

Using Praat, an acoustic analysis software program, averages for each pitch target were measured for all tokens. The graph below is intended to provide the reader with an idea concerning the way in which the pitch targets of each word were measured.

Figure **3-1**: Spectrogram of /tʲṵ́tʲú!/



The above figure is a spectrogram and pitch analysis provided by Praat. The spectrogram provides information concerning the production of a word, including the formant values, transition points between segments, intensity, sound quality, as well as the nature and rate of vocal fold vibration. Imposed on top of the spectrogram are a series of lines that denote the location of the pitch throughout the production of the word, in this case, /tʲṵ́tʲú!/, ‘paper.’ The small rectangular boxes are meant to indicate the approximate location where a measurement of pitch target would have been taken for this segment as well as others.

Most importantly to point out, there are several positions that are best avoided during measurement recording. First, it is dangerous to take a pitch measurement that is either at the absolute beginning or the absolute end of a syllable as these periphery positions are often sites of initially unstable voice control. The image above shows a slight amount of instability on the first syllable of the word, and on the second syllable, the pitch tracking line begins much before the target of the syllable is actualized on the vowel, resulting in a jump in f^0 during the consonant-vowel transition point. The best place to measure this target is at the point in the syllable where the pitch reaches its highest or lowest point and remains relatively stable for a brief period of time before or after an adjacent transition. Second, processes of laryngealization often affect the implementation of tone targets near the end of the vowel. Thus, it is best to gather an f^0 measurement near the front end of the vowel and avoid taking a measurement at the onset of the CM creaky-voicing pattern.[1]

---

[1] The onset of laryngealization (or creaky voicing) is best seen in the spectrogram at the point in which the vocal fold vibrations begin to spread out on the initial syllable /tʲṵ́/. While not shown here, an additional cue to the onset of laryngealization is a drop in amplitude, shown in the waveform of the segment.

Finally, incongruent and outlying tokens were excluded from the final analysis[2] and charts and tables were made using Microsoft Excel software.

Under the regulations of Penn State's Office for Research Protections (IRB #28368), all participants were guaranteed anonymity and were financially reimbursed for their time. Participants were also asked to sign a consent waiver and fill out a linguistic background questionnaire. The participants (n=7) ranged in age from 22 to 46. Five females and two males were included in the study. All are bilingual speakers of CM and Mexican Spanish and below is a more detailed account of each individual's language background.

3.2 Participant language background

E: Female, age 22. E began learning CM from birth and continually uses it in the home and in the village of San Juan Coatzospan. Her first exposure to Spanish was in primary school at age 6, but says that she uses both languages equally. She principally uses CM at home but when leaving the village she speaks primarily in Spanish.

Ev: Female, age 24. Ev began learning CM from birth and continually uses it in the home and in San Juan. Her first exposure to Spanish was in primary school around age 10, and claims that her command of CM is greater than her command of Spanish. She principally uses CM at home but when leaving San Juan she speaks primarily in Spanish.

L: Female, 34. L began learning CM from birth and continually uses it in the home and in San Juan. Her first exposure to Spanish was in primary school around age 6, and claims that her command of CM is greater than her command of Spanish. She principally uses CM, but when leaving the village she generally speaks in Spanish.

[2] When speakers admitted to making an error in the tone pattern, or when a different word was inadvertently produced, it was excluded from the analysis. A tone pattern was marked as an outlier when it was 20 Hz or more from the overall average of the remaining tokens for that speaker.

M: Female, age 46. M began learning CM from birth and continually uses it in the home and when in San Juan. Her first exposure to Spanish was in secondary school at age 15, but she did not complete high school. Now a primary resident of Puebla, she lives near other CM family members but travels back and forth to San Juan regularly.

O: Female, age 29. O began learning CM from birth and continually uses it in the home and in San Juan. Her first exposure to Spanish was in primary school around age 8, but says that she uses both languages equally. She principally uses CM at home but when leaving San Juan she speaks primarily in Spanish.

F: Male, age 38. F began learning CM from birth and continually uses it in the home and in San Juan. His first exposure to Spanish was also in primary school around age 6, and claims to use CM on a more regular basis than Spanish. Again, this participant uses Spanish primarily when traveling outside of San Juan.

P: Male, age 32. F began learning CM from birth and continually uses it in the home and in San Juan. His first exposure to Spanish was also in primary school around age 6, but says that he uses both languages equally.

3.3 Pitch in isolation forms

Before we begin a description of the implementation of tone in multiple-word phrases, it is important to begin with a baseline idea of how isolated tones are pronounced in CM. For example, we know from table 2.7 that H tones can appear in a variety of patterns such as H.H., L.H., H.L., and others. It seems necessary to ask ourselves if H is implemented in the same way in each of its potential patterns. For example, is the initial H of an H.H. pattern identical to the final H? How about to the final H of a L.H. word? In order to investigate the interaction of tone in phrases, as I will attempt to do in chapter

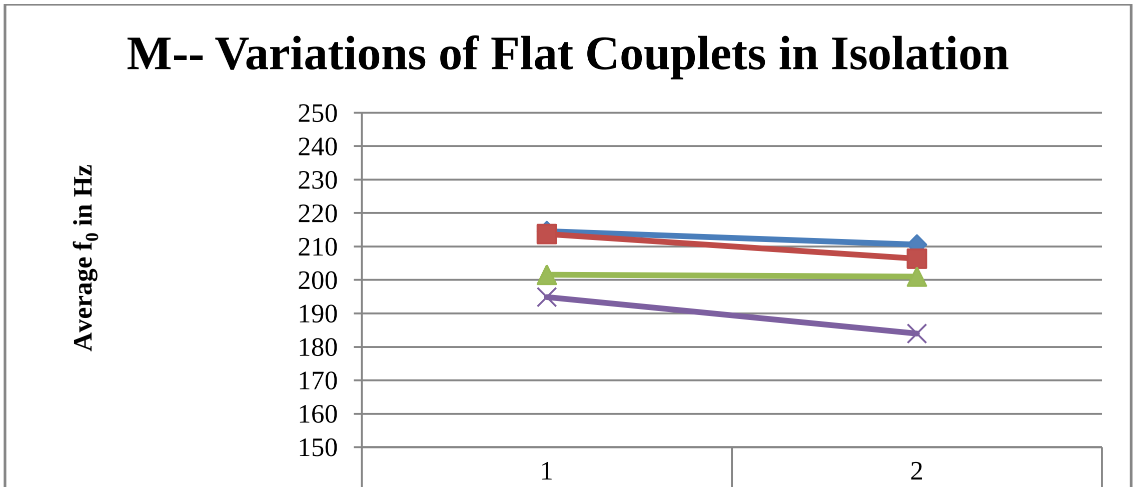
4, it is best to begin with an analysis of the most simple type of tone implementation: tones in isolation forms. In the coming sections we will investigate what tones look like as a whole, in preparation for looking at how tones affect each other during speech.

Data from three speakers will be used to provide the reader with an overall portrait of CM tones in isolation. Other speakers will be included in the description coming in chapter 4, but for the purposes of this chapter, the data from three speakers suffice to provide us with a general idea of the shape of these isolation patterns.

The first participant to be described is speaker M. M has the most experience with linguistic research and field work. She has worked extensively with Gerfen (1999) and has served as a consultant in field methods courses taught by Gerfen in Mexico and thus has the ability to consistently provide citation forms to researchers. Anecdotally, while living with her in San Juan Coatzospan, she carefully taught me how to discern the tone contrasts of CM, and her clear and careful speech makes her tokens particularly reliable for measurement. For this reason I begin this analysis with her recordings, before moving on to investigate the recordings provided by other participants.

As seen in table 2.5., CM utilizes 5 basic tone patterns in isolated lexical couplets. These are H.H., L.L., L.H., L.LH., and H.LH. However, the two patterns that contain contour tones (L.LH and H.LH) are by far the least attested in the CM lexicon, whereas the simple bi-tonal couplets are overwhelmingly predominant. For this reason, the continuing analysis will deal primarily with these three common isolated tone patterns: H.H., L.L., and L.H. With the addition of the process phoneme that has been postulate to cause downstep (per Pike and Small, 1974), there are three variations of the H.H. tone pattern: H.H., H.H!, and !H.H. For the purposes of comparing the implementation of flat tone couplets (i.e., couplets with no contour tones), we will take a brief look at all three patterns and how they compare with L.L. tone couplets.

Figure **3-2**: Variations of flat tone couplets for speaker M

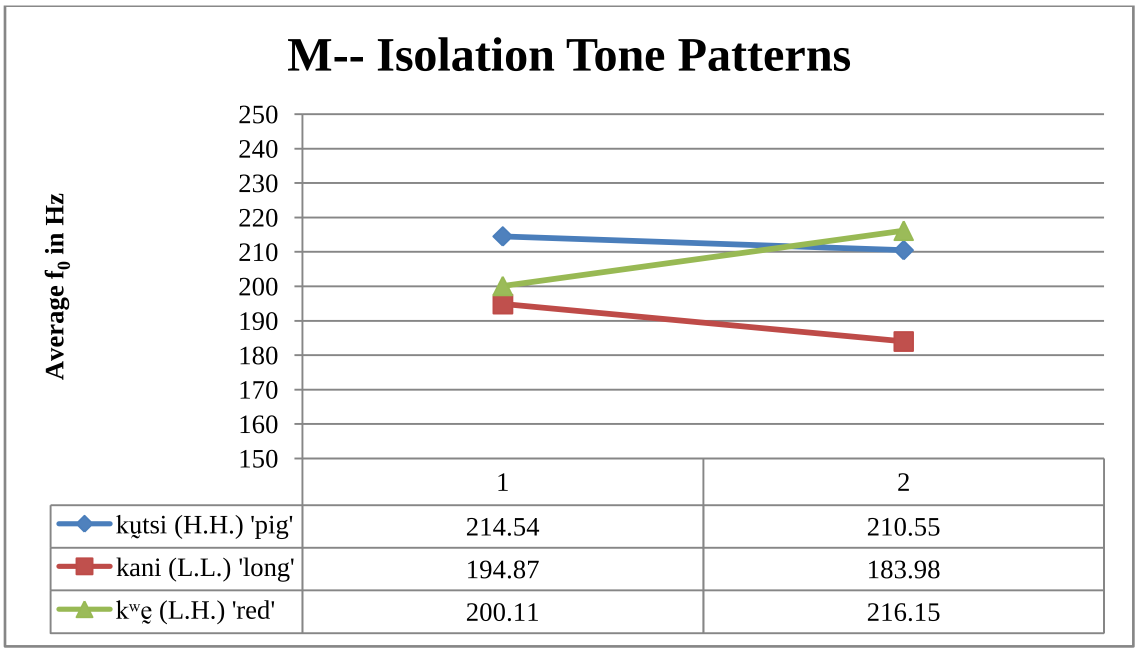


	1	2
kṵtsi (H.H.) 'pig'	214.54	210.55
tʲṵtʲṵ (H.H!) 'paper'	213.73	206.37
ndivu (!H.H.) 'ancient'	201.54	200.98
kani (L.L.) 'long'	194.87	183.98

Pike and Small (1974) observed that isolated sequences of H tones with no contrasting L seemed to have somewhat lower targets, whereas isolated sequences of L tones with no contrasting H seem to have slightly higher targets, resulting in both flat patterns being produced identically in isolation (110). The chart above, which contains all the variations of H.H. as well as a word from pitch class L.L., does not visually show these four patterns to be identical. Nonetheless, M's tokens don't obligatorily confirm a difference between these patterns as the initial pitch targets of all three H.H. type couplets and the L.L. couplet fall within a narrow range of 20 Hz (194.87—214.54 Hz) and that does not even include an analysis of token variance. While the available data are not sufficient to test for a statistically significant difference between these tone patterns, the relative proximity of the f_0s makes it understandable why Pike and Small came to the conclusion that H.H. and L.L. patterns neutralize to some mid pitch target, and the similarity across the examples indicates that, at least in these isolation forms, speakers appear not to disperse the tone targets in H.H. and L.L. forms to order to achieve a clear distinction between the two classes.

In the following chart we will turn our attention to a description of the three most frequent tone patterns in CM: H.H., L.L. and L.H.

Figure **3-3**: Isolation couplets for speaker M



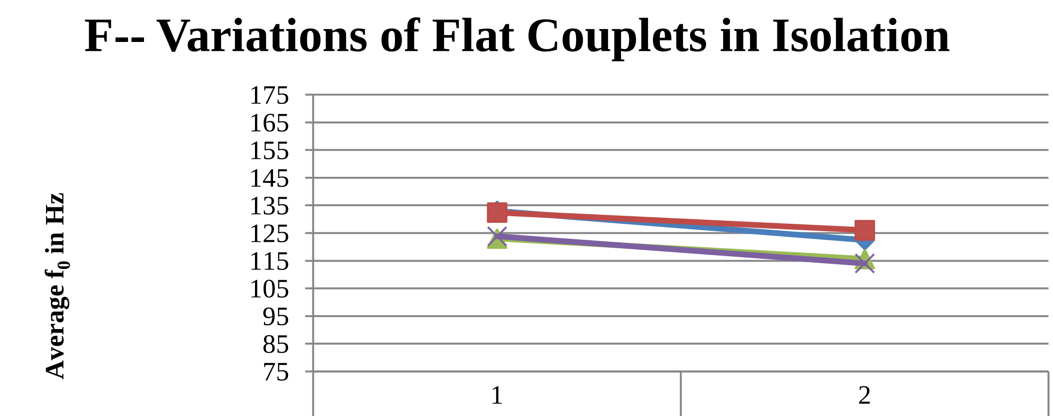
Let’s start with the initial tones of each of these words. As seen here, as well as in figure 3.1., M produces the initial tone of an H.H. couplet at a higher pitch than that of an L.L. couplet (214.54 Hz v. 194.87 Hz). The L of the L.H. pattern closely approximates the initial pitch of the L.L. couplet (200.11 Hz v. 194.87 Hz). This is noteworthy insofar as we see that the initial L target of the L.H. is almost identical to the initial L of the L.L. form, suggesting that there is not, at least for this sample, a notable difference in the acoustic target for L in L.L. versus L.H.

Both the H.H. and L.L. patterns show a slight decrease in f_0 over the course of the word, resulting in falling pitches ranging between 3.99—10.89 Hz. Arguably, we can attribute this falling pattern to pitch declination (see §2.3.1. for a discussion). While pitch declination is a frequent process in many of the world's languages, it is particularly interesting in tone languages because it indicates important information about pitch targets. In a language like Yorùbá, sequences of identical H tones are phonetically realized with a gradual rise in pitch throughout the word(s) until the H f_0 target is reached later in the sentence (Laniran, 1993; see §2.4 for a discussion). Declination is not seen until late in the word or phrase, appearing only after the f_0 target is reached. CM shows the opposite pattern in isolated words, with the pitch target of both H.H. and L.L. words being produced on the first vowel and declination in the second.

The L.H. pattern exhibits a sharp contrast to the slightly declining patterns of the previous two items discussed. While the initial L tone approximates the f_0 of the L.L. pattern, the final H tone rises to a point that is higher than the final target of H.H (216.15 Hz v. 210.55 Hz). It even rises to an f_0 that is above the initial H target of the H.H. pattern (216.15 Hz v. 214.54 Hz respectively). This quick and drastic rise in f_0 shows how pitch may be used to show a sharp contrast between the tone categories of H and L in CM. M highlights this contrast plainly by jumping 16.04 Hz to reach a noticeably high target on the second syllable of the word /kʷḛ̌ː/.

Now having taken a closer look at the implementation of tone by one speaker, I will here turn to look at the production of tone by two other speakers. The following participants have had less experience working with linguists and are less aware of the pressure to produce a citation form, but their data show relatively similar tone implementation to that of speaker M.

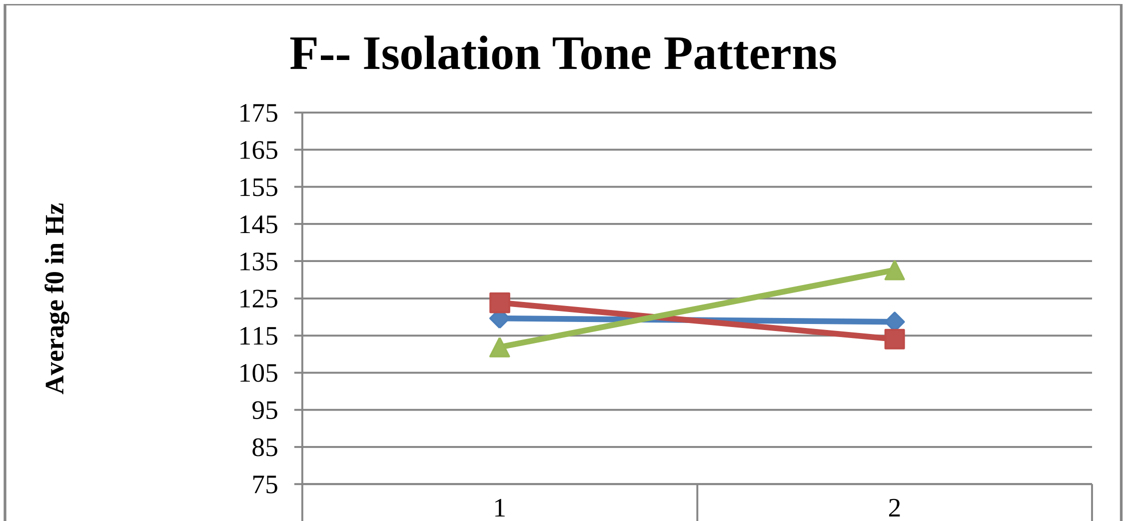
Figure **3-4**: Variations of flat tone couplets for speaker F



	1	2
iđu (H.H.) 'horse'	132.91	122.41
tʲṵtʲṵ (H.H!) 'paper'	132.4	125.99
ndivu (!H.H.) 'ancient'	122.98	115.59
kani (L.L.) 'long'	123.82	114.04

F's production of couplets with flat tone patterns seems to even better exemplify the hypothesis argued by Pike and Small (1974:110) for the neutralization of f_0 in isolated contour-less couplets. While the L.L. pattern is still slightly lower in pitch than most of the other couplets, F's data show a more narrow distribution of f_0 targets than that of speaker M.

Figure **3-5**: Isolation couplets for speaker F

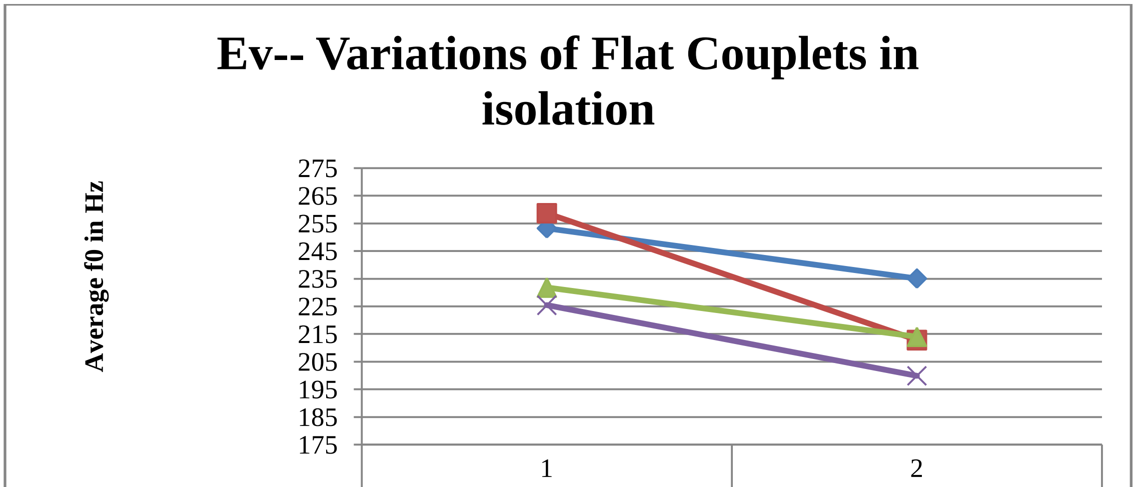


	1	2
ku̯tsi (H.H.) 'pig'	119.61	118.69
kani (L.L.) 'long'	123.82	114.04
kʷe̯ (L.H.) 'red'	111.87	132.67

Both the H.H. and the L.L. patterns show declination in the second syllable, as seen in M's production data. Any contrast between these flat tone couplets is not seen in these two words, as the L.L. /kà:nì/ begins at a higher f_0 than its H.H. counterpart /kú̯:tsí/ and shows slightly less declination. The L.H. /k^{w}ḛ̌:/ also shows a similar pattern to speaker M, but F highlights the contrast even more drastically with a pitch rise from 111.87 to 132.67 Hz, a difference of 20.8 Hz. Perhaps a more important observation here is that the tone targets for the L.H. form are noteworthy in two respects. First, the L tone in the LH form is produced at a lower f_0 than the L tone in the L.L. form, suggesting either a lowering of the initial L target in the form containing a change from L to H throughout the couplet, or alternatively, suggesting a slight raising of the L target in the "flat" L.L. form. Similarly, the realization of the H tone in the L.H. form is higher than the initial H in the flat H.H. form. Again, this suggests that in the flat isolation form, the

H target is potentially lowered to what we might descriptively call a mid tone, whereas in the L.H. form, a more clear dispersion of the L and H targets is evidenced.

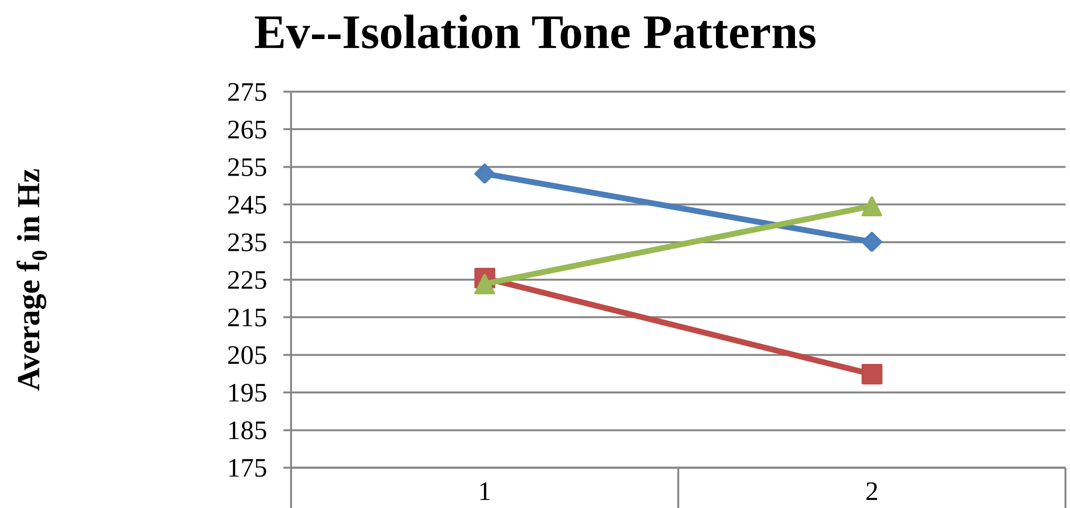
Figure **3-6**: Variations of flat tone couplets for speaker Ev



	1	2
lṵku (H.H.) 'crazy'	253.19	235.08
tʲṵtʲṵ (H.H!) 'paper'	258.69	212.77
ndivu (!H.H.) 'ancient'	231.78	213.98
kani (L.L.) long'	225.4	199.87

Ev’s flat couplets seem to be distributed over a larger pitch area than the two speakers shown above. All of the words reach their f_0 target early, followed by declination. While her amount of declination is greater than the other two participants, the spread is somewhat inconsistent, especially for the three variations of H.H. The L.L. pattern is consistently the lowest and does not cross into the pitch domain of any other the other patterns.

Figure **3-7**: Isolation couplets for speaker Ev



	1	2
lu̯ku (H.H.) 'crazy'	253.19	235.08
kani (L.L.) long'	225.4	199.87
kwe̯ (L.H.) red'	223.86	244.63

Ev's basic couplets also show a similar f_0 pattern to those demonstrated above, except for a more marked difference between the H.H. and L.L. couplets as mentioned under the previous table. Her production of /k^{w}ḛ̆:/ is different in that her target for the second tone (H), though it reaches an f_0 above the second H of the H.H. couplet, is still not as high as the initial H of the H.H. couplet. Overall, for Ev, we seem to see an initial L target for L.L. words that is similar to that of M, with no clear difference between the L in L.L. and the L in L.H. Regarding the implementation of H, the H target in the H.H. form remains higher than the H in the L.H. form. It may thus be the case that L.L. and H.H. forms, at least for this speaker in this recording session, were dispersed rather than neutralized as per the description of Pike and Small (1974). That is, it may be the case that Ev is realizing isolation forms by implementing more clearly dispersed H and L pitch targets in H.H. and L.L. forms, respectively.

3.4 Summary

In this chapter I have attempted to provide the reader with a portrait of the way isolated tone patterns are implemented in CM, and I have also provided a sense of the variability in the realization of tones across speakers. Recorded data of the three most frequent couplet patterns produced by three L1 speakers of CM showed that flat tone patterns like H.H. and L.L. reach their f_0 targets early on the first syllable of the word and decline on the second identical tone. This is true of all three speakers. There seemed to be a slight difference between the isolated flat patterns, but the difference was small and was not identical across speakers. The limited data presented here are not sufficient to run a statistical analysis of isolated flat f_0 patterns, but the observations made by Pike and Small (1974) concerning the neutralization of H.H. and L.L. in isolation do not seem entirely unwarranted and may be borne out by a larger sample of both tokens and speakers.

The L.H. pattern of the word /kʷḛ̆:/, meaning ‘red,’ was consistently pronounced with two clear pitch targets by all three speakers. The word-initial L tone of L.H. approximated the pitch of other initial L tones (L in L.L. couplets), whereas the final H of the L.H. pattern approximated the word-initial H target of H.H. patterned words. This sharp rise reveals the importance of making a clear contrast when more than one pitch target appears in a word or phrase. The primary difference across the three speakers had to do with the comparison of the realization of LH forms with the initial L and final H targets of each person's LL and HH forms.

In the following chapter the basic tone contrasts seen here will be examined in light of the process of terracing downstep. In order to do this, the isolated patterns demonstrated above will be combined into two word phrases, allowing for an investigation into the way toned from separate words interact in combination.

Chapter 4

The phonetic implementation of terrace tone downstep in CM phrases

4.1 Terracing effects and lowering processes

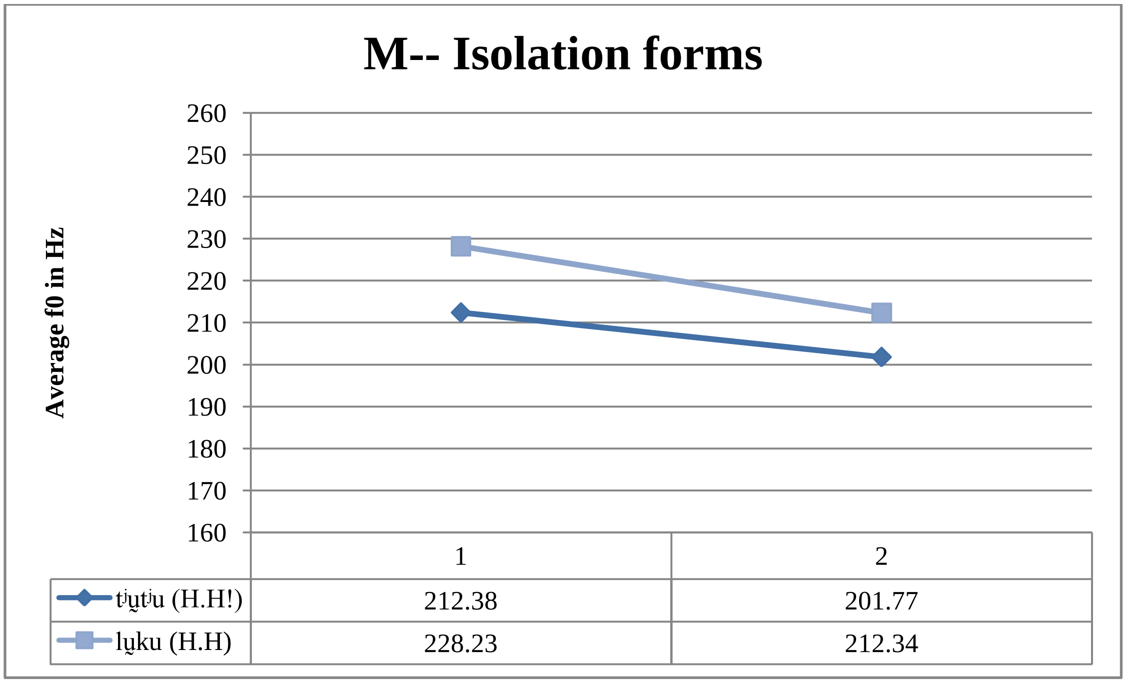
In §2.3.2. and 2.7.2. the process phoneme /!/ was introduced as a concept hypothesized by Pike and Small to cause terraced downstep in certain phonological environments of CM. This process phoneme is thought to have no specific phonetic content of its own, but nonetheless causes a change in pitch key by exerting a lowering influence when an H immediately follows (Pike and Small, 1974:106). This process is unpredictable in its manifestation, given that certain morphemes seem to trigger downstep whereas others do not, suggesting that the trigger for downstep must be lexically specified The subsequent section provides a description of the implementation of tone terracing downstep in CM. Following a similar pattern to chapter 3, this chapter focuses on how downstep affects the three most common isolation tone patterns in CM: H.H., L.L., and L.H. Combined with an initial H.H! tone word, /tʲṵ́:tʲú!/, meaning 'paper,' that has been posited to cause downstep (Pike and Small, 1974:106), the implementation of these three basic tone patterns within a two-word phrase is investigated.

4.2 Phonetic implementation of H.H. class couplets following /!/

The following figures and charts show how the tones of an H.H. couplet are influenced by the presence of a downstep phoneme /!/. As mentioned, Pike and Small report that when /!/ is immediately followed by an H tone, the result is a change to a lowered pitch key (1974:115). For each of the three speakers, the isolation tones of the couplet are shown in the first line chart, followed by an analysis of the same words spoken in connected speech. The phrase used to investigate the acoustic manifestation of downstep is /tʲṵ́:tʲú! lṵ́:kú/, which means 'crazy paper.'

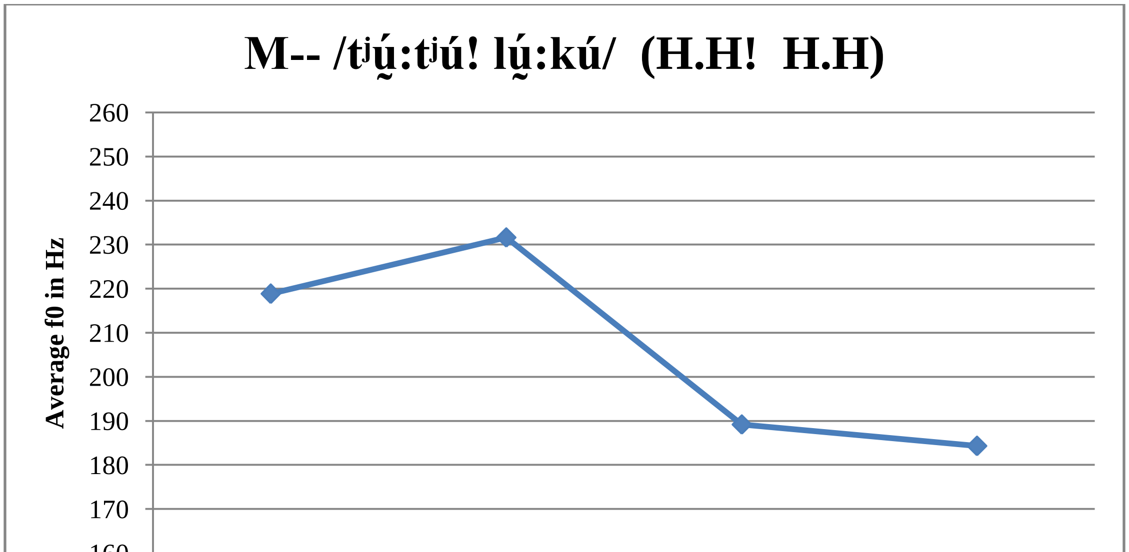
4.2.1 Speaker M's production of /tʲṵ́:tʲú lṵ́:kú/

Figure **4-2-1**: Isolation forms for speaker M /tʲṵ́:tʲú!/ and /lṵ́:kú/



In isolation these two words appear to have similar tone patterns. As discussed in chapter 3, the f_0 target is reached in the first syllable and is followed by a declination in pitch on the second syllable. When spoken in combination however, the implementation of these two couplets is markedly different:

Figure **4-2-2**: Downstep form for speaker M /tʲṵ́:tʲú! lṵ́:kú/

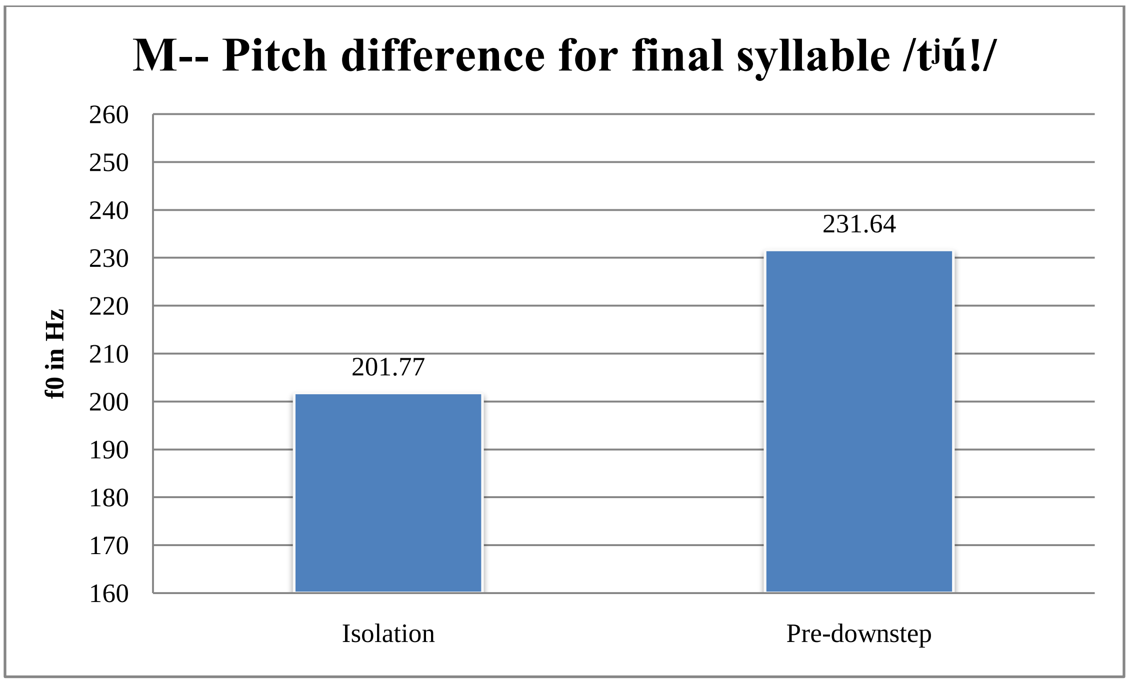


	tʲṵ́	tʲṵ́!	lṵ́	kú
M	218.85	231.64	189.21	184.3

Pike and Small (1974) posit that the word-final process phoneme of /tʲṵ́:tʲú!/ will cause a downstep when a H tone immediately follows it. The above figure strongly advocates for this observation in the evident pattern of a step-up in pitch followed by a drastic step-down. This pattern provides valuable insight into the implementation of downstep, particularly in regards to the way downstep exerts a clear influence on the first of the two couplets.

The first and most striking observation to be made here is that the f_0 target of /tʲṵ́:tʲú!/ no longer falls on the initial syllable of the word, as seen in figure 4.2.1. Instead of declination on the second syllable /tʲú!/, a rise leads to a final pitch target of 231.64 Hz, suggesting that the location of the peak target has changed in the form. Interestingly, the result is a pattern that looks much like that demonstrated by Laniran in her data on Yorùbá, in which the f_0 target in sentences of adjacent identical tones was not reached until late in the phrase (1993). In addition to being realized on the second instead of on the first syllable, the pre-downstep f_0 target is also higher than the f_0 target of the same word in isolation (231.64 Hz and 212.38 Hz respectively; a difference of 19.26 Hz). Speaker M may be using this switch in target placement as well as a rise in the value of the f_0 target as a mechanism to increase the acoustic salience of the pitch drop-off caused by downstep. Another way to consider this is that the process phoneme /!/ may also be exerting a type of 'up-step' effect on the phrase.

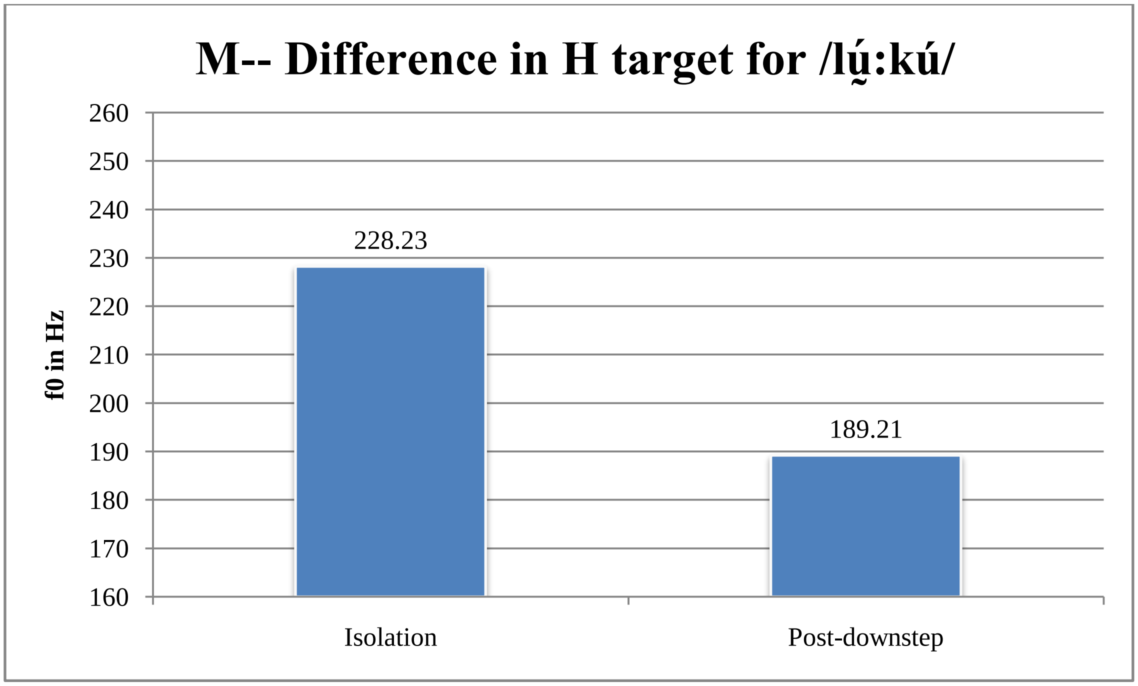
Figure **4-2-3**: Pitch difference for final syllable /tʲú!/ for speaker M



Here we can again visually see how the pre-downstep syllable /tʲú!/ avoids declination and instead rises prior to the third syllable in the string.

Secondly, a marked difference is visible between the implementation of the word /lṵ́:kú/ in isolation and in sentence context. While the f_0 target is still reached on the first syllable in both environments, as **4-2-2** shows, a difference in the value of the f_0 of the target is clearly seen:

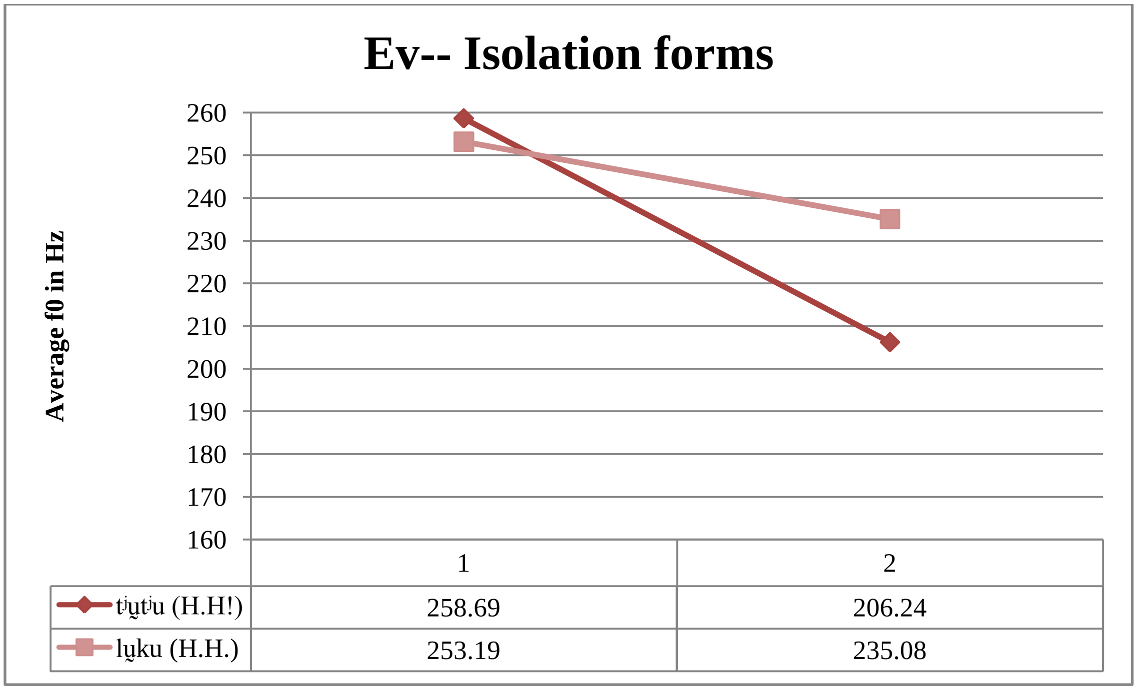
Figure **4-2-4**: Difference in H target for /lṵ́:kú/ for speaker M



Instead of approximating to the H isolation f_0 target of 228.23 Hz, M only reaches 189.21 Hz, a difference of 39.02 Hz. M's production of this phrase seems to indicate that when these two words are spoken in a sentence, both words be implemented with different targets than when produced in isolated speech. Combined with the shift in target manifestation in /tʲṵ́:tʲú!/, an apparent step-up, step-down pattern is clearly seen. This tone dispersion pattern may be a mechanism used by speaker M to strongly indicate the presence of downstep and thereby increase the acoustic salience for the listener. However, as is shown in the subsequent data, it is not only M that uses this pattern—a pattern of dispersion, which is the dissimilation of items in an attempt to distinguish each from the others, is also produced by other speakers.

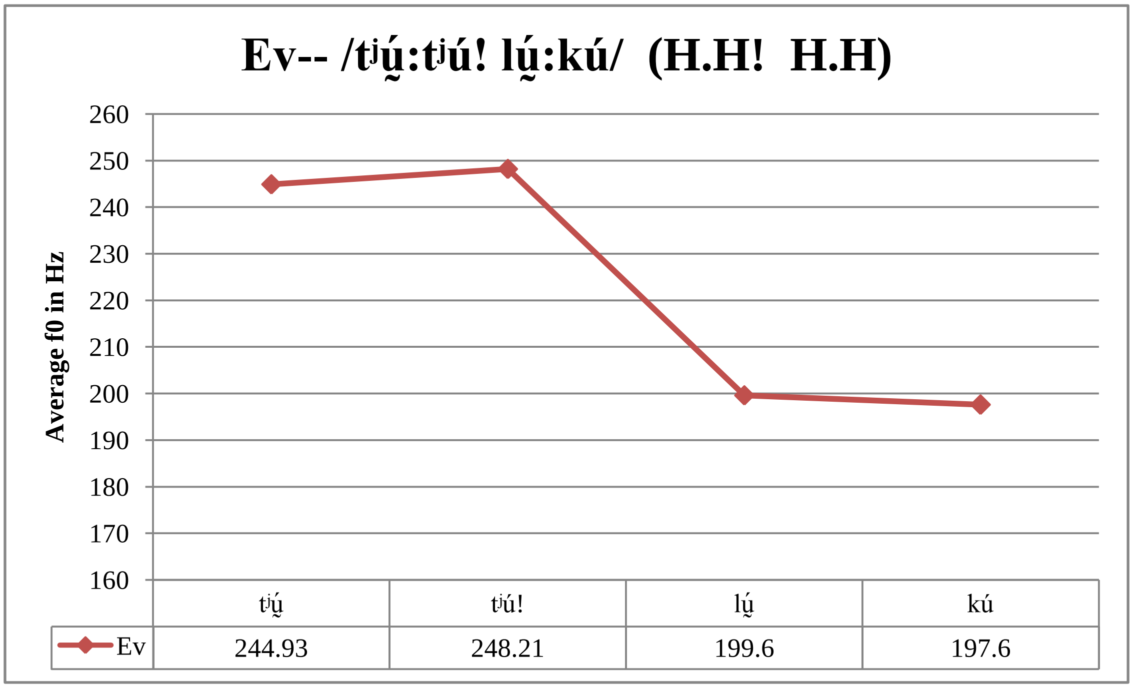
4.2.2 Speaker Ev's production of /tʲṵ́:tʲú lṵ́:kú/

Figure **4-2-5**: Isolation forms for speaker Ev /tʲṵ́t:ʲú!/ and /lṵ́:kú/



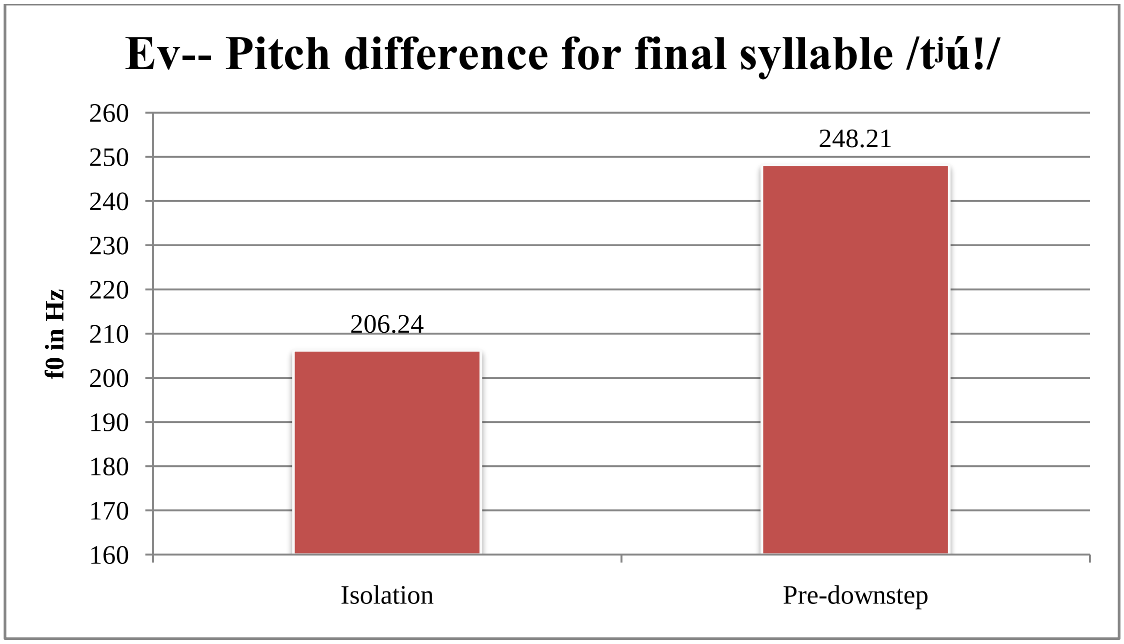
Ev's isolation forms look slightly different than those of speaker M. The amount of declination across both forms differs, but the H f_0 targets are relatively similar and fall on the initial syllables (see §3.3). Like M, these tone patterns are implemented differently when spoken in context:

Figure **4-2-6**: Downstep form for speaker Ev /tʲṵ́:tʲú! lṵ́:kú/



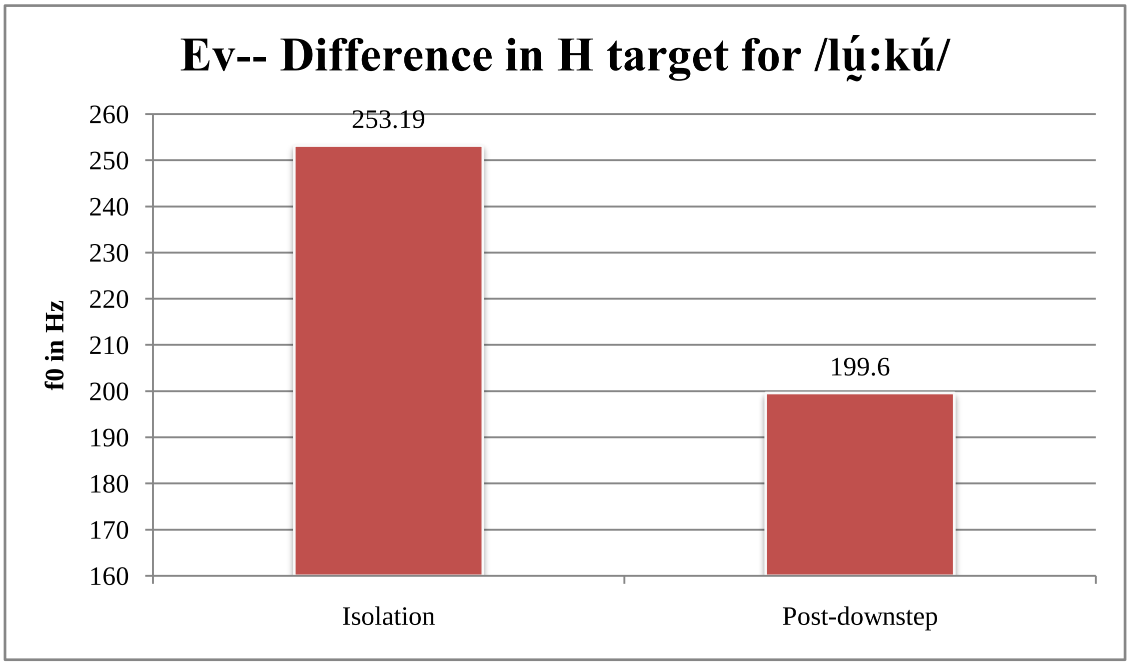
Ev's data also show a sharp drop in pitch between the two couplets. Her pattern mirrors that of speaker M in that the H target in the first couplet moves away from the initial syllabe and is placed on the second, resulting in a step-up, step-down pattern as seen previously. The step-up is not as obvious as that seen in figure 2.1.1., but the f_0 nonetheless rises slightly and resists the declination process that is prevalent across isolated, flat-toned words (see §3.3).

Figure **4-2-7**: Pitch difference for final syllable /tʲú!/ for speaker E



In the pre-downstep syllable, /tʲú!/, we see a much higher pitch that what is produced by Ev in isolation. Unlike speaker M, however, Ev does not raise the f_0 target to the same height as in the isolation form (248.21 Hz v. 258.69 Hz respectively), but still avoids declination.

Figure **4-2-8**: Difference in H target for /lṳ́:kú/ for speaker Ev

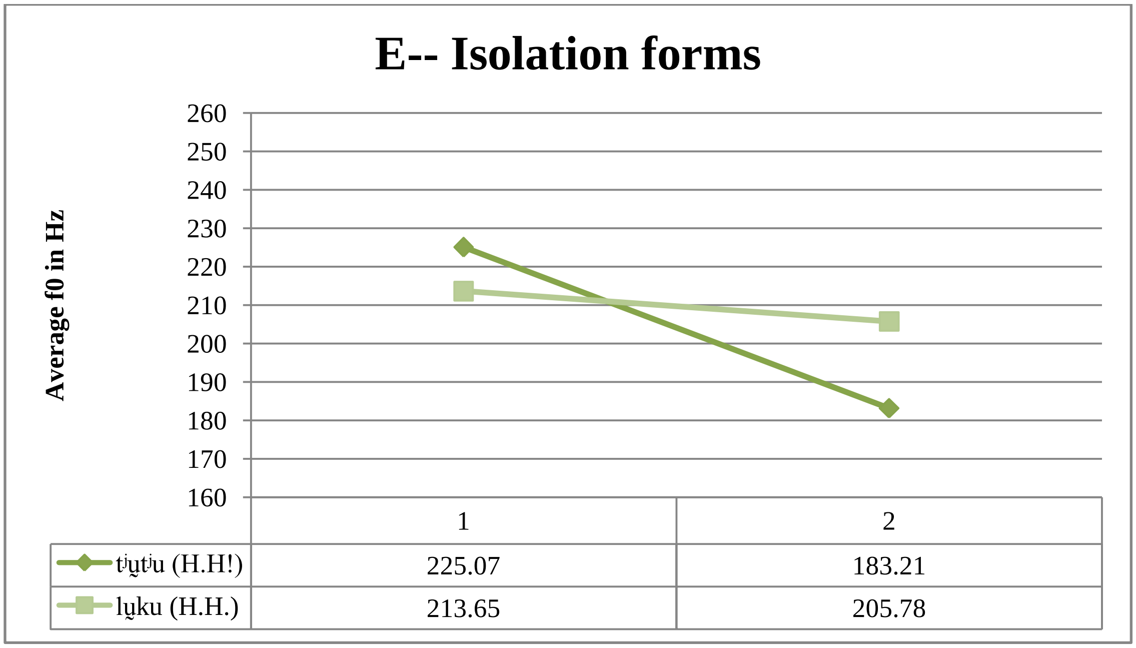


In the post-downstep syllable, /lṳ́:/, the f_0 target appears to be lowered, with a difference of 53.59 Hz across the isolation and the context targets. This difference is much greater than that produced by M, who demonstrated only a 39.02 difference between her isolated and contextual productions of the syllable /lṳ́:/. This heightened drop may offset the rather slight rise Ev implements on the pre-downstep syllable. For Ev, the combination of a slight rise in pitch on the pre-downstep syllable and the sharp fall on the post-downstep syllable result in a pitch fall of 48.61 Hz. For M, even with a sharper rise on the pre-downstep syllable and a drop on the post-downstep syllable, achieved a slightly more narrow pitch fall of 42.43 Hz.

While the implementation method used by Ev diverges in some ways from that used by speaker M, the end result is nonetheless similar. By avoiding declination and implementing a slight rise on the pre-downstep syllable while lowering the pitch target of the post-downstep syllable, speaker Ev highlights the presence of downstep in this two word phrase, affectively increasing the salience of the different H targets.

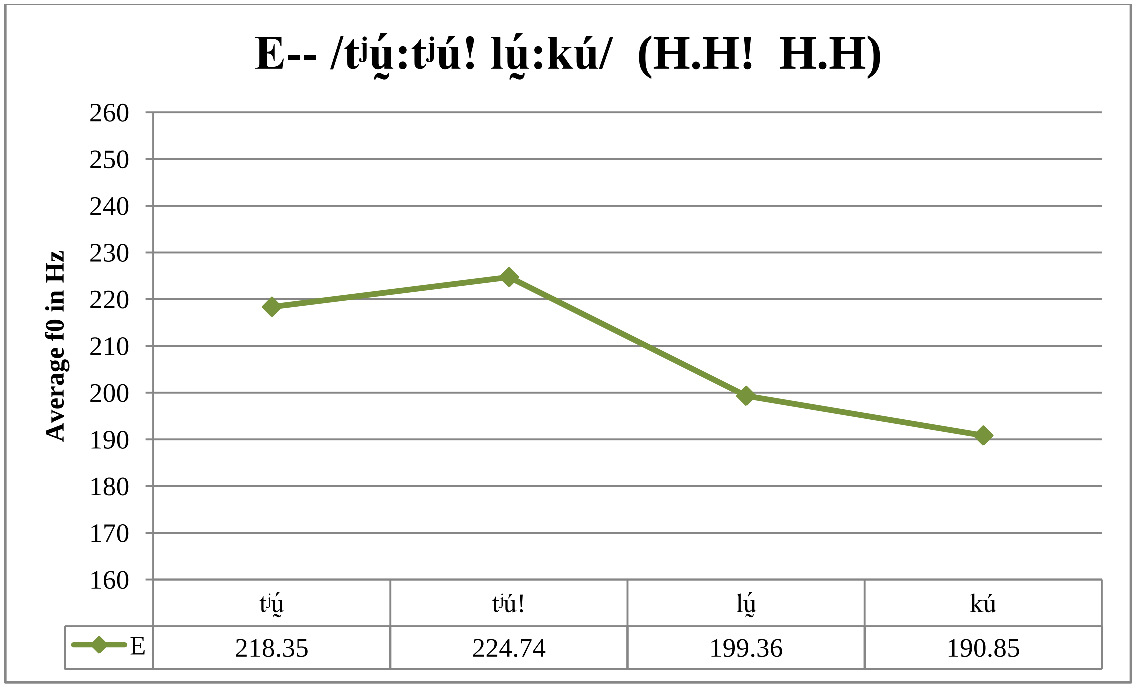
4.2.3 Speaker E's production of /tʲṵ́:tʲú lṵ́:kú/

Figure **4-2-9**: Isolation forms for speaker E /tʲṵ́:tʲú!/ and /lṵ́:kú/



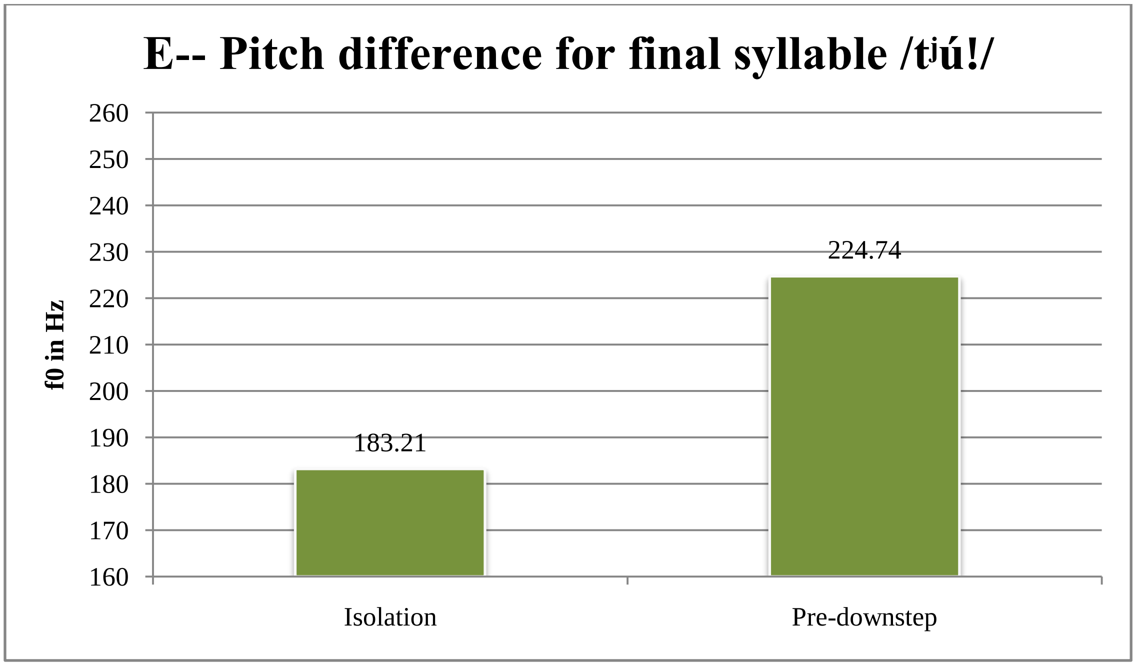
Our final speaker exhibits isolation patterns that parallel those of Ev. While the f_0 targets and rate of declination of E's isolated forms appear to have different slopes, the difference is rather slight. In both words, as seen above and in chapter 3, the pitch target is reached on the first syllable, following by a drop in pitch on the second. Speaker E, like speakers M and Ev above, also shows a clear contrast in tone implementation when these two words are produced in combination.

Figure **4-2-10**: Downstep form for speaker E /tʲṵ́:tʲú! lṵ́:kú/



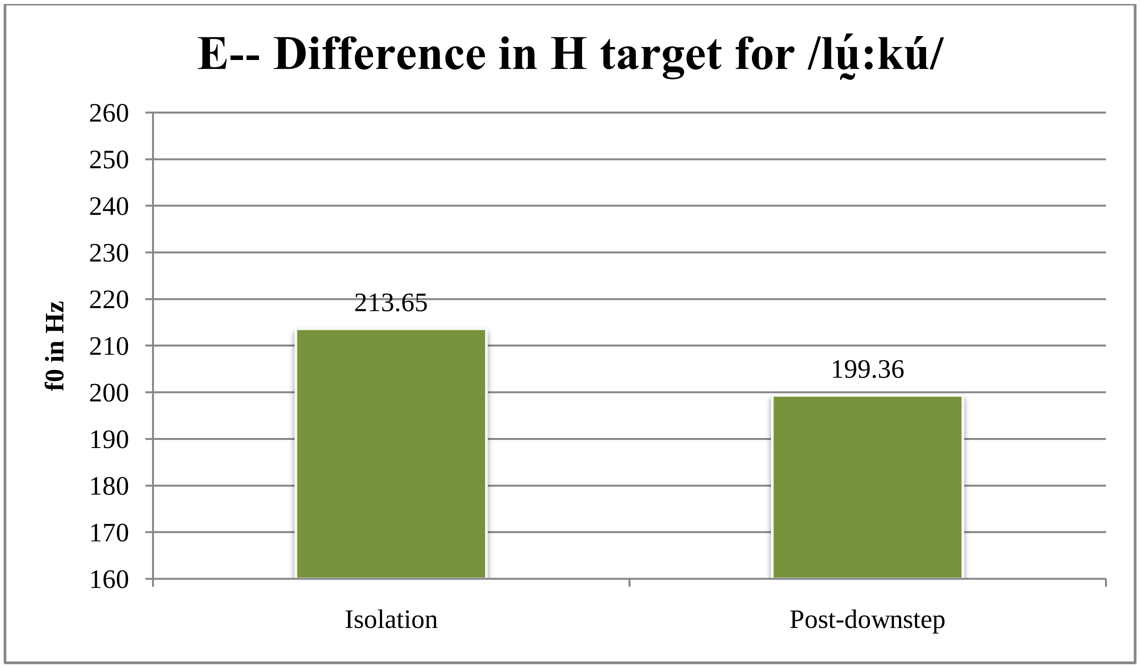
As seen in the previous charts and graphs, E also produces a pre-downstep pitch rise followed by a marked fall on the post-downstep syllable. The f_0 target for /tʲṵ́:tʲú!/ again is displaced from the first syllable and is pronounced on the second. The target for /lṵ́:kú/ is not shifted, but is lower than the target that is produced when the word is spoken in isolation. Again, this anticipatory rise followed by a sharp fall provides an enhanced acoustic signal of downstep, and can be more clearly seen in the bar graphs below.

Figure **4-2-11**: Pitch difference for final syllable /tʲú!/ for speaker E



In isolation, the f_0 target of the word /tʲṵ́:tʲú!/ is produced on the first syllable, with a target of 225.07 Hz. The final syllable has an average frequency of 183.21 Hz for speaker E. However, when downstep will be triggered by the presence of an adjacent word beginning with an H tone, anticipatory measures are taken and the process of declination is avoided. For speaker E, the word's f_0 target remains the same (225.07 Hz in isolation and 224.74 Hz in context), but the target is shifted to a point late in the syllable as a preparation for the coming pitch drop.

Figure **4-2-12**: Difference in H target for /lṵ́:kú/ for speaker E

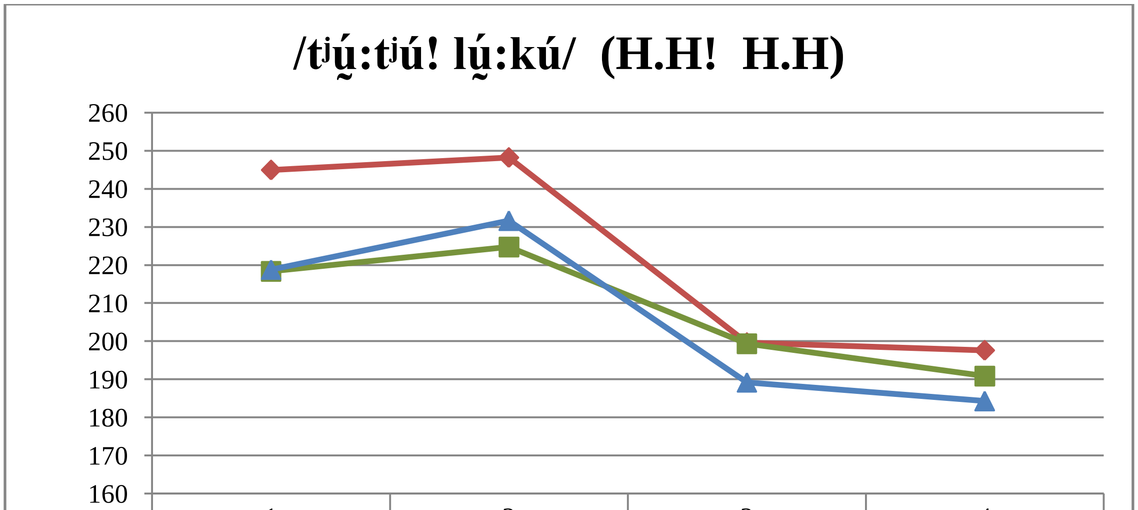


The post-downstep syllable of /lṵ́:/ maintains the position of its target, but its value does change. As with speakers M and Ev, E implements a lower target in order to enhance the acoustic salience of the downstep process, resulting in a difference of 14.29 Hz between the isolation and context targets.

4.2.4 Summary for /!/ + H.H. phrases

For all three speakers above, the phonetic implementation of tone in isolated words and in the two-word phrase /tʲṵ́:tʲú! lṵ́:kú/, 'paper crazy,' was markedly different, as shown in the following chart, which includes the context forms produced by all three speakers:

Figure **4-2-13**: /tʲṵ́:tʲú! lṵ́:kú/ for all speakers



	1	2	3	4
Ev	244.93	248.21	199.6	197.6
E	218.35	224.74	199.36	190.85
M	218.85	231.64	189.21	184.3

In addition to the shifting of the f_0 target point from the first syllable of /tʲṵ́:tʲú!/ to its pre-downstep syllable, the value of the targets immediately adjacent to the point of downstep were subject to change. All speakers noticeably lowered the H f_0 target value of the post-downstep word /lṵ́:kú/, with an average difference between isolation and context targets of 35.62 Hz across all three speakers.[3] While the pre-downstep syllable strongly resisted the influence of pitch declination, the extent of the difference in pitch target differed for each speaker. M produced a pitch target in context that was higher than the isolation target, Ev produced one that was slightly lower than the isolation variant, whereas E maintained the same pitch target in both the context and the isolation forms.

The combination of a late f_0 peak followed by a lowered f_0 target may point to speakers' efforts to disperse the H tones surrounding the downstep trigger as much as

[3] A large amount of variance is seen across the three participants. The f_0 difference for each is as follows: M=39.02 Hz, Ev=53.59 Hz, E=14.29 Hz.

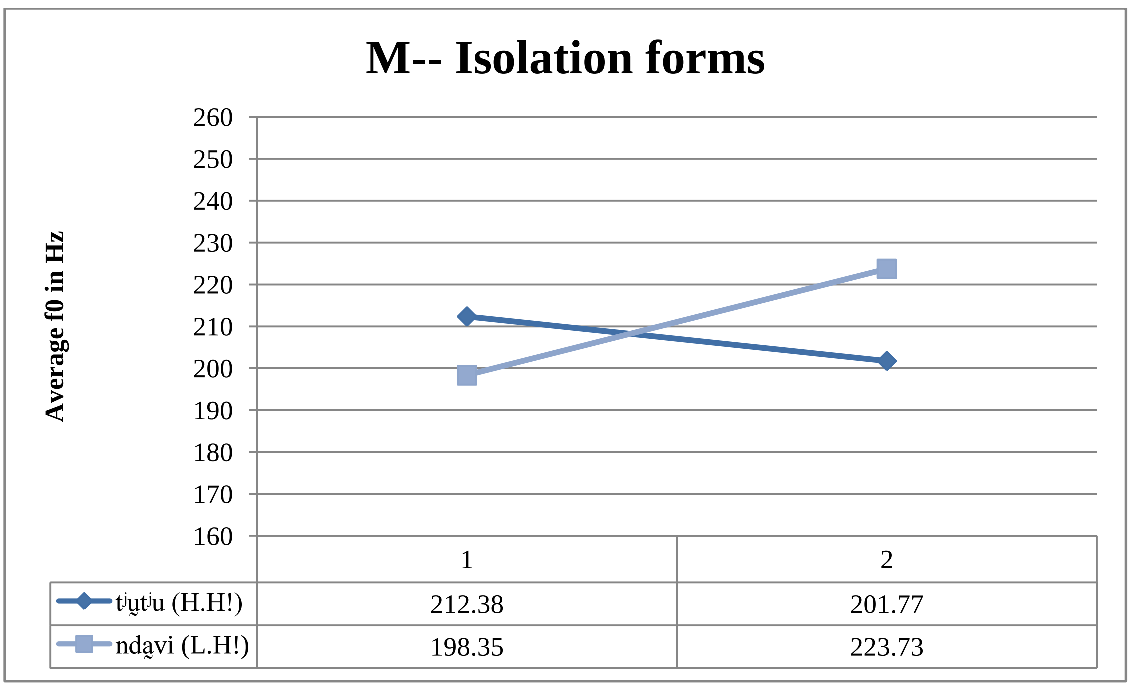
possible. By adjusting both of the H tones that lie immediately adjacent to /!/, speakers may enhance the acoustic saliency of the downstep process.

4.3 Phonetic implementation of L.H. class couplets following /!/

According to rule 2 of Pike and Small's analysis of tone downstep in CM, a process phoneme /!/ will be lost when contiguous to L and will fail to cause downstep (1974:115). The tones of the L.H. couplet are not expected to undergo any processes of tone sandhi and should retain its same rising pattern even when spoken in sentence context. The phrase used below to demonstrate the implementation of tone in a /!/ plus L.H. couplet utterance is /tʲṵ́:tʲú! ^{n}dà̰:ví/, meaning 'poor paper.'

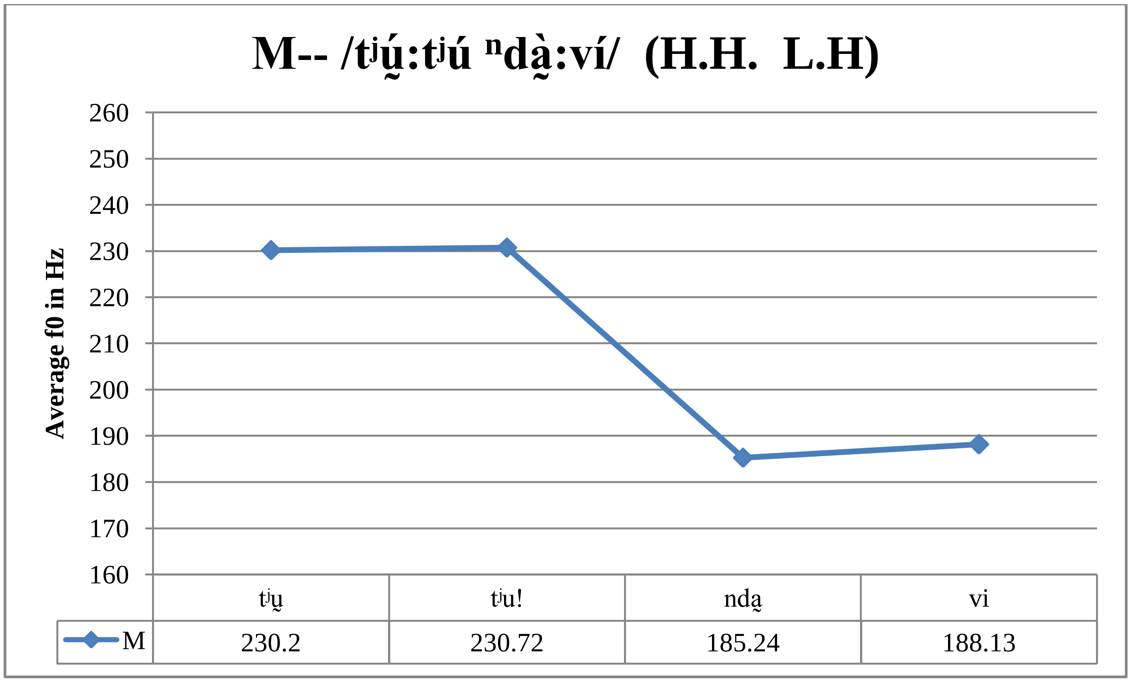
4.3.1 Speaker M's production of /tʲṵ́:tʲú! ^{n}dà̰:ví/

Figure **4-3-1**: Isolation forms for speaker M /tʲṵ́:tʲú!/ and /^{n}dà̰:ví/



In isolation, M's production of the H.H! couplet /tʲṵ́:tʲú!/ is the same as what is described above. The H f_0 target is reached on the first syllable of the word while the second syllable is vulnerable to declination. The L.H. couplet /^{n}dà̰:ví/ consists of two targets (as discussed in chapter 3). The L target is placed on the first syllable, and has an average value of 198.35 Hz before a sharp rise to the H target on the second syllable, with a value of 223.73 Hz. When these words are spoken in context, these patterns alter slightly.

Figure **4-3-2**: Context form for speaker M /tʲṵ̰́:tʲú! ^{n}dà̰:ví/

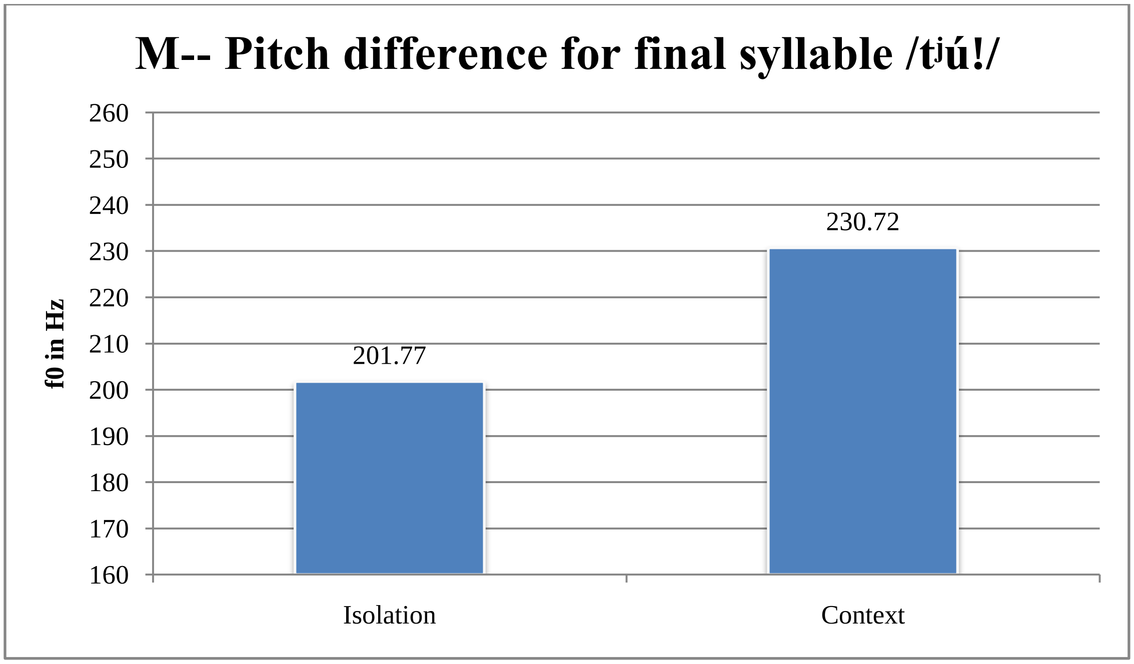


As demonstrated in the previous section, it seems that the H f_0 target of the first word /tʲṵ̰́:tʲú!/ has been displaced to the second syllable, resulting in a pattern that is markedly different from that of its isolation form. While there is no substantial increase in pitch across the two syllables, M resists declination, resulting in a level pattern before a sharp drop to the L target of the following word. The target of the H.H. couplet in sentence context is 230.72 Hz, whereas it is only 212.38 Hz when spoken in isolation. The following L tone is in striking contrast with the previous H, and while the rising tone of the word /^{n}dà̰:ví/ is not as salient as in isolation, the lack of declination indicates its separation from flat-toned patterns.

What may strike the reader is the fact that this line graph looks similar to that of Figure **4-2-1**, where a post-process phoneme H tone is lowered in order to highlight the implementation of terraced tone downstep. This graph shows a similar shape, but there are several factors that may afford some clarity in regards to any potential confusion. It is important to remember that in §4.2, both the words /tʲṵ́:tʲú!/ and /lṵ́:kú/ are H.H. tone couplets. That means that in terms of phonology, they should have relatively the same pitch value (see §2.2 for discussion). However, we have seen how phonetic processes may influence the implementation of these tones, making an H tone appear differently in different phonetic environments.

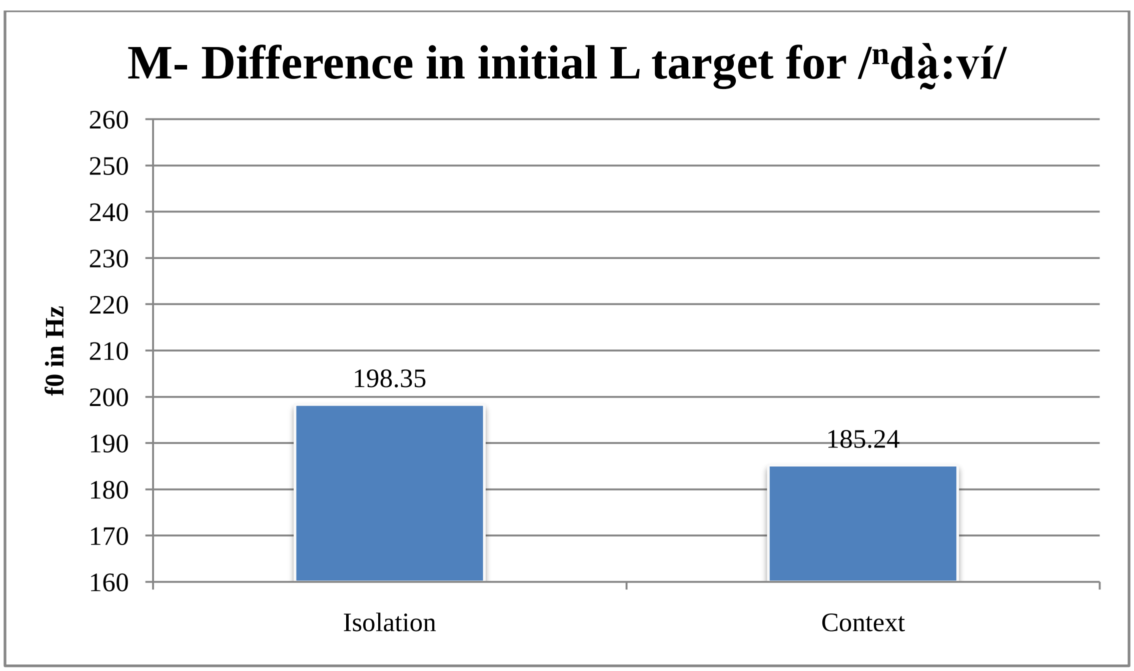
The first syllable of the word /^{n}dà̰:ví/ contains a L f_0 target in isolation. The chart above seems to indicate that a similar pitch target is retained even when spoken in sentence context. Thus, unlike /lṵ́:kú/, which experiences a drastic change in terms of its manifestation as an H.H. couplet, the effect of phonetic environment on the implementation of /^{n}dà̰:ví/ is relatively small. M's use of a similar pattern as that discussed in §4.2 may be the manifestation of another style of tone dispersion—this time in an attempt to create a strong contrast between an H tone and an adjacent L tone. This dispersion can be further seen in the following two bar charts, where the difference in the isolation and the context pitches are shown.

Figure **4-3-3**: Pitch difference for final syllable /tʲú!/ for speaker M



With the shifting of the f_0 target to syllable and the subsequent lack of declination, the pre-pitch drop syllable /tʲú!/ rises to a Hz level that is higher than its isolation counterpart, in preparation for the adjacent L target.

Figure **4-3-4**: Difference in L target for /ⁿdà̰:ví/ for speaker M

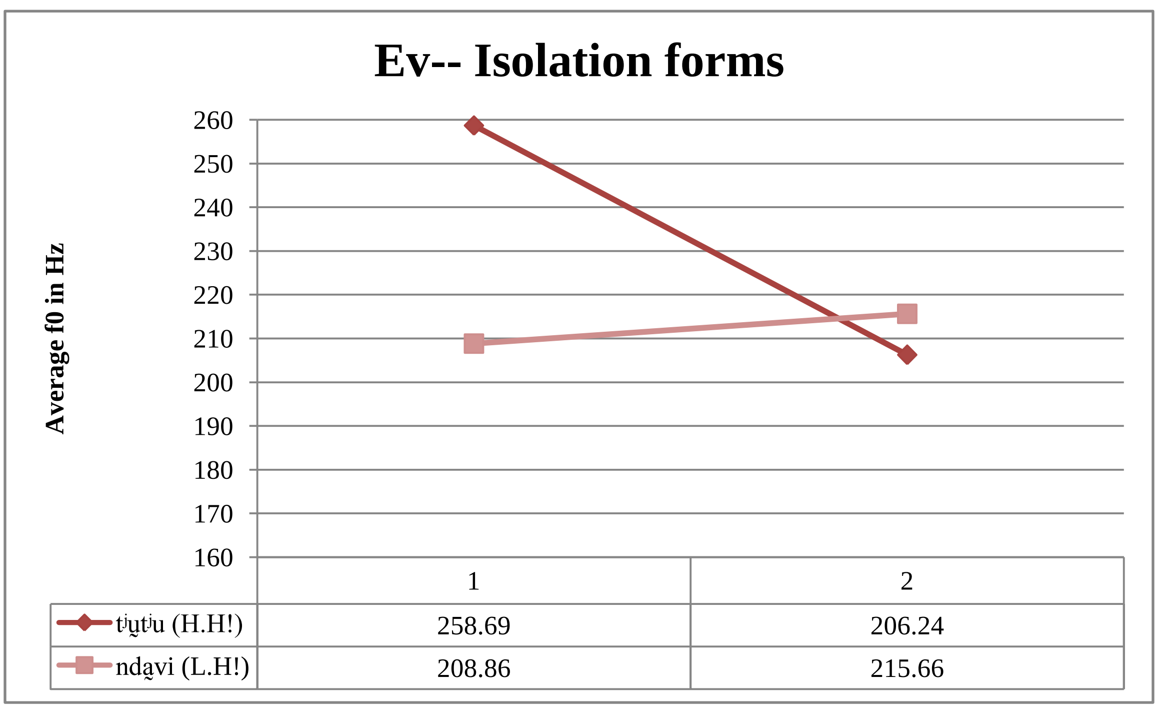


After reaching this H target, a sharp fall in f_0 occurs as M drops to produce a L target of 185.24 Hz. This target is lower than that produced in isolation, with a difference of 13.11 Hz. Combined with a heightened adjacent H tone, this exaggeration of the L target allows for increased dispersion between the two pitch targets.

An observation to keep in mind is the fact that this L target is close in value to the lowered H tone of the previous phrase discussed, /tʲṵ́:tʲú! lṵ́kú/, in which the post-/!/ syllable had a target of 189.21 for the same speaker. Thus, M's downstepped H tone of §4.2.1 is not necessarily different from a post-H L tone in terms of f_0. This may indicate that a lowered H can encroach on the phonetic domain of a L tone is certain phonetic environments.

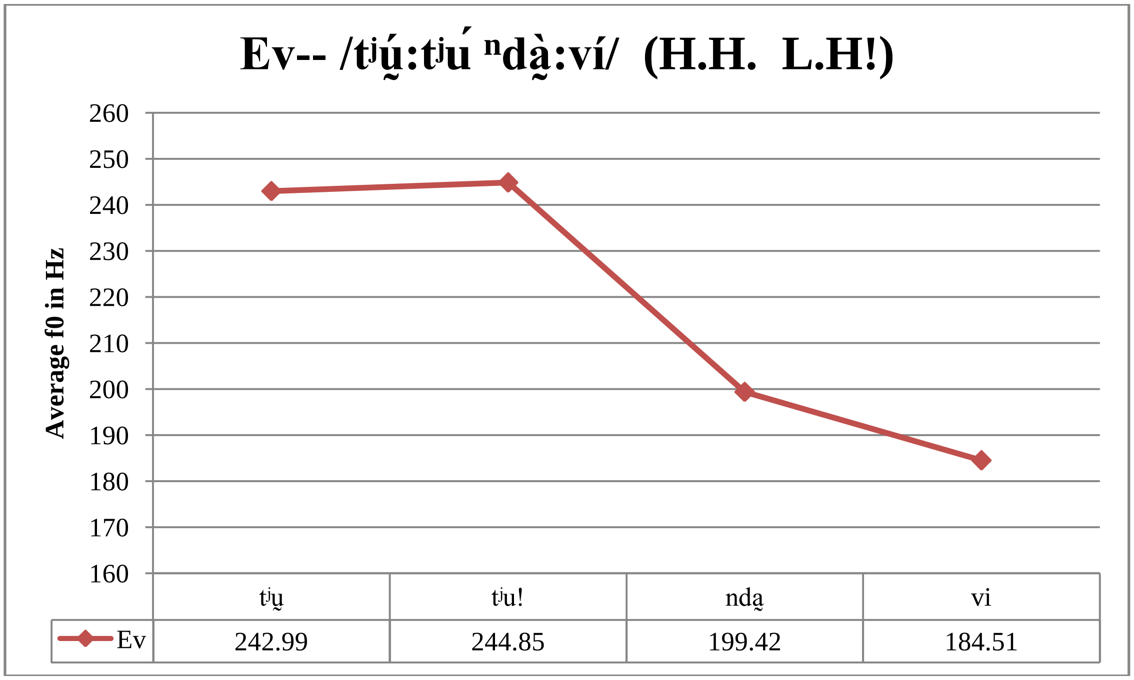
4.3.2 Speaker Ev's production of /tʲṵ́:tʲú! ^{n}dà̰:ví/

Figure **4-3-5**: Isolation forms for speaker Ev /tʲṵ́:tʲú!/ and /^{n}dà̰:ví/



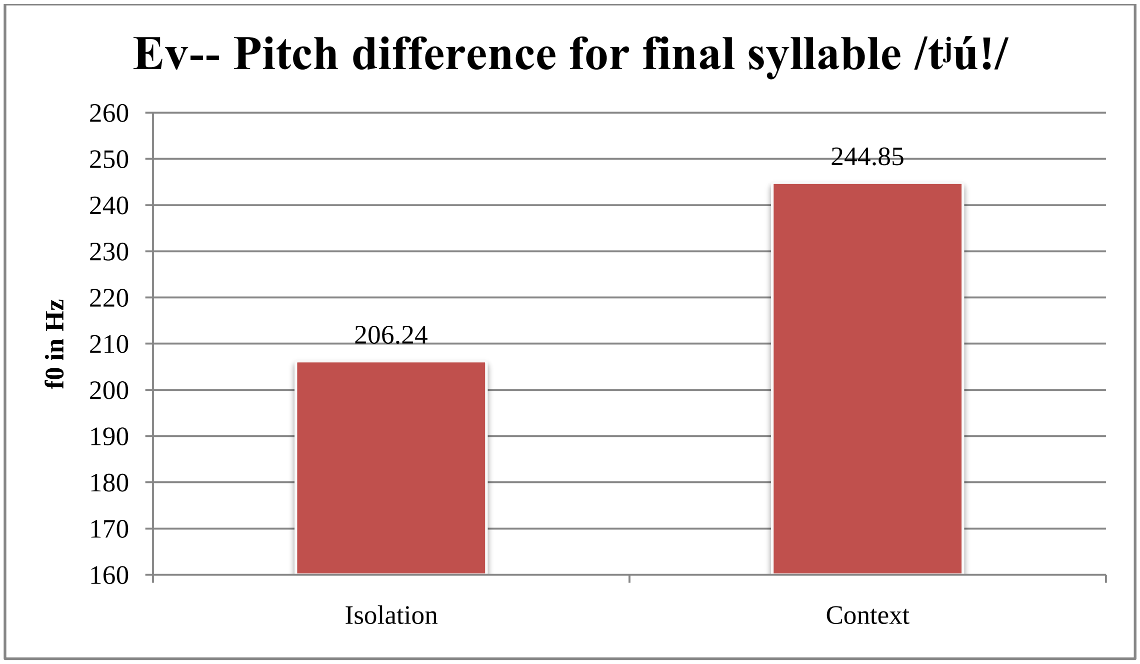
Ev's isolation patterns differ from speaker M in a number of ways. First, there is a greater disparity between the initial pitch targets of these two words in isolation, with the initial L tone of /^{n}dà̰:ví/ being produced at a frequency that is a full 49.83 Hz lower than the H target of /tʲṵ́:tʲú!/. The declination on the second syllable of /tʲṵ́:tʲú!/ is sharp. Contrastively, the rise to the H target of /^{n}dà̰:ví/ is slight.

Figure **4-3-6:** Context form for speaker Ev /tʲṵ́:tʲú! ^{n}dà̰:ví/



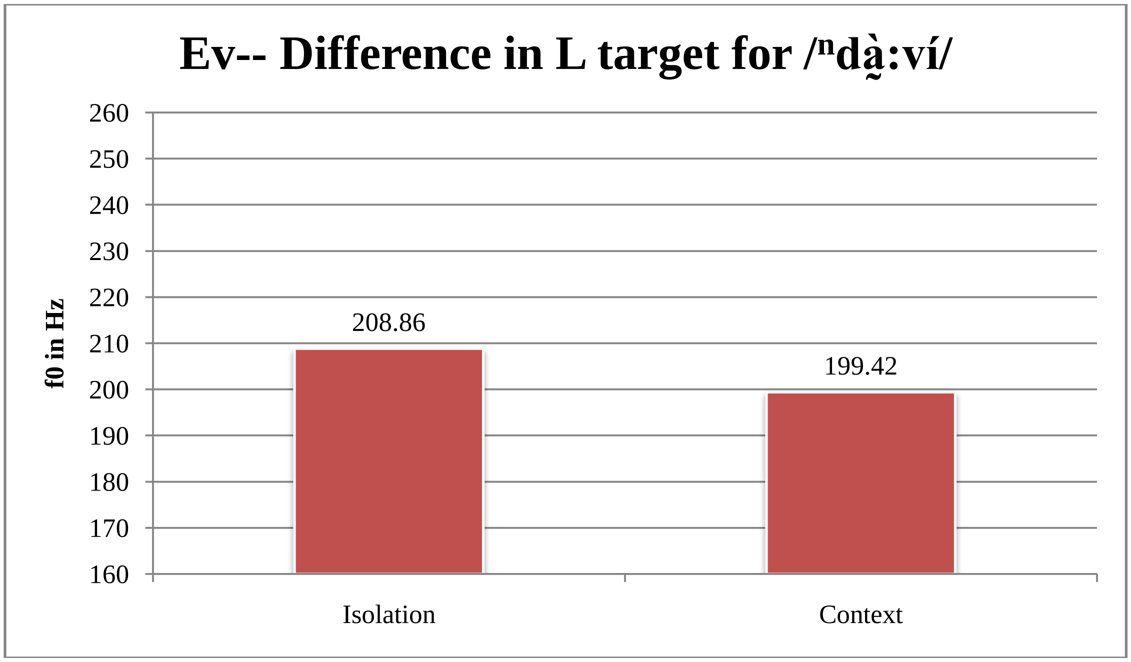
Ev’s context pattern shows some similarities to that of speaker M. Again, the ajunction of an H target next to a sharp pitch fall motivates the movement of the H target of /tʲṵ́:tʲú!/ to the second syllable, also resulting in a resistance to declination. However, the f_0 target value produced here does not near the level of the f_0 target demonstrated in isolation (244.85 and 258.69 Hz respectively). Following the H target of the first word is the expected sharp drop in pitch, reaching a L target of 199.42 Hz. Ev seems to abandon the expression of the rising tone pattern of /^{n}dà̰:ví/ and rather than reach a final H target, instead produces a strongly declined f_0 target on the phrase-final syllable. The following bar graphs highlight the difference between isolation and contexts tones occurring at the edge of the H to L f_0 drop.

Figure **4-3-7**: Pitch difference for final syllable /tʲú!/ for speaker Ev



Confirming the analysis of the data seen so far, on the syllable prior to the substancial f_0 drop, Ev avoids declination by shifting the pitch target to the second syllable, allowing for a maximum amount of contrast on the following L tone. The difference between the declined isolation syllable and the sentence context syllable is 38.61 Hz.

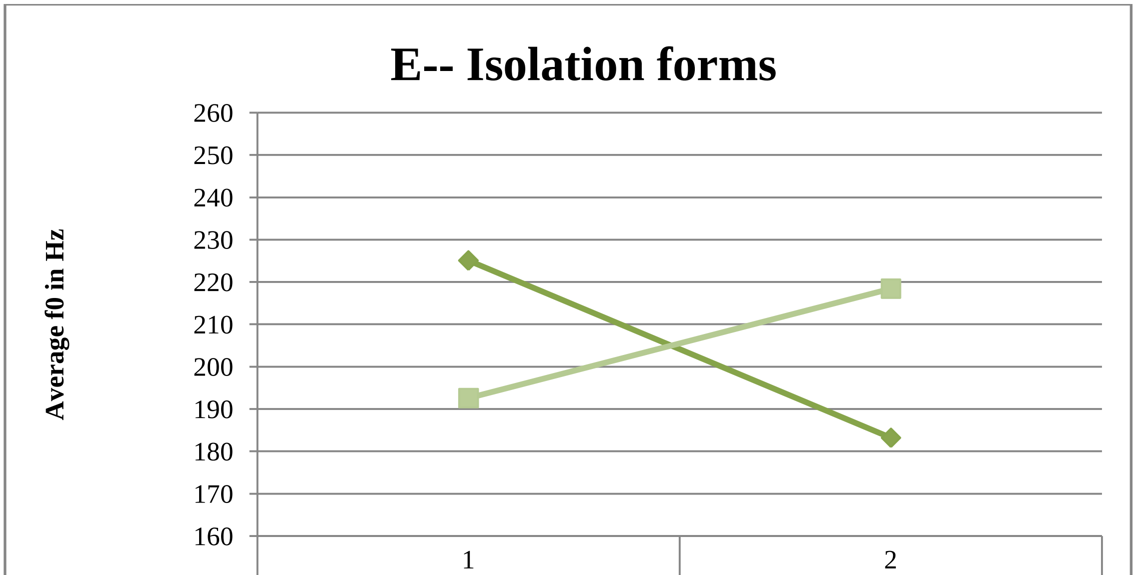
Figure **4-3-8**: Difference in L target for /^{n}dà̰:ví/ for speaker Ev



In context, the L target of the LH word /^{n}dà̰:ví/ is lowered, with a difference of 9.44 Hz between the isolation and context f_0 targets. While this difference is slight, it may indicate that speaker Ev is utilizing a mechanism of target pitch lowering in an attempt to provide further contrast between H and L tones in spoken language.

4.3.3 Speaker E’s production of /tʲṵ́:tʲú! ^{n}dà̰:ví/

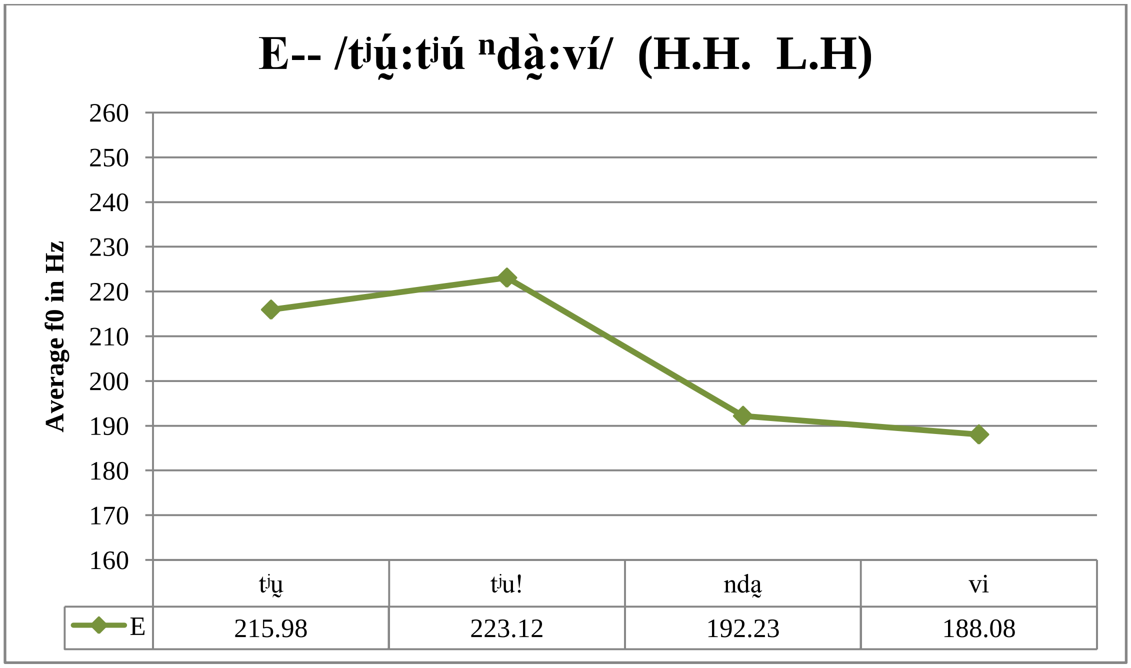
Figure **4-3-9**: Isolation forms for speaker E /tʲṵ́:tʲú!/ and /^{n}dà̰:ví/



	1	2
tʲṵtʲu (H.H!)	225.07	183.21
nda̰vi (L.H!)	192.61	218.43

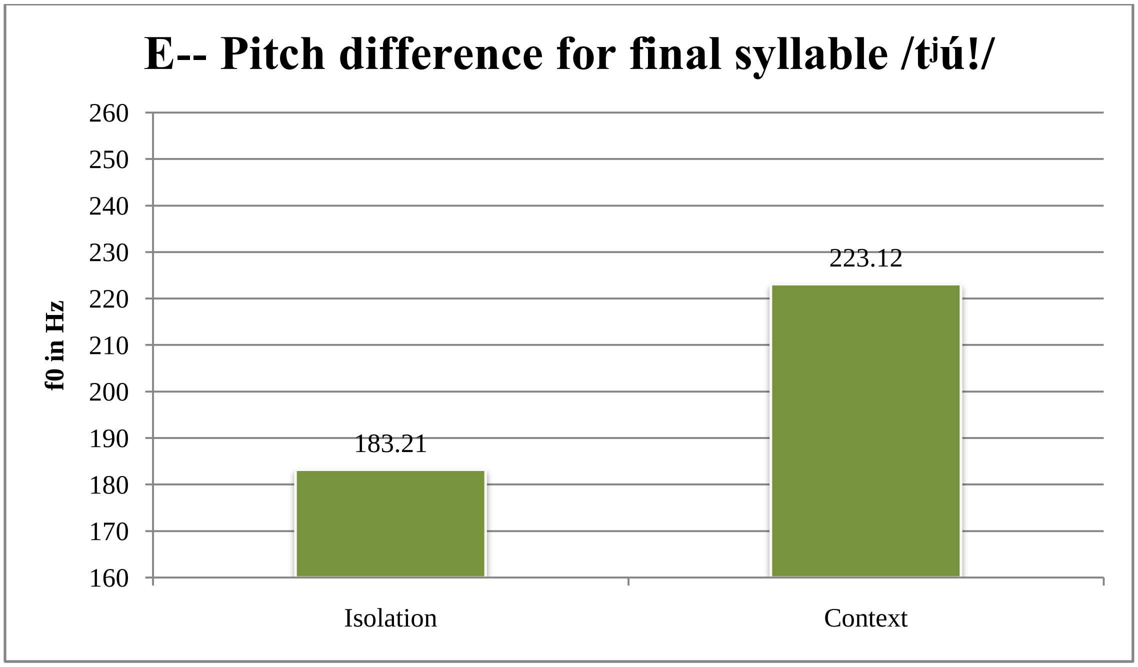
The isolation forms produced by speaker E are similar in some ways to the both of the sets of forms produced by M and Ev. Like speaker M, E creates a large contrast between the L and the H tone of the couplet /^{n}dà̰:ví/, made visible in the sharp rise in f_0 that occurs between the two targets. Additionally, speaker E’s isolation forms mirror those of Ev in the way that the initial tones of the two couplets have very different pitch targets. While speaker M’s isolation forms, whether L or H, seem to set a very similar initial target, E and Ev’s forms show a greater distinction between L and H even in isolation.

Figure **4-2-10**: Context form for speaker E /tʲṵ́:tʲú! ^{n}dà̰:ví/



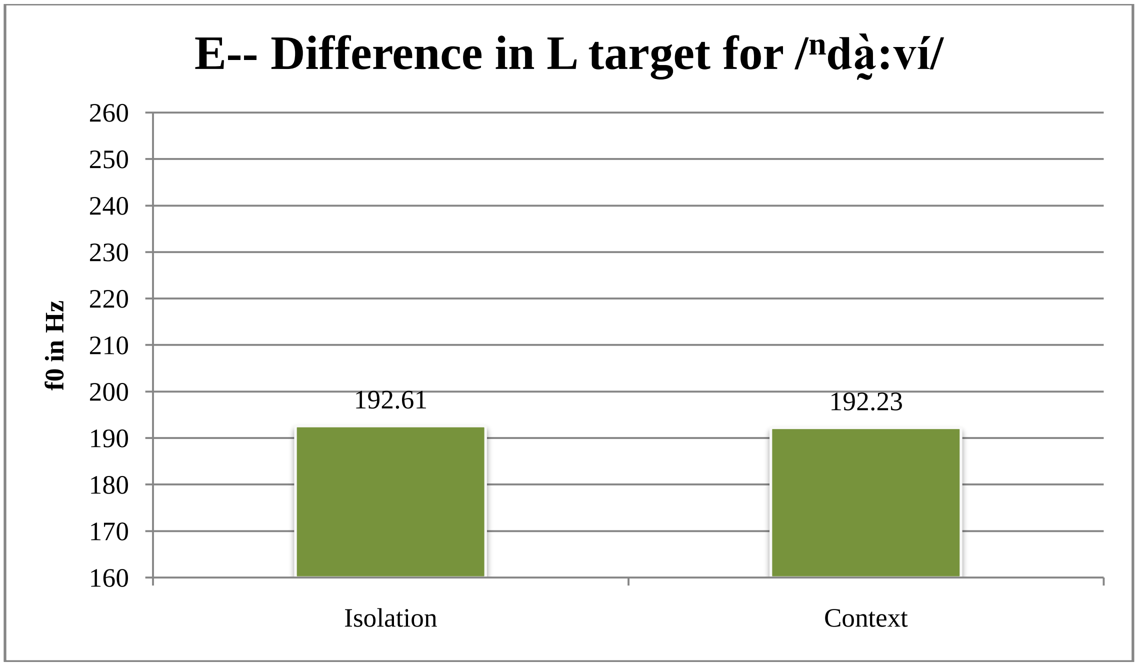
In context, these targets undergo a series of changes. First, we should not at this point be surprised to see that speaker E avoids the process of declination in the first couplet, shifting the target of /tʲṵ́:tʲú!/ to the second syllable in preparation for the coming contrastively L tone of the second couplet. E's /tʲṵ́:tʲú!/ f_0 target in the isolation and the context form is for all intensive purposes identical, with average frequencies of 225.07 and 223.12 Hz. The L target of /^{n}dà̰:ví/ remained on the first syllable with relatively little change, but as with speaker Ev, the final rise to H is seemingly lost, as declination is visible on the second syllable of the couplet.

Figure **4-3-11**: Pitch difference for final syllable /tʲú!/ for speaker E



The difference between the declined isolation f_0 target and the pre-L tone context target is 39.91 Hz. The target value itself, as stated above, is essentially identical, but by shifting the target and avoiding declination processes, E is able to prepare for a coming L tone and provide a heightened contrast between H and L to the listener.

Figure **4-3-12**: Difference in L target for /ⁿdà̰:ví/ for speaker E

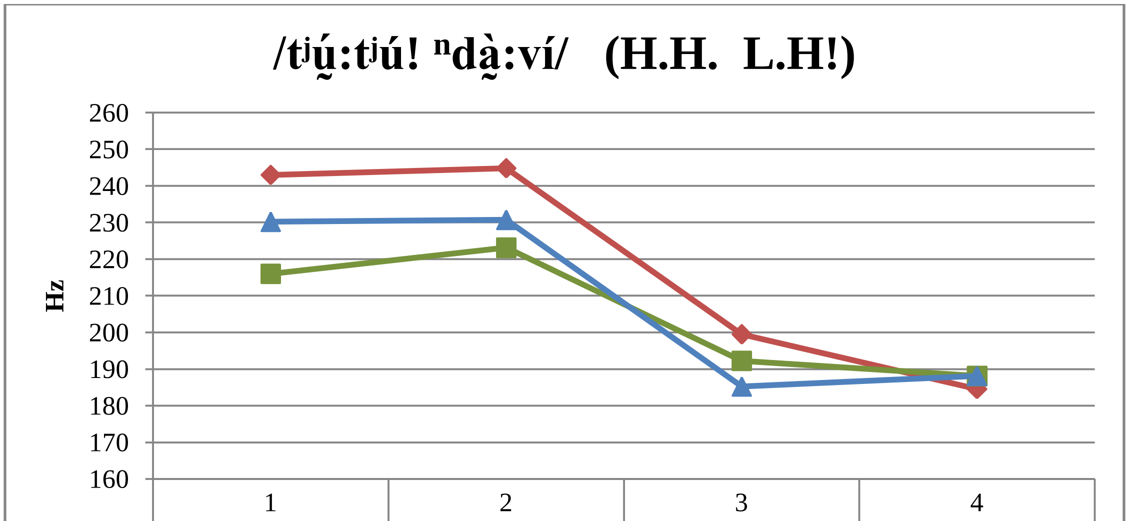


The adjacent L tone is essentially identical in both forms. Unlike speaker Ev, E does not resort to a lowered L f_0 target in order to heighten the contrast between adjacent H and L tones. Her production data seem to indicated that she is most likely to emphasize the contrast by a simple H target shift in the first couplet of the phrase.

4.3.4 Summary for /!/ plus L.H. phrases

Similarly to the tone patterns seen in §4.2, the implementation of the isolated couplets /tʲṵ́:tʲú!/ and /ⁿdà̰:ví/ differ greatly from the production of the phrase /tʲṵ́:tʲú! ⁿdà̰:ví/, as seen in the following graphic:

Figure **4-3-13**: /tʲṵ́:tʲú! ^{n}dà̰:ví/ for all speakers



	1	2	3	4
Ev	242.99	244.85	199.42	184.51
E	215.98	223.12	192.23	188.08
M	230.2	230.72	185.24	188.13

Additionally, the shape of the pattern is remarkably similar in both sections but the similarities seen may be the result of rather distinct processes.

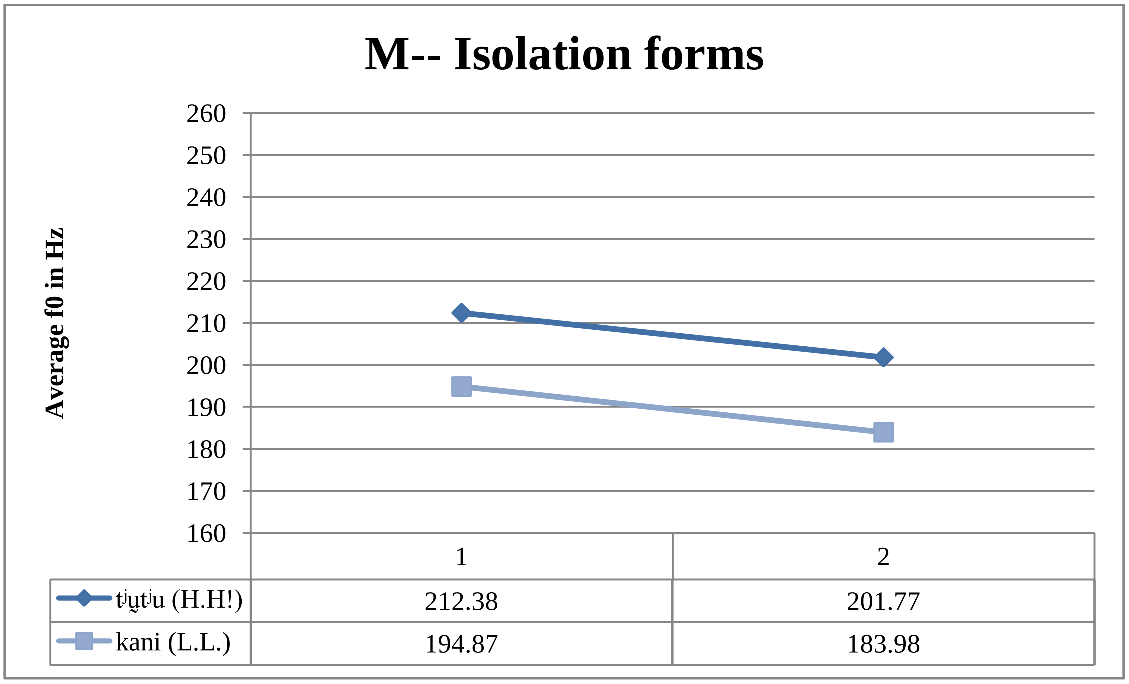
In §4.2, a series of adjacent H tones was markedly lowered following a lexical process phoneme (per Pike and Small 1974, Pike 1967). This created a clear contrast between the implementation of phonologically identical tones in that although all of the tones of the phrase are specified as H, they were not all implemented identically. Contrastively, in the charts show above, the phrase /tʲṵ́:tʲú! ^{n}dà̰:ví/ includes an underlying falling pitch, with the H tones associated with /tʲṵ́:tʲú!/ appearing before a L tone associated with the first syllable of /^{n}dà̰:ví/. According to Pike and Small (1974), the process phoneme lexically contained by the morpheme /tʲṵ́:tʲú!/ should not apply before a lexical L tone. This prediction seems to be the case, since no additional drop is f_0 is witnessed on the L tone of /^{n}dà̰:ví/. However, the pattern bears some resemblance to that described in the above down-stepped phrases in that the H f_0 target of /tʲṵ́:tʲú!/ is relocated to the second syllable, resulting in a emphasized drop in pitch between the H and the L f_0 targets. While in the case of the down-stepped patterns this target shift is used to denote a coming downstep, in /tʲṵ́:tʲú! ^{n}dà̰:ví/ it seems to function as a tool to accentuate the phonetic difference between H and L tones during speech, perhaps for the benefit of the listener.

4.4 Phonetic implementation of L.L. class couplets following /!/

The following phrase also includes a second couplet beginning with a L tone. Again, Pike and Small's analysis of tone downstep in CM predicts that the process phoneme /!/ lexically contained at the end of the word /tʲṵ́:tʲú/ will be lost when contiguous to L and will thus not result in downstep (1974:115). The tones of L.L. couplets are likewise not expected to undergo tone sandhi processes post-H.H! and should preserve their flat shape even when spoken in sentence context. The phrase used below to demonstrate the implementation of tone in a /!/ plus L.L. couplet utterance is /tʲṵ́:tʲú! kà:nì/, meaning 'long paper.'

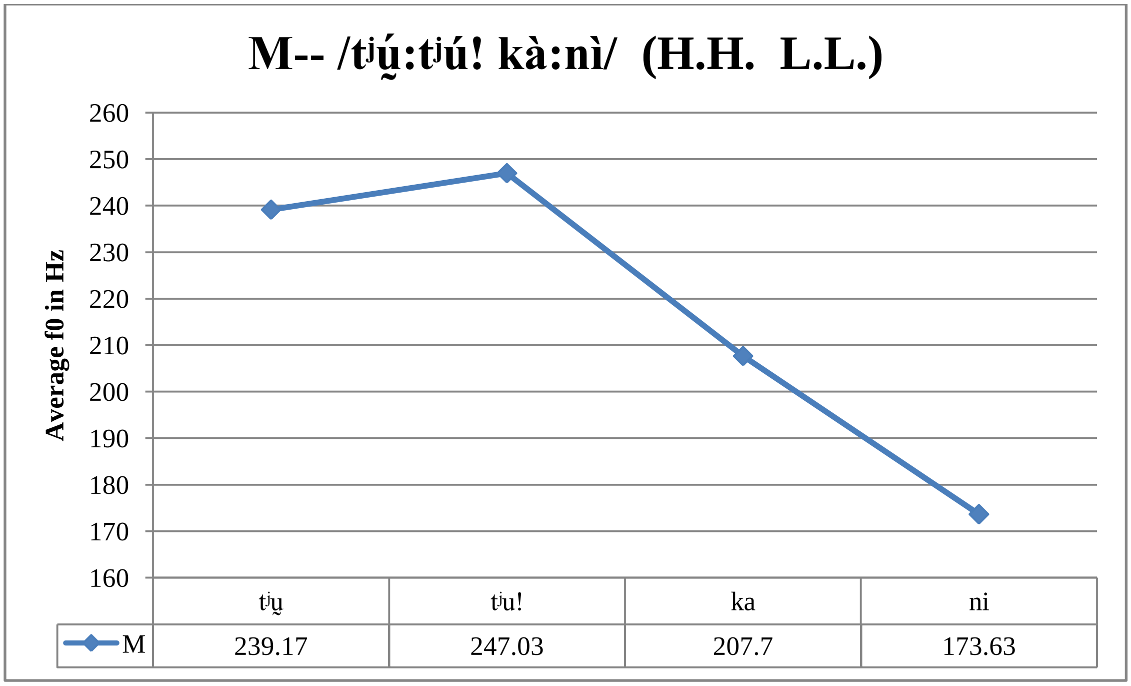
4.4.1 Speaker M's production of /tʲṵ́:tʲú! kà:nì/

Figure **4-4-1**: Isolation forms for speaker M /tʲṵ́:tʲú!/ and /kà:nì/



For speaker M, the isolation forms of these H.H! and L.L. couplets follow a similar declination pattern. The target f_0s are placed on the first syllables of both words, with declination freely taking place on the second. The value of the H and L targets are not identical in the data provided.

Figure 4.4.2 Context form for speaker M /tʲṵ́:tʲú! kà:nì/



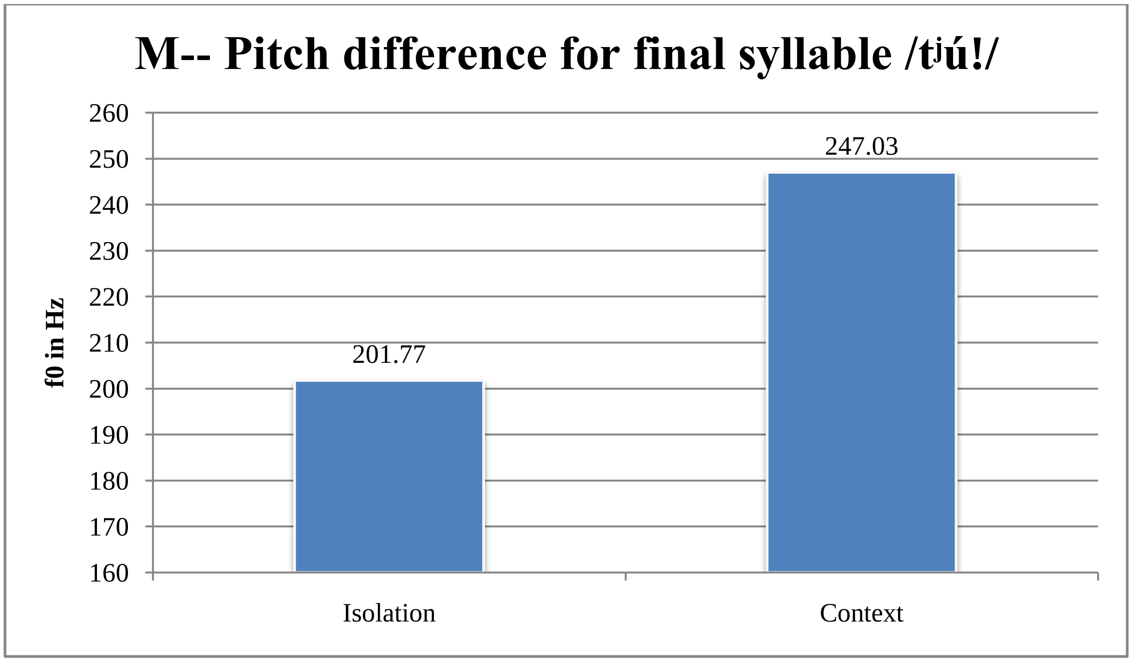
When spoken in sentence context, there is no surprise that the implementation of tone changes drastically. Nonetheless, the pattern seen here continues to parallel the patterns demonstrated earlier in a number of ways, yet differs in others. Let's begin with the similarities:

First and foremost, the H target of the first word /tʲṵ́:tʲú!/ has been shifted to take place on the second syllable instead of the first. In addition to resisting the process of declination, the newly shifted H target takes a higher f_0 value than that produced in isolation (247.03 Hz v. 212.38 Hz respectively, a difference of 34.65 Hz). Secondly, a sharp drop in f_0 occurs between the H target of /tʲṵ́:tʲú!/ and the L target of /kà:nì/, similar to the sharp fall before the L tone of the L.H. couple /^{n}dà̰:ví/.

The most obvious difference between the implementation of the H.H. L.H. phrase of §4.3 and the H.H. L.L. phrase demonstrated here is the large fall in f_0 between the L tone target placed on the syllable /kà:/ and the implementation of the L target of the syllable /nì/. With a fall of 34.07 Hz, the drop in pitch is considerably greater than the normal amount of declination that visible in the isolation form, which has only a 10.89 Hz fall between the two L tones.

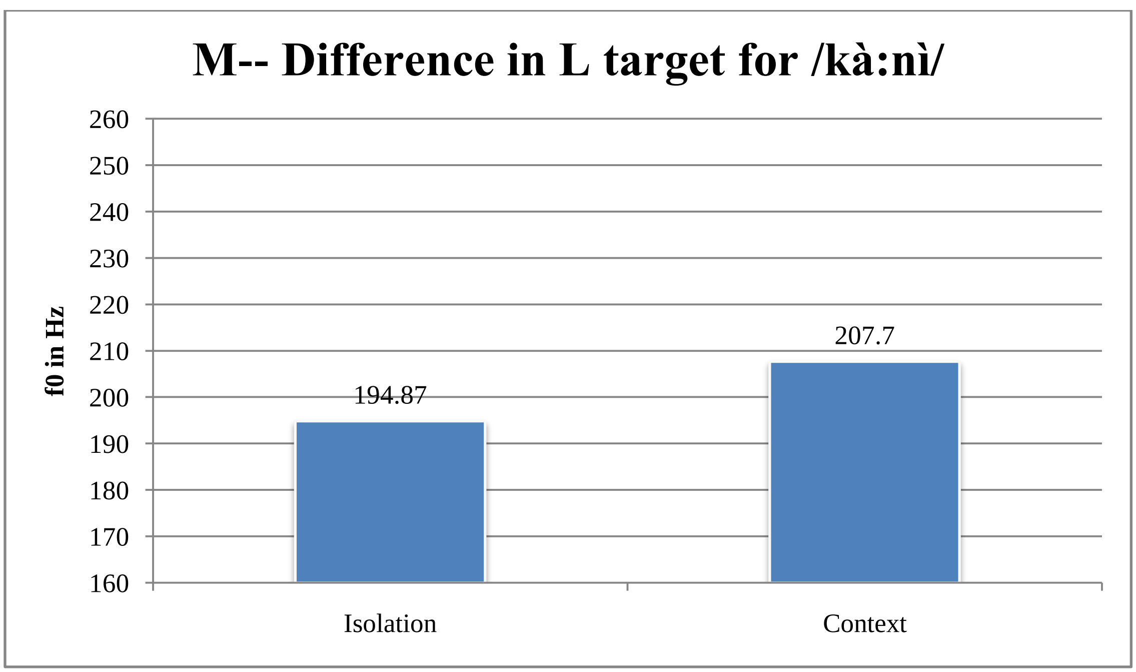
The question becomes: what is the purpose of this large final drop in fundamental frequency? While this sharp fall may be explained in a variety of ways, I believe that it may be best attributed to the following reason. As we saw in §4.2 and §4.3, the Hz value of a lowered H f_0 target approximates value of a L tone that follows a H tone. This increased fall in pitch on the second syllable of the L.L. couplet may be a mechanism implemented by the speaker to highlight the status of the final syllable as being associated with a low tone, and not with a lowered H, easing the perceptual burden placed on the listener. Because of this, it may be best to explain this fall in terms of a L target shift. By moving the L target from the first to the second syllable, the speaker affectively produces an acoustically salient lowering throughout the final couplet of the phrase, allowing it to be clearly distinguished from a lowered H.H. phrase that may encroach on the phonetic domain of L.

Figure **4-4-3**: Pitch difference for final syllable /tʲú!/ for speaker M



With the shift of the H f_0 target to the second syllable of the word, the target pitch for the word /tʲṵ́tʲú!/ is raised noticeably in context, reaching 247.03 Hz instead of the isolation variant of 212.38 Hz.

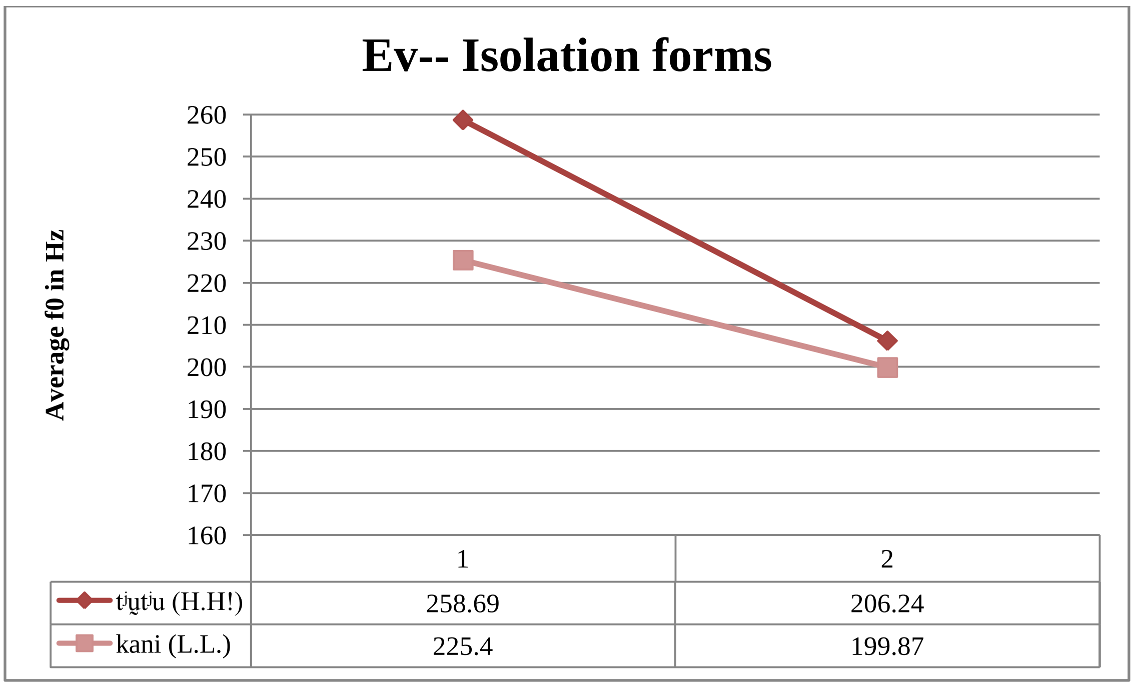
Figure **4-4-4**: Difference in L target for /kà:nì/ for speaker M



The L target of the word /kà:nì/ is neither shifted to the latter syllable nor drastically changed in terms of Hz value. In fact, the context form's target rises slightly, with a total average difference of 12.83 Hz. The following syllable, however, seems to accommodate the shifted f_0 target, with an additional fall of 34.07 Hz.

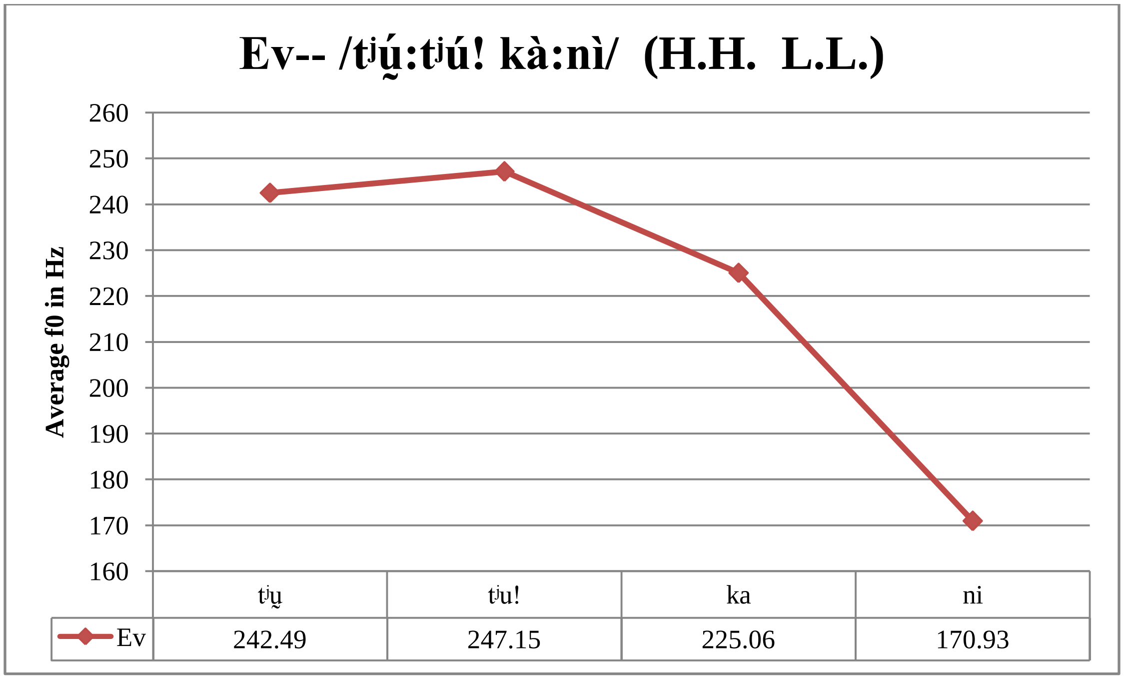
4.4.2 Speaker Ev's production of /tʲú̯:tʲú! kà:nì/

Figure **4-4-5**: Isolation forms for speaker Ev /tʲú̯:tʲú!/ and /kà:nì/



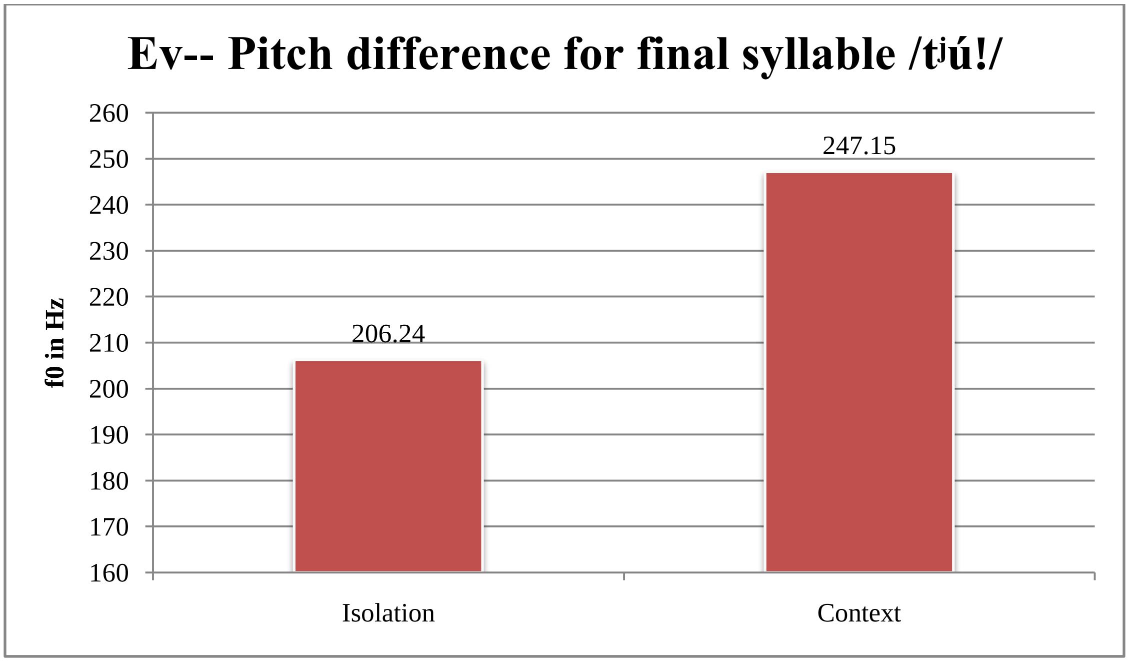
The isolation forms produced by speaker Ev show a larger amount of declination than those spoken by M. Additionally, the initial targets of the H.H! and L.L. couplets are more widely distributed and here do not appear to neutralize (see chapter 3 for further discussion).

Figure **4-4-6**: Context form for speaker Ev /tʲṵ́:tʲú! kà:nì/



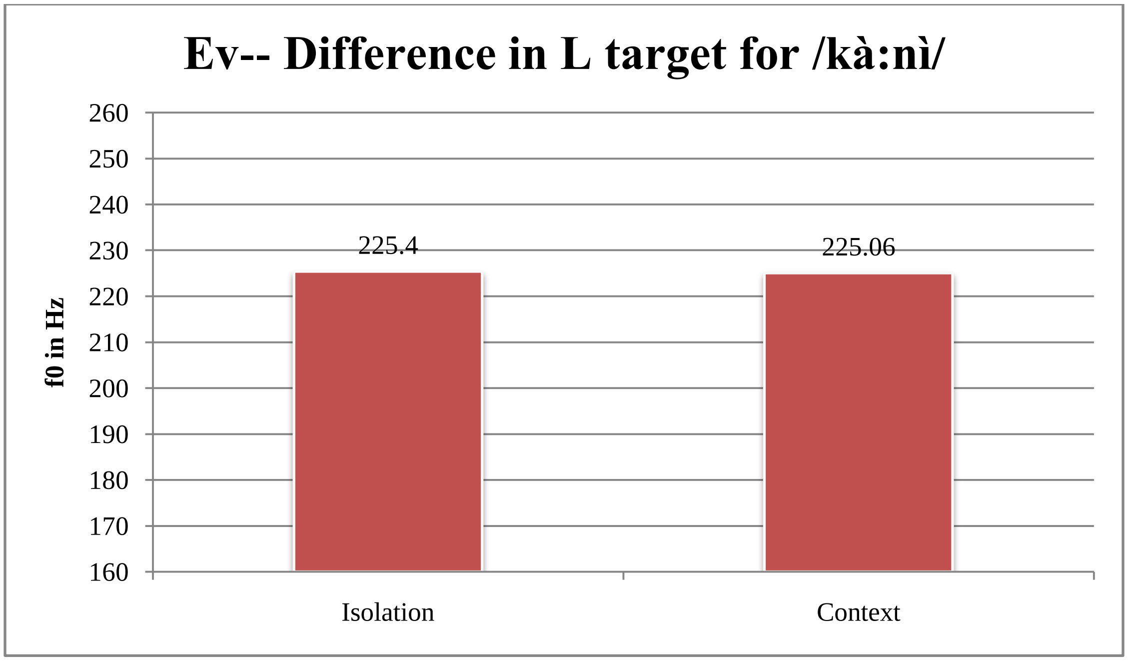
In sentence context, the phrase /tʲṵ́:tʲú! kà:nì/ closely resembles the pitch shape exhibited by speaker M. The H target of the word /tʲṵ́:tʲú!/ is shifted to the second syllable, resulting in a preparatory rise before the adjacent L tone. Like M, the L target of the couplet /kà:nì/ is not shifted, but the tone produced on the second syllable is clearly lower than its isolation equivalent. Instead of a slight declination of 25.53 Hz in the isolated form, /kà:nì/ undergoes a 54.13 Hz drop across the two L syllables when spoken in context, indicating that perhaps the L target has been moved to the rightmost syllable of the couplet.

Figure **4-4-7**: Pitch difference for final syllable /tʲú!/ for speaker Ev



In addition to avoiding the process of declination, the second syllable of the couplet /tʲṵ́:tʲú!/ is reanalyzed as the location for the H pitch target. While providing heightened acoustic contrast between the adjacent H and L tones, this pre-drop pitch target is not quite as high as its isolation equivalent (247.15 Hz and 258.69 Hz respectively).

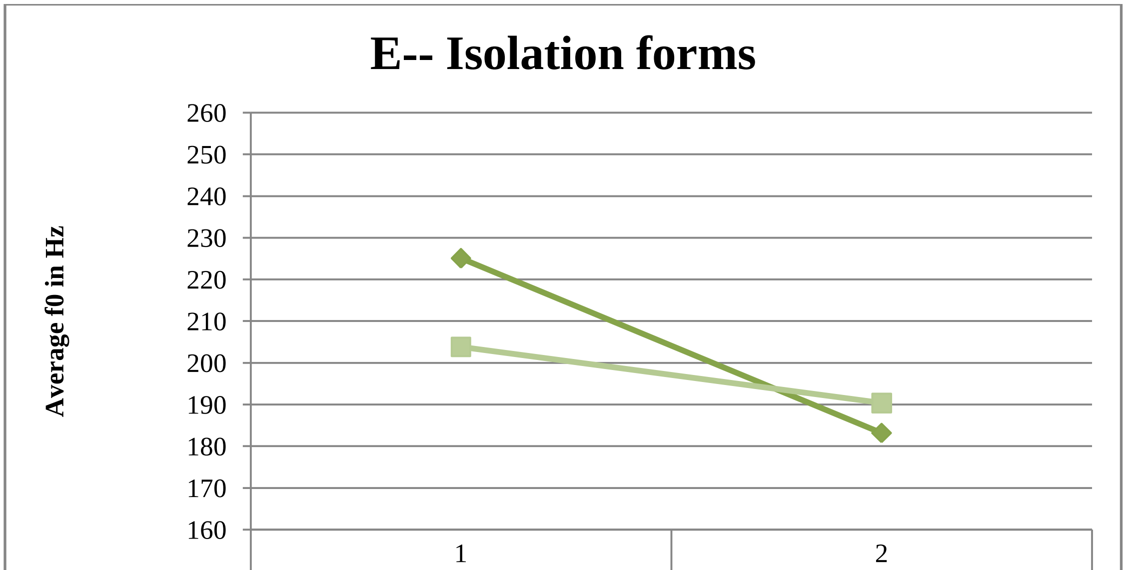
Figure **4.4.8**: Difference in L target for /kà:nì/ for speaker Ev



As demonstrated by speaker M, Ev's the first L tone of /kà:nì/ does not differ greatly across phonetic environment. It is the following syllable that shows the greatest drop, with an additional fall of 54.13 Hz. Again, this sharp fall may indicate the f_0 target shift from the first syllable to the second, perhaps motivated by a desire to create an acoustic contrast between a L.L. couplet and other tone patterns that appear in sentence-context.

4.4.3 Speaker E’s production of /tʲṵ́:tʲú! kà:nì/

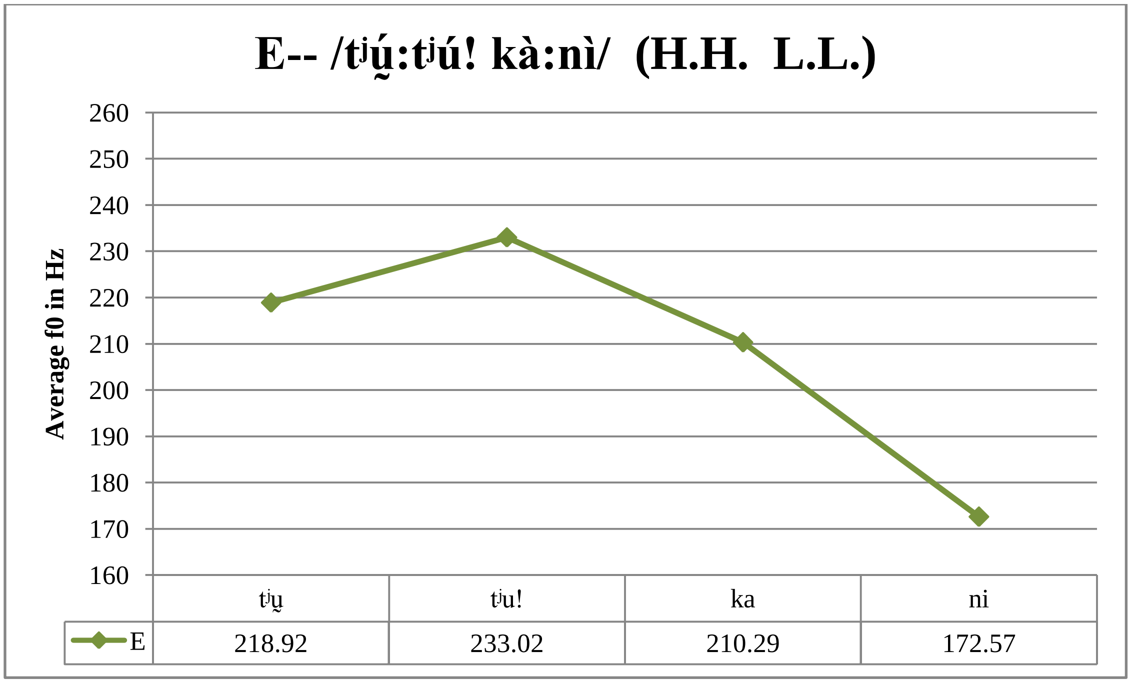
Figure **4-4-9**: Isolation forms for speaker E /tʲṵ́:tʲú!/ and /kà:nì/



	1	2
tʲṵtʲu (H.H!)	225.07	183.21
kani (L.L)	203.83	190.4

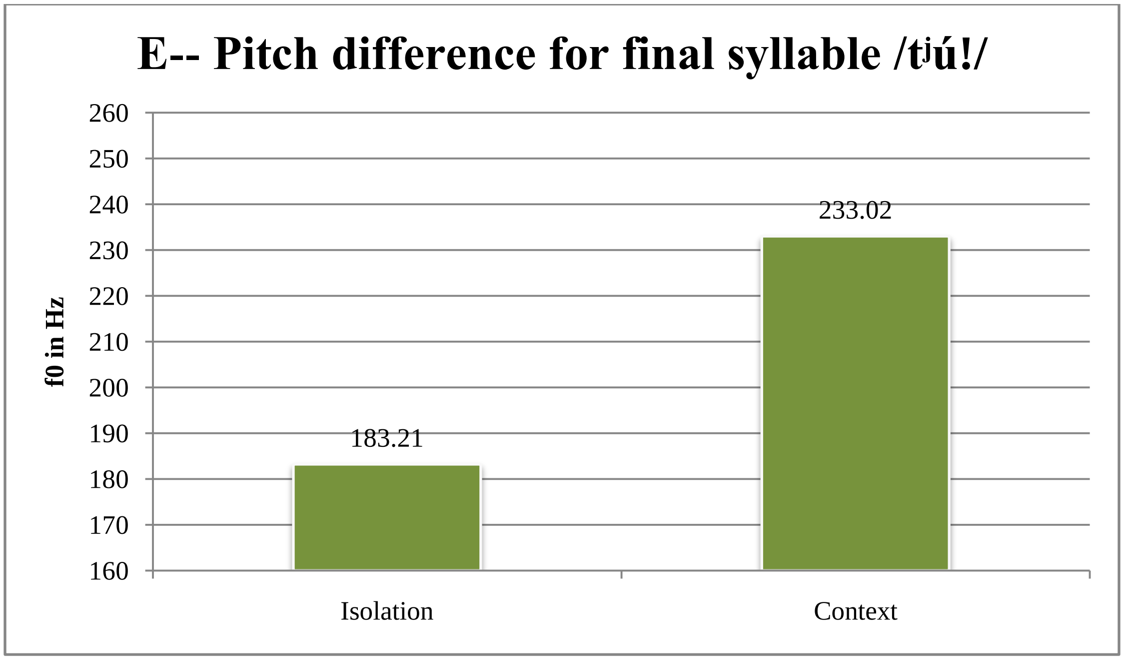
E’s isolation forms seem to be somewhat neutralized in terms of implementation in isolation. While the initial values of H and L are different, the rates of declination and final pitch targets are not consistent across the two couplets. As with the speakers shown above, the context variety of these two words differs greatly than those produced in isolation.

Figure **4-4-10**: Context form for speaker E /tʲṵ́:tʲú! kà:nì/



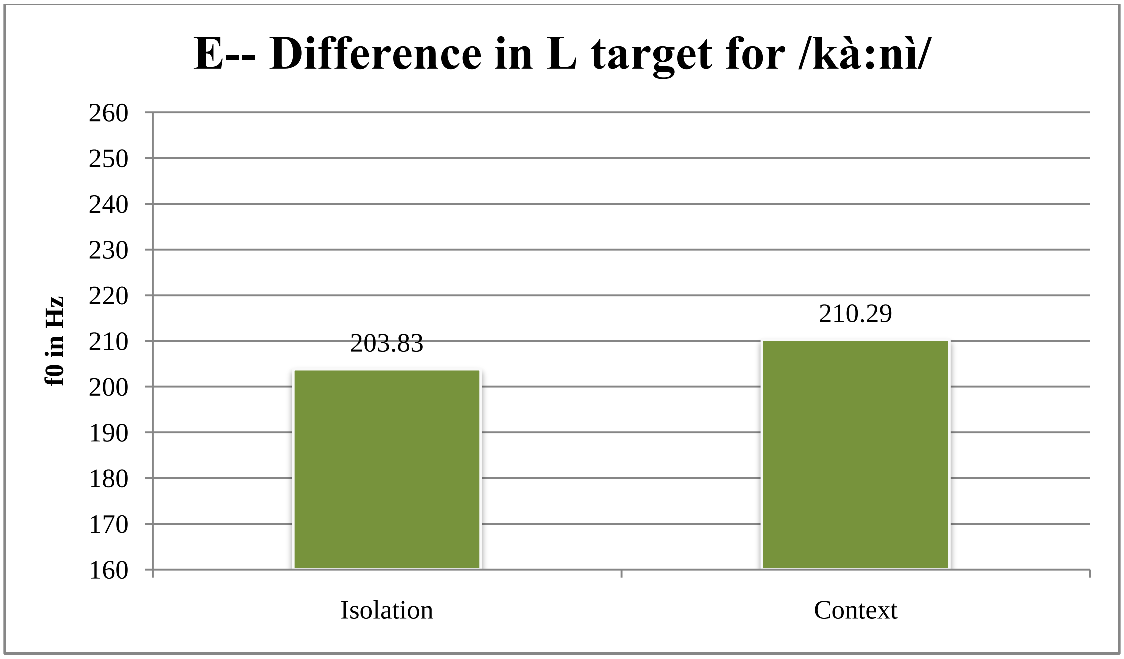
Strongly resembling the f_0 patterns produced by the speakers above, E exhibits a shifted H target on the first word /tʲṵ́:tʲú!/ in preparation for an adjacent L tone. However, her implementation of this H target is higher than that produced in isolation and is also rather high in comparison to the initial H tone. This creates a more concave fundamental frequency pattern across the initial three syllables than that demonstrated by the previous two speakers. Finally, the large drop in pitch between the two L tones of the couplet /kà:nì/ occurs in E's speech as well, totaling a fall of 30.72 Hz.

Figure **4-4-11**: Pitch difference for final syllable /tʲú!/ for speaker E



In addition to avoiding the process of declination on the second syllable of the couplet /tʲṳ́:tʲú!/, the target is shifted to the final syllable and undergoes a slight rising process causing it to be implemented at a pitch level that is 7.95 Hz higher than its isolation counterpart. This rise in f_0 is made even more apparent in that it is 14.1 Hz higher than the initial tone of the phrase (/tʲṳ:/).

Figure **4-4-12**: Difference in L target for /kà:nì/ for speaker E

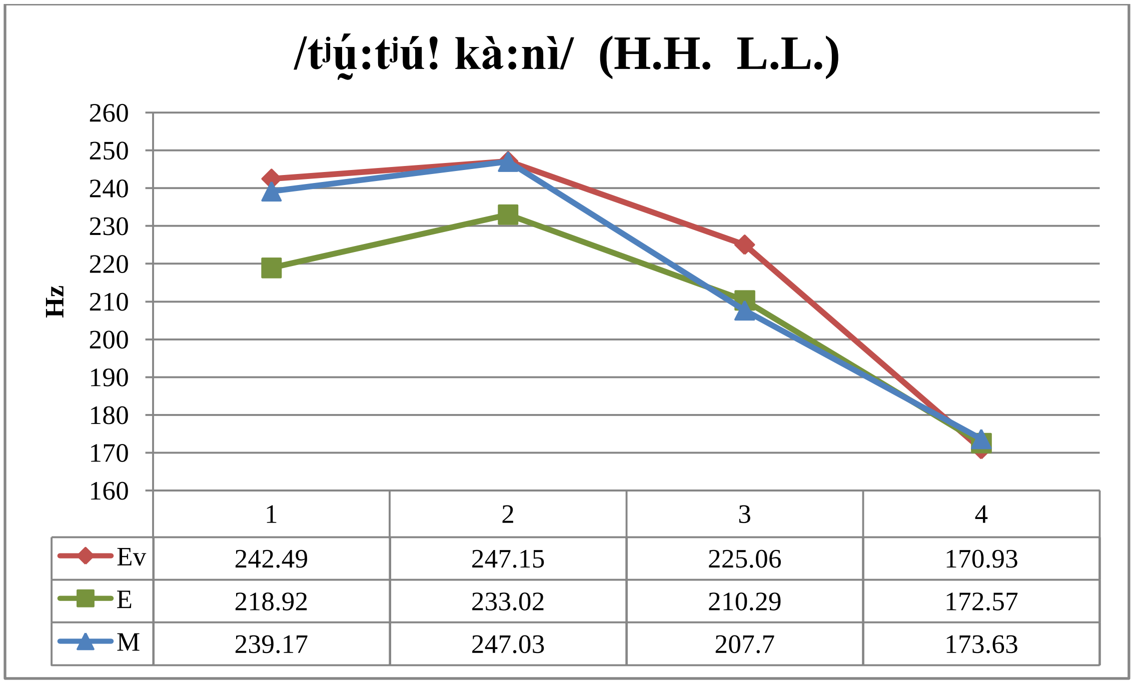


The initial L tone of /kà:nì/ does not undergo a shift in placement, nor does it drastically change in terms of the value of the target across isolation and context variants. As the bar graph above shows, the value of the first tone is close to identical in both environments. The final L tone is the tone that is most affected by the presence of an adjacent H.H! couplet, as a large fall appears between the two L syllables. Thus, it is the adjacent H tone and the final L tone that seem to be most affected by the presence of another couplet.

4.4.4 Summary for /!/ plus L.L. phrases

The /tʲṵ́:tʲú! kà:nì/ tone pattern parallels the implementation of tone in the other two phrases discussed in the chapter in a few pivotal ways.

Figure **4-4-13**: /tʲṵ́:tʲú! kà:nì/ for all speakers



	1	2	3	4
Ev	242.49	247.15	225.06	170.93
E	218.92	233.02	210.29	172.57
M	239.17	247.03	207.7	173.63

The process of H tone target shifting is also evident here, with the H target of /tʲṵ́:tʲú!/ appearing on the latter syllable instead of the former, as is seen in isolation. This target shift may be a mechanism used by the speaker to highlight the pitch contrast between the H and L tones of the adjacent couplets.

The value of the initial L tone of the couplet /kà:nì/ is implemented in a similar way in both the isolation and the context environments. No shift is seen and there is little if any change in f_0 value across all three speakers.

However, the final L tone of /kà:nì/ undergoes a surprising process of lowering in relation to the initial L tone. This sharp drop has lead me to argue that perhaps the target L of the couplet has shifted from the first syllable to the second, allowing the speaker and the listener to more clearly distinguish the contrast between a L.L. tone pattern and a lowered H.H. or L.H. when spoken in context.

4.5 Summary

This chapter summarizes an investigation of the phonetic implementation of terrace tone downstep in Coatzospan Mixtec in three phonological environments: /!/ before a couplet of class H.H., L.H., and L.L. The findings have shown that implementation of tone patterns is manifested differently in isolation versus in sentence context. This disparity was seen in the acoustic data via the following observations:

- A couplet of class H.H! consistently undergoes a shift in pitch target location when appearing before an adjacent tone target that requires a large drop in f_0. This shift involves the realization of the H f_0 target on the second syllable of the couplet and not on the first syllable (as is produced in isolation).
- The H f_0 target of the H.H! class couplet is raised by some speakers, potentially as a means of saliently contrasting distinct adjacent tone values.
- Couplets of the tone pattern H.H. experienced a large f_0 drop when following a couplet of class H.H!. This large drop has been postulated to be due to the presence of a null terracing-downstep operator tone, known as a process phoneme, /!/ (Pike and Small, 1974).
- Couplets of tone patterns L.H. and L.L. did not appear to be affected by the same process of downstep in that their initial f_0 value after the process phoneme /!/ is not consistantly different.
- Couplets of class L.H. demonstrate a tendency to lose their sharp rise when spoken in sentence context, but still strongly resist the process of declination.
- Couplets of class L.L. undergo what at first glance seems to be a dramatic amount of declination when spoken in sentence context. However, the large range of the

fall does not match the shape of declination that is typically seen in CM, prehaps indicating that instead of the process of declination the couplet is undergoing a target shift. It seems plausible that a target shift from the first L syllable to the second L syllable may be a mechanism used by the speaker to maintain a distinction between a lowered H and an L appearing contiguously an H.

Chapter 5

Conclusions and future research

5.1 Conclusions

In an attempt to further our knowledge of the world's lesser-known languages, this project has attempted to provide a description of how lexical tone is realized phonetically in Coatzospan Mixtec both in words produced in isolation as well as in combination with other words.

An investigation of tones in isolation found that flat tone patterns may be neutralizing when spoken in isolation, as there is no need to distinguish between distinct tone targets. Additionally, all flat tone couplets showed declination in the second syllable of the word, whereas the f_0 target was seemingly reached in the first syllable.

When couplets were combined into two word phrases, these basic tone patterns underwent a variety of changes. A postulated process phoneme /!/ was demonstrated to have a strong lowering effect on an adjacent H.H. couplet in the phrase /tʲṵ́:tʲú! lṵ́:kú/. This same lowering effect was not manifested when a couplet of tone class L.L. or L.H. followed.

When contiguous to a large drop in pitch, whether due to an adjacent L tone or a lowered H tone, the f_0 target of /tʲṵ́:tʲú!/ was shifted to the second syllable of the couplet, thus avoiding declination and making the pitch drop more acoustically salient. This target shift may be a mechanism used by speakers to provide for greater tone dispersion in downstep forms, but its appearance is not unique to downstep, and thus it makes the contrast between distinct tones increasingly clear to the listener in multiple contexts. Interestingly, this target shift causes the implementation of tone targets to at times parallel that recorded by Laniran in her studies of Yorùbá (1993), and shows that a tone language may utilize more than one method of f_0 target placement.

Similarly, a couplet of the pattern L.L. shows a sharp drop in pitch across both syllables when preceded by the H.H! couplet /tʲṵ́:tʲú!/. This patterns differs from the slight declination seen in the phrases /tʲṵ́:tʲú! lṵ́kú/ and the general resistance to declination in /tʲṵ́:tʲú! ^{n}dà̰ví/. Why this sharp drop appears in the L.L. couplet may potentially be attributed to a shift in the L target from the initial syllable to the latter, a target shift that may help the speaker differentiate between a lowered H.H. couplet and an L.L. couplet when spoken in context.

5.2 Future work

This research only represents a small percentage of the work left to be completed on the tone system of Coatzospan Mixtec. The manifestation of terracing downstep in more diverse and complex phonological situations has yet to be discussed, as does the rich and complex tone sandhi system that plays an integral role in the implementation of tone in CM. Additionally, a cross-linguistic comparison of CM and other tone languages may bring to light typological similarities and differences that could advance our understanding of the universal commonalities as well as language specific attributes that comprise tone systems in the languages of the world.

Bibliography

Bradley, C. Henry. (1970) A Linguistic Sketch of Jicaltepec Mixtec. SIL Publications.

Brown, Becky. (1998) Register theory and the autosegmental framework. *Texas Linguistic Forum*, 29: 23—39.

Chen, Matthew Y. (2000) Tone sandhi: Patterns across Chinese dialects. Cambridge, U.K.: Cambridge University Press.

Chomsky, Noam, and Morris Halle. (1968) The Sound Pattern of English. Cambridge: MIT Press.

Gerfen, Chip. (1999) Phonology and phonetics in Coatzospan Mixtec. Boston: Kluwer Academic Publishers.

Gerfen, Chip and Kirk Baker (2005). The production and perception of laryngealized vowels in Coatzospan Mixtec. *Journal of Phonetics*, 33: 311—334.

Goldsmith, John A. (1990) Autosegmental and metrical phonology. Oxford: Basil Blackwell.

Hyman, Larry M. and Russell G. Schuh. (1974) Universals of Tone Rules: Evidence from West Africa. *Linguistic Inquiry*, 5, 1: 81—115.

Josserand, Judy Kathryn (1982) Mixtec dialect history. Ph.D. dissertation, Tulane.

Keating, Patricia. (1996) The phonology-phonetics interface. In Interfaces in Phonology, *Studia grammatica 41*, Ursula Kleinhenz (ed.). Berlin: Akademie Verlag: 262—278.

Ladd, D. Robert. (1996) Intonational Phonology. Cambridge Studies in Linguistics, #79. Cambridge University Press, Great Britain.

Laniran, Yetunde Olabisi. (1993) Intonation in Tone Languages: The Phonetic

Implementation of Tones in Yorùbá. Dissertation by Cornel University Department of Modern Languages and Linguistics. Ithaca, NY: Cornell University.

Lewis, M. Paul, ed. (2009) Ethnologue: Languages of the World, Sixteenth edition. Dallas, Tex.: SIL International. Available online at http://www.ethnologue.com/, accessed on 2010-03-13.

Lubker, James and Thomas Gay. (1982) Anticipatory Labial Coarticulation: Experimental, Biological and Linguistic Variables. *Journal of the Acoustic Society of America* 71.

Macaulay, Monica. (1996) A grammar of Chalcatongo Mixtec. Linguistics, Vol. 127. Berkeley: University of California Press.

Maddieson, Ian. (2008) Tone. In The World Atlas of Language Structures Online, Haspelmath, Martin and Dryer, Matthew S. and Gil, David and Comrie, Bernard (eds.). Munich: Max Planck Digital Library, chapter 13. Available online at http://wals.info/feature/13, accessed on 2010-03-13.

Ohala, John. (1978) Production of Tone. Fromkin, Victoria (ed.), in Tone: A Linguistic Survey. Academic, New York.

Pike, Kenneth L. (1948) Tone Languages: A Technique for Determining the Number and Type of Pitch Contrasts in a Language, with Studies in Tonemic Substitution and Fusion. Ann Arbor, Michigan: University of Michigan Press.

Pike, Kenneth L. (1967) Suprasegmentals in reference to phonemes of item, of process, and of relation. The Hague: Mouton: 1545—54.

Pike, Eunice V. and Priscilla Small. (1974) Downstepping Terrace Tone in Coatzospan

Mixtec. Brend, Ruth M. (ed.), in Advances in Tagmemics. North Holland, Amsterdam.

Rensch, Calvin R. (1976) Comparative Otomanguean Phonology. Language Science Monographs, Vol. 14. Bloomington, Indiana: Indiana University.

Simpson, John, and Edmund Weiner (eds.). (1989) The Oxford English Dictionary. Oxford, England: The Oxford University Press.

Small, Priscilla. (1990) A syntactic sketch of Coatzospan Mixtec. C. Henry Bradley and Barbara E. Hollenbach (eds.), in Studies in the syntax of Mixtecan languages, Vol.2. Dallas: Summer Institute of Linguistics and the University of Texas at Arlington: 261—479.

Silverman, Daniel. (1995) Phrasing and Recoverability. Ph.D. dissertation. Los Angeles, CA: UCLA.

Van Reenen, Pieter. (1982) Phonetic feature definitions. Dordrecht, Holland; Cinnaminson, N.J.: Foris Publications.

Yip, Moira. (2002) Tone. Cambridge, United Kingdom: Cambridge University Press.

Appendix A

List of acronyms

C – Consonant

CM – Coatzospan Mixtec

E – A female speaker of Coatzospan Mixtec

Ev – A female speaker of Coatzospan Mixtec

F – A male speaker of Coatzospan Mixtec

f_0 – The fundamental frequency of vocal fold vibration

H – A High level tone

L – A female speaker of Coatzospan Mixtec, or a Low level tone

LH – A rising contour tone

HL – A falling contour tone

Hz – Hertz, a unit of frequency measuring the number of cycles per second

M – A female speaker of Coatzospan Mixtec, or a Mid level tone

O – A female speaker of Coatzospan Mixtec

P – A male speaker of Coatzospan Mixtec

TBU – Tone bearing unit

V – Vowel

Academic Vita

Janalyn Anne Sheetz
The Department of Spanish, Italian and Portuguese
The Pennsylvania State University
http://www.personal.psu.edu/jas920

Education:

The Pennsylvania State University (University Park, PA) 2008 – 2010
M.A. in Spanish Linguistics

The Pennsylvania State University (University Park, PA) 2005 – 2010
B.A. in Spanish and in International Studies
B. Ph in the Bachelor of Philosophy Program
Member of the Schreyer Honors College
Senior Thesis: The Phonetic Implementation of Tone in Coatzospan Mixtec

Extended Education:

La Universidad IberoAmericana (Puebla, Mexico) May – July 2007
University Study Abroad
Pursued a basic understanding of linguistic field work and data collection, beginning with a hands-on study of Coatzospan Mixtec. Additionally studied Mexican history and culture and lived with a host family.

Faculdade de Tecnologia Empresarial (Salvador, Bahia, Brazil) May – July 2006
University Study Abroad
Was immersed in the culture while furthering professional objectives through an intense study of the Portuguese language, studying a broad range of South American history and culture, and by living with a host family.

Rio Grande Bible Institute (Edinburgh, Texas) Jan – May 2005
Studied Spanish in an intensive immersion program during final year of high school.

Job Related Skills/Experiences and Work History:

Training with proficiency oriented language educational methods Fall 2009
Completed Penn State's Spanish-instruction course in teaching methodology and practiced teaching skills through microteaching presentations, grammar and vocabulary presentations and quiz and assignment development.

Teaching with Technology Certificate (Pennsylvania State University) December 2009

Gained experience as an online-developer: extensive experience with Penn State's course management system, developed advanced skills of Power Point and acquired basic knowledge of html/Dreamweaver, Photoshop and Adobeconnect.

Spanish tutor (The Pennsylvania State University) 2007 – 2010

Morgan Academic Support Center for Student Athletes

Assisted student athletes who had questions and/or difficulties concerning the material covered in elementary Spanish courses as well as 100 and 200 level linguistics and Spanish grammar and conversation courses.

Linguistic field work (University Park, PA and Puebla Mexico) May 2008 – 2010

Gathered recorded data on the Coatzospan Mixtec language for an undergraduate honors thesis. Included data collection, organization, entry, and coding. Collected data were measured through acoustic analysis programs such as Praat and were used to compile a basic description of the system of downstep in this indigenous Mexican dialect.

EMT/ Medical Interpreter (Susquehanna Valley EMS, Lancaster PA) 2006-2008

Provided basic emergency care and interpreted for Spanish-speaking patients and respective EMTs and other medical personnel.

Volunteer at El Jardín del Edén (Salcedo, Ecuador) 2003

Volunteered in an Ecuadorian orphanage for two months; practiced Spanish while helping construct several concrete buildings and interacting with children through after-school activities, tutoring, and soccer each day.

Languages:

- Native speaker of American English
- High-proficiency of Spanish
- Proficient in Brazilian Portuguese

Awards, Honors, and Distinctions:

- Invited to present research at the Pennsylvania State University Liberal Arts alumni reception, "Liberal Arts Today: From a Student View" (2010).
- Recipient of the Eric Steindl Award for excellence in community service and Spanish (2009).
- 2nd place recipient of the Penn State Undergraduate Poster Exhibition award in Social and Behavioral Sciences (2009).
- Recipient of the Evan Pugh Scholar Award for Seniors (2009).
- Recipient of the Evan Pugh Scholar Award for Juniors (2008).
- Recipient of a Summer Discovery Grant awarded by the Office of Undergraduate Education (2008).
- Recipient of the John White Scholarship for excellence in Spanish (2007).
- Recipient of the President's Sparks Award (2007).

- Recipient of the President’s Freshman Award (2006).

Activities, Interests:

- Ministry team and Bible study leader, Reformed University Fellowship (RUF)
- Co-organizer and pianist for RUF and Oakwood Presbyterian Church’s monthly service conducted at Hearthside Nursing Home in State College, PA.
- Performing member and dance instructor/choreographer, Penn State International Dance Ensemble (PSIDE).
- Competition team member and Salsa instructor, Penn State Ballroom Dance Club.