Implications of Autosegmental Analysis in the

Exploration of Prosodic Phonology in Mandarin Chinese

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A Senior Thesis submitted in partial fulfillment
of the requirements for graduation
in the Honors Program
Liberty University
Spring 2014

Acceptance of Senior Honors Thesis

This Senior Honors Thesis is accepted in partial
fulfillment of the requirements for graduation from the
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Abstract

Autosegmental Phonology (Goldsmith, 1979) is a theoretical framework for understanding the phonological effects of suprasegmentals such as tone, stress, etc. Using data taken from an experiment in which Mandarin Chinese tone sandhi (the acknowledged rules governing specific tone shifts across segments) is explored, a number of phonologists, specifically Kenstowicz (2003), have shown that the relationship between the segment and the tone is autonomous. In the experiment, non-sense words with a potential tone sandhi rule are presented to the Mandarin speakers. The speakers automatically apply the tone sandhi rule which is then analyzed using an autosegmental framework.  The speakers consciously separate the tones from the non-sense words and apply tone sandhi rules; the application of the tone sandhi rule is independent of semantic meaning.

This research is expanded to include the exploration of loanword phonology (the phonological changes that occur when a tonal language borrows non-tonal language words) to further understand the autonomous relationship between tones and segments. As can be seen in the following example, the English word *Disney: di$^2$-si$^1$-ni$^2$* (numbers account for the differing tones), certain tones are distributed to loanwords.

Implications of Autosegmental Analysis in the

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Mandarin Chinese is unlike English in many significant linguistic ways, but the most noticeable difference lies in the tonal properties that Mandarin Chinese exhibits. English is not a tonal language so this is a novel structure to native English speakers.

In an effort to gain a deeper understanding of tonal languages, specifically Mandarin Chinese, several experiments were conducted to ascertain the nature of tone. Finding the results encouraging, the research was further extended to a completely different area of phonology; however, the experiments are crucially linked.

A literature review is provided in the first sections as a basis for the experiments. All three experiments revolve around the framework of Autosegmental Phonology. This framework is novel in its structure and aids in the analysis of the prosodic nature of tone.

## 1. Overview of Tone

Tone is a very flexible word that spans across many different disciplines. In the discipline of music tone can be described as "the quality or character of sound" (Farlex, 2014, p. 1). In the discipline of English Literature tone can be described as "a particular style or manner" (Farlex, 2014, p. 2). However, in the discipline of linguistics tone takes on a completely different meaning. In the technical, physical aspect, tone is the rising and lowering of pitches. These distinct pitches are not only composed of different frequencies and resound at different levels of hertz, but they can, in some languages, carry a different lexical meaning.[1] Moira Yip (2002), in her book *Tone,* describes a language as tonal "if

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[1] Lexical meaning refers to the definition of a word found in a lexicon or dictionary. Moira Yip further states that "a language with tone is one in which an indication of pitch enters into the lexical

the pitch of the word can change the meaning of the word. Not just its nuances, but its core meaning" (p. 180). This idea seems rather exotic to most English speakers; however, 60-70 percent of the world's languages are tonal and Mandarin Chinese alone has around 885,000,000 speakers (Yip, 2002). To further expand on this definition of tone a well-known linguistic example in Mandarin Chinese is used, but first a discussion of the tonal system of Mandarin Chinese is presented.

Mandarin Chinese has four distinct tones. These four tones are high, rise, low and fall. San Duanmu's notational system of tones will be used throughout this paper. His notational system is provided below.

Tones provide lexical meaning to a word or a segment. For example, the Chinese word for *mother* is composed of a fairly simple syllable segment of just two sounds, an [m] sound and an [a] sound. However, what distinguishes the word *mother* from three completely semantically different words is a small, simple tone. The table below offers a more succinct overview of the Mandarin Chinese tonal system:

| (1) | Tone name | First | Second | Third | Fourth |
|---|---|---|---|---|---|
| | Tone feature | H | LH | L | HL |
| | Syllable | ma | ma | ma | ma |
| | Gloss | 'mother' | 'hemp' | 'horse' | 'scold' |
| | Chinese Character | 媽 | 麻 | 馬 | 罵 |

*Figure 1.* Representation of Mandarin Tones on Lexical Segments

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realization of at least some morphemes" (2002). Therefore, tone and lexical meaning are related. Tone provides lexical information.

Duanmu (2005) explains that by "using standard tonal features, according to which contour tones are made of two (or more) level tones, the four tones are represented in (1).[2] In the alphabet system Pinyin, the words in (1) can be transcribed as $ma^1$, $ma^2$, $ma^3$, and $ma^4$, where tones are represented by the superscript numbers 1-4" (p. 3). In this table the word for *mother* carries a level first tone. The lexical meanings of the following three words are completely different from that of *mother*. They have no semantic connections. All four tones can be used to make a lexical difference on one segment. The following chart gives a more visual approach.
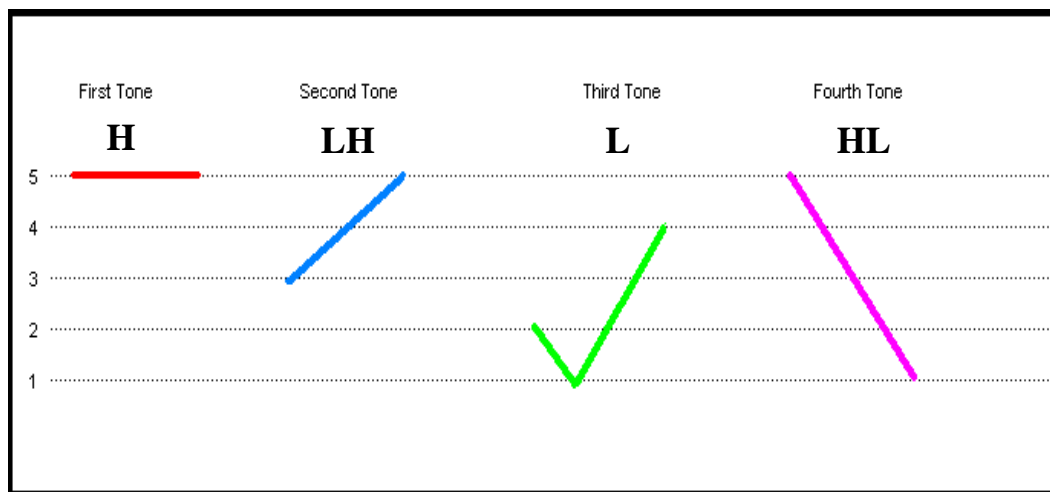


*Figure 2*. Mandarin Chinese Tones[3]

Mandarin Chinese relies on tonal contrast to convey lexical meaning. Yip (2002) explains that:

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[2] Level tones are tones in which no rising or falling occurs. The level tones in Mandarin Chinese are high and low. When high and low tones are used the speaker keeps a level pitch. Contour tones are when two level tones are combined. In Mandarin Chinese the contour tones are rise and fall. The speaker does not keep a pitch, but instead rises or lowers one's pitch to create a contour tone.

[3] The numbers on the left-hand side signify pitch levels. It is important to understand that these are relative. Each speaker will have his or her own range of specific hertz and frequency levels, called a register. The numbers above are just used to show the relative rising and lowering of the pitches. For example, one speaker might register a first tone at a much higher hertz value than another speaker, but each speaker will "fall" and "rise" their tones at the same intervals, just in different pitch ranges.

If a language places a heavy information load on its tonal contrast, level tones do not suffice. There are many languages that contrast four or more tones and this number of contrasting levels is rare. Instead, a smaller number of level tones is supplemented by the addition of one or more contours. These may be simple rises or falls, or tones which first rise and then fall (convex tones) or first fall and then rise (concave tones). The existence of the more complex tones usually implies the existence of simple rises and falls. Falls are much more common than rises. (p. 180)

Yip's diagnosis of tonal contrasts matches with the Mandarin data presented above in Figure 2. Mandarin Chinese has level tones, but these level tones are supplemented with a concave contour tone. The existence of the concave contour tone also implies that Mandarin will have rises and falls, which it does.

Tone has not always been viewed through the same frame of mind. The traditional understanding of tone was based upon the concept of whole segments. The tones were glued to the segment and, therefore, were an inherent part of the segment. Traditionally, tones were understood to be inseparable from the word or segment. Thus, in the Mandarin example used before, the four different *ma* segments would be separate words that would not share any segmental value. Each word, composed of a tone and segment, would be viewed as a separate entity. To further explain, the four words were looked at as completely different, as different as the words 'pizza' and 'ball' are in English. The tone and the segment were one and in no way separable (Goldsmith, 1976). These tones were understood as providing lexical information, but were categorized as a part of the lexical

segment. To further understand the traditional theory of tone, a discussion of Mandarin

Chinese syllable structure is presented below.

According to Duanmu (2005), "English has around 10,000 monosyllables

(excluding homophones). In contrast, Mandarin Chinese has a very small syllable

inventory, just around 400 syllables excluding tones (or around 1300 syllables including

tones)" (p. 2).  The Mandarin Chinese lexicon consists of a small amount of syllable

variations in contrast to English, therefore resulting in a smaller lexicon. For example, in

English words can consist of many different syllable structures such as CV, VC, CVC,

CCVC, CVCC to name a few; whereas in Mandarin there are only two variations CV or

CVC where the last consonant is a nasal (2005).

Therefore, in the traditional understanding of tones the *ma* words used in the

above examples would be classified as four different words. In a Mandarin Chinese

dictionary there would be four entries. Mandarin Chinese would be viewed as having

1300 syllables, instead of 400.

Traditionally, tones and segments are inseparable. However, is this approach the

best way to view tones and segments? Furthermore, does this approach capture the nature

of tones accurately? The big question is therefore: could tones be autonomous? Three

experiments were conducted to further understand the nature of tones and to ascertain the

best approach to the Mandarin Chinese tonal system.

## 2. Analysis of Tone Sandhi

According to Yip (2002), "Tone sandhi is a term that refers to phonological

changes that take place across word boundaries; in the Chinese tradition it is used for all

systematic tone changes, even when they take place word-internally across morpheme

boundaries" (p. 180). It is a phenomenon that occurs when tones shift on the basis of their specific environments. For example, the Mandarin Third Tone Rule (T3 rule) occurs when two third tones occur adjacently: "When two syllables with identical tones come together the first one changes. Mandarin takes a sequence of two low tones ('third tones') and turns the first one into a high rising tone ('second tone'). This rule is based on the Obligatory Control Principle, which prohibits two adjacent identical tones" (p. 180).[4] The rule is stated in the manner below:

$$[3] \longrightarrow [2]/\_ [3]$$

*Figure 3.* Third Tone Sandhi Rule

This rule can be read like this: A third tone becomes a second tone when occurring before another third tone. Duanmu (2005) expresses the T3 Rule as follows, "a third tone changes to a second tone when another third tone follows, or T3-T3 becomes T2-T3" (p. 7).

The following Mandarin example will make the rule clearer. In Mandarin, the standard greeting for *hello* is *nihao*. This word has two adjacent third tones. According to the Obligatory Control Principle, this is not possible. In tonal languages, having two identical tones side by side is undesirable because one of the general mantras of language structure is "contrast, contrast, contrast." It is what defines the linguistic system of language. Without contrast there would not be any language. In order to keep to this general mantra, languages devise coping mechanisms to fix undesirable outcomes, such as having two identical adjacent tones. Therefore, the word for *hello* must cope. The way

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[4] According to Yip (2002), the Third Tone Rule is "usually attributed to an OCP-driven avoidance of low sequences. However, this only happens if the two low tones are in the same domain. The domains are largely prosodic" (p. 180).

Mandarin copes with this undesirable outcome is through tone sandhi. The T3 rule is imposed on the original or underlying form of *nihao*. After the rule is completed the new or surface form is much different. The figure below will further explain this rule:

| UR[5] | $ni^3\ hao^3$ |
|-------|---------------|
| T3 Rule | $[3] \longrightarrow [2]/\_\ [3]$ |
| SR[6] | $ni^2\ hao^3$ |

*Figure 4.* Imposition of T3 Rule

The UR form has a 33 tonal pattern. When the T3 rule is enacted the form is changed from a 33 pattern to a 23 pattern, thus giving the needed contrast in the SR form. This rule is not random.

**2.1 Rationale**

To determine whether or not tone is an independent phonological feature, the first experiment explores the physical, phonetic nature of tone sandhi. In order to further understand the phonological tonal system of Mandarin Chinese the first area to be explored should be phonetics. Phonetics proceeds phonology. Phonetics gives the physical representation of tones, while phonology goes deeper into understanding the relationship of those tones. To ascertain if tones are inseparable or autonomous the phonetic basis of the tonal system must first be understood.

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[5] UR stands for Underlying Representation. An Underlying Representation is the subconscious underpinnings or the form before the rule is enacted. UR is not reserved for tonal discussion.
[6] SR stands for Surface Representation. Surface Representation is the conscious, observed linguistic form. In other words, this is the form that shows the effects of the rule.

**2.2 Method**

The first step was finding six examples of Mandarin phrases that have the T3 rule

applied to them naturally. Data was then gathered from four native Mandarin Chinese

speakers through a reading of the phrases into the PRAAT software.[7]

All four speakers underwent the experiment separately in order to not influence

the other speakers' results. After all the data was collected in the PRAAT software, it was

analyzed and graphs were given providing diagrams of the tonal processes.

The experiment's main objective was to observe and record the physical phonetic

properties of tone sandhi in a natural environment. PRAAT further helped in the analysis

of the phonetic properties.

**2.3 Results**

The following PRAAT graph is included of speaker one as a representative of the

data. Not all were included because the data yielded six graphs for each speaker. It is also

indicative of the results because the overwhelmingly large majority of the data followed

the same pattern as will be shown.

Before looking at the PRAAT graph, a deeper explanation of the PRAAT

software is given. First, the numbers on the sides of the graph represent the hertz range of

the speaker. This is not extremely important because each speaker has their own unique

range or register. Women tend to have higher ranges, while men tend to have lower

ranges. Second, the top half of the graph shows the frequency bars of the distinct parts of

the word. The first black shaded area is the first syllable, while the second area is the

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[7] The PRAAT software records and assesses tones by diagramming the pitches which in turn helps native English speakers visualize the different tones being verbalized. The tonal system of Mandarin Chinese is fairly straightforward; however, to English speakers any tonal language can be hard to decipher, as English is not a tonal language.

second syllable. Each area has a third tone in the underlying representation (these are the

*ni* and *hao* syllables respectively). Third, the bottom part of the graph shows what is

going on inside the mouth through the shading in the spectrogram. This is a little

technical and not as relevant to this discussion, so it would be best to understand it as

another visual representation of the top part. Lastly and most importantly, the blue lines

in the bottom part of the graph show the fluctuations in the pitch. These are the focus of

the experiment because they show which tones are being produced and the separation of

each syllable in the break of the blue lines. Arrows and tonal numbers are added to the

graphs to aid the reader.

　　　　The first graph below is of speaker one. The speakers were given a segment, such

as *nihao*, a word that is composed of a 33 pattern, the expected outcome being a 23

pattern after tone sandhi occurs. This happens naturally in the language, so this was set as

the control. Tone sandhi should and will occur no matter the outside circumstances in
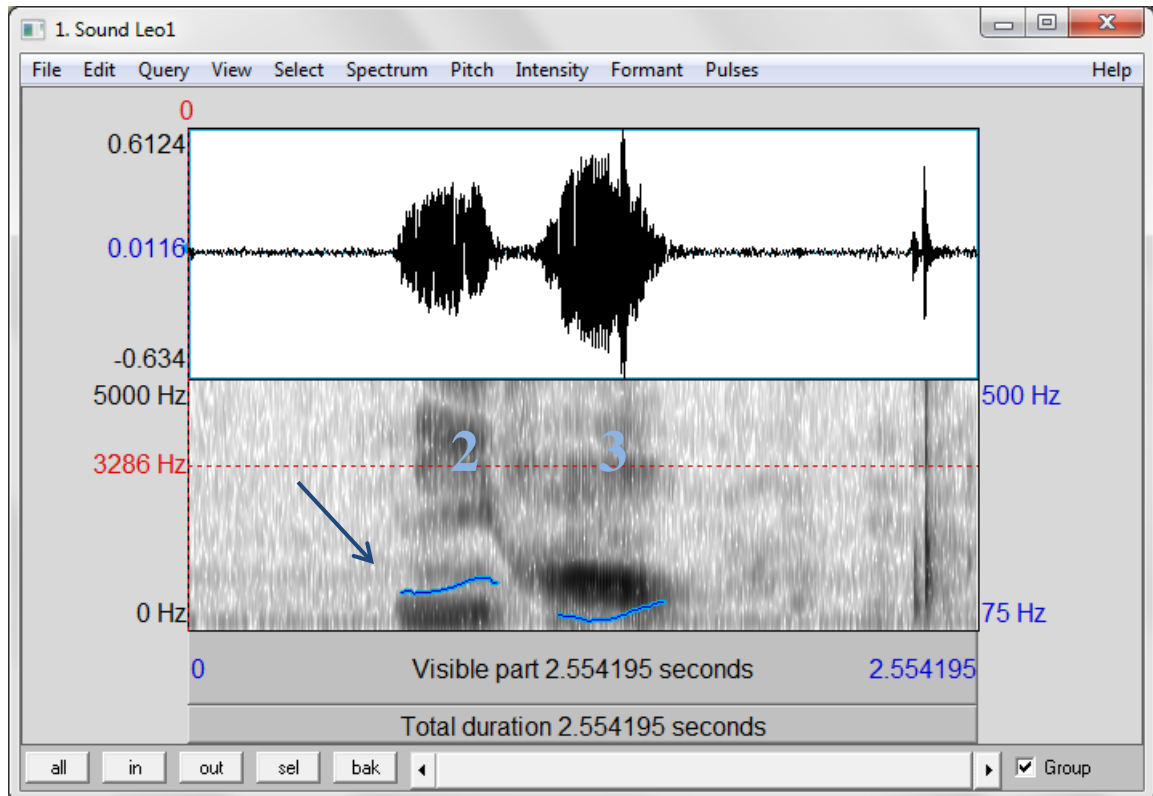
these words.

*Figure 5.* Speaker One: Tone Sandhi Segments (native words containing 33 pattern)

The speaker's blue lines offer the expected 23 pattern. This can be seen by comparing the blue lines with figure 2. The first blue line starts at a lower hertz level and slowly rises to a higher hertz level signifying a rising tone (2 or LH). The blue line coincides with the first syllable of the word. The second syllable offers a small, but definitive dip representative of a third tone. The small falling and then rising of the blue line indicative of a third tone is clearly seen (a 3 or L tone). The pattern is 23 and each tone is evenly distributed to its proper syllable, a model example of natural, native Mandarin tone sandhi pattern.

## 2.4 Discussion

The results show that Mandarin speakers produce the third tone sandhi by applying a tonal change. These results offer a basis for the problem: are tones inseparable

(or autonomous) from the segments? The results show that tones have a relationship with other tones which spurs a phonological process. The question of autonomy is only partially answered through this experiment. Traditionally, tone sandhi can be accounted for by viewing the tone sandhi segments as separate lexical items. Therefore, *ni3* and *hao3* are two separate lexical items and *nihao23* is a separate lexical item, having no relation to the individual syllables.

However, tone sandhi could also produce evidence of autonomous tones, in that the segments are not deciding factors in the tonal association. In other words, why does tone sandhi occur in such a systematic way? If tones and segments were inseparable and tones depended on the segment, then would not the segment hold some inherent quality that would afford that the tone change according to the segment's value? Yet, each third tone changes to a second tone regardless of the sound segments that make up the syllable segments or words.

In conclusion, the data results in partial evidence of autonomous tones. Tones do not depend on the phonetic properties of the segments. Therefore, the [m] or [a] sounds or length of the vowel does not determine the tonal association. It further seems that the segment does not hold any inherent value or reason for which the tone sandhi rule always changes a third tone to a second tone. Further, evidence shows that it is suspicious that the tones change and not the segment if in fact tones and segments are inseparable. For example, why does the phrase *nihao* not change to *nahao* or *nuhao* to offer contrast? Would these vowel changes not be sufficient contrast? Yet, Mandarin Chinese instead employs a phonological process of tonal change to affect meaning.

## 3. Tonal Behavior in Loanword Phonology

The next experiment explores how Mandarin Chinese interacts with foreign words. These words come to the native speakers without tone and most of the segments will be sequences that are unfamiliar in CV structure, stress, etc. The treatment of these foreign words will be crucial to the understanding of the tonal system. In this experiment, the subconscious understanding of tones will surface.

Loanword phonology in relation to Mandarin Chinese describes the phonological changes that occur when a tonal language borrows non-tonal language words. Mandarin Chinese assigns tones to English borrowed words. For example, the English word *Disney* is borrowed into Chinese and the result is: $di^2$-$si^1$-$ni^2$ (Hall-Lew, 2002).

If tones and segments are autonomous, then the tones will not lexically depend on the segments or words. This is the main objective of the experiment. The Mandarin speakers are given new lexical items. If tones depend on the lexical meaning of the words, then it would follow that tones are derived from an inherent linking of tone and lexical meaning. However, what happens when Mandarin speakers are given new lexical items that will have no previous linking to tones?

### 3.1 Results

The data was pulled from various dissertations and a sample is presented in the figure below.  A detailed description of the data is given following the figure.

Michigan → $mi^3\ xi^1\ gen^1$

Texas → $de^2\ ke^4\ sa^4\ si^1$

Bart → $ba^1\ te^4$

Maryland → $ma^3\ li^3\ lan^2$

Paul $\rightarrow$ *bao³ luo²*

Alabama $\rightarrow$ *a¹ la¹ ba¹ ma¹*

*Disney* $\rightarrow$ *di² si¹ ni²*

*Figure 6.* Loanword Data

The above data reflect a seemingly random distribution of tones. Each syllable has a tone

assigned to its vowel, which was expected. Other than this observation though, the data

did not support a pattern and even exhibited times where tone sandhi was ignored, like in

the *Maryland* example. These results could stem from multiple reasons; however, a valid

synopsis of the irregularities could be that Mandarin speakers are consciously

categorizing these words as loanwords and in doing so are consciously breaking tone

sandhi rules. The same process occurs in English as well. For example, the phrase "en

route" has remained untouched by native English phonological processes. English

speakers do not change the vowel in the "en" segment to "on" to accommodate the

English vowel system. Another factor is the amount of time a loanword has been present

in the language and the frequency at which the speakers use the word. State names such

as *Maryland* are probably not spoken very much in China; however, words such as

*Disney* are probably spoken at a very high frequency. It would make logical sense that if

a word is spoken at a high frequency and for a longer amount of time, then the word

would have more chances to go through a native phonological process and become

popularized in this state. Overall, it seems that tonal processes do not extend to borrowed

words; however, the tones themselves do.

**3.2 Discussion**

This data did, however, help in ascertaining the nature of tones concerning autonomy. The data shows that Mandarin Chinese speakers superimpose tones onto borrowed English words which do not have tone. The data interestingly shows a violation of tone sandhi rules, probably in an effort to match the original English stress patterns. The tones are applied according to syllable structure, each vowel received a tone.

Also, the data reveals that tone does not depend on the lexical item. Tones were reassigned to new lexical items. This realization further leads to the validation of autonomous tones. Tones therefore can be assigned to new lexical items, regardless of the segment. The segment does not have an inherent value that links it to a certain tone, instead the tone is not inherently linked either phonetically (shown in the first experiment) or lexically to the segment.

## 4. Application of Tone Sandhi in Non-Sensical Phrases

In the first experiment the phonetic properties of tone sandhi were explored and it was concluded that tone sandhi does not depend on the phonetic properties of the individual segments. In the second experiment it was further concluded that tones do not depend on the lexical qualities of a segment. However, there is one large area that has not been explored: semantics. Do tones depend on semantic meaning of the segments? This third experiment explores this question. The experiment forced the Mandarin Chinese speakers to choose between applying the T3 rule to the underlying representations of the nonsensical phrases and thus receiving a surface representation similar to the one of the Mandarin greeting of *hello* shown earlier or keeping the two adjacent third tones (the underlying representation).

**4.1 Method**

The method for the third experiment closely resembles the first experiment. The first step was finding six examples of nonsensical phrases composed of two separate syllables carrying the third tone. For example, the two syllables would be words that naturally occur in Mandarin Chinese with a third tone, such as the Mandarin words for *foot* and *inch.* These two words were presented as adjacent Chinese characters. These two words placed together form the nonsensical meaning of *inchfoot* or *footinch*. Data was then gathered from four native Mandarin Chinese speakers through a reading of the phrases into the PRAAT software.

All four speakers underwent the experiment separately in order to not influence the other speakers' results. After all the data was collected in the PRAAT software it was analyzed and graphs were given providing diagrams of the tonal processes.

**4.2 Results**

The following PRAAT graph is included of speaker one as a representative of the data. It is also indicative of the results because the overwhelmingly majority of the data followed the same pattern as the ones shown below.

This graph will show the results of the tonal process in the nonsensical segments. This is the crucial graph. The blue line pattern in this graph will show whether or not tone sandhi was enacted or if the underlying representation of 33 was kept.
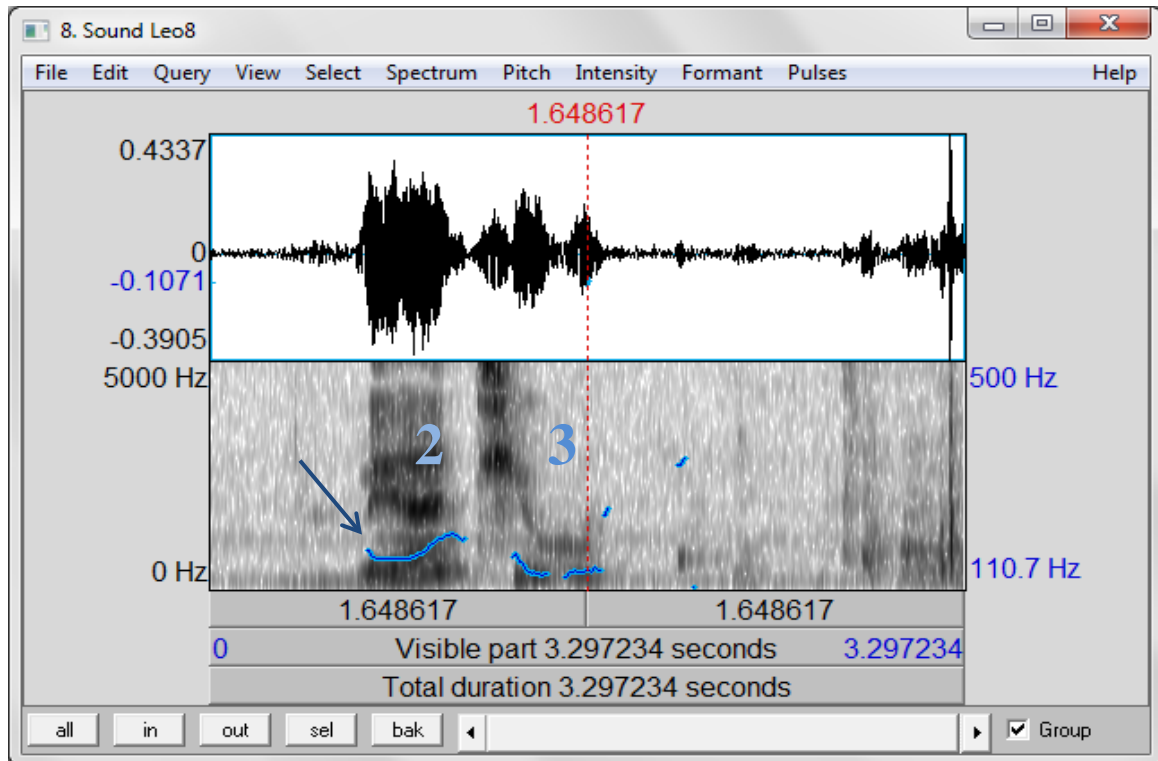
*Figure 7.* Speaker One: Nonsensical Segments (Made up words containing a 33 pattern)

The same speaker was used to show the nonsensical data and the natural tone

sandhi in the first experiment so that it could be as controlled as possible and in the same

hertz range. The speaker, although given a 33 pattern in a word that did not make sense

and that he had never seen before, gave a resulting 23 pattern. The speaker enacted tone

sandhi. Interestingly, the tones are more defined and evident. The tone sandhi pattern was

strong. The pattern holds the same rising and then falling rising as the standard tone

sandhi graph in the first experiment.

During the experiment, it was noted that the speakers only had trouble when there

was a communication breakdown due to the language barrier. The speakers used were of

low English proficiency. They were told that some of the words did not make sense, but

sometimes this could not be communicated clearly enough. Even accounting for this small problem, the data overwhelmingly exhibited a 23 pattern.

**4.3 Discussion**

The data showed strong evidence that tones do not depend on the semantic meaning of words. Using nonsensical words eliminated the semantic property of segments and in turn forced the tones to either act independently of the segments and follow a tonal process (tone sandhi) or not. The evidence clearly showed that tones were autonomous and were able to function on their own and even function within the known tonal, phonological process of tone sandhi.

Therefore, tones are autonomous because they do not depend on the segment for phonetic, lexical or semantic properties. Tones are further autonomous because they have their own processes, such as tone sandhi, that are not dependent on the segment.

All three of these experiments worked to bring opposite ends of the spectrum together. The first experiment successfully proved that tone is autonomous and therefore separate from the segment and could undergo tonal processes without the interference of the segments. The second experiment worked from the other side in that it took a word without tone and offered it to the tonal system. The tones proved to be autonomous again and independent of segments even in a new environment and acted in their own sphere to come up with a coping mechanism for nontonal words. Tone sandhi was not followed in all instances, but instead a prosodic feature matching mechanism was put into place so that the tones mimicked the stress patterns of the English words. The last experiment further cemented the autonomy of tones in showing that tones were not dependent on the semantic value of segments and could function on their own in a phonological process.

These experiments worked together to show in effect that tone is autonomous, but that tonal processes are also autonomous and can function on their own.

## 5. Autosegmental Phonology-based Analysis of Tone Sandhi

Now that it has been concluded that tones are autonomous, traditional theoretical frameworks are not adequate to fully explain or express the tonal system of Mandarin Chinese. The framework of Autosegmental Phonology will be adopted to reinterpret the results of the experiments explained above.

Tones are now understood to be separate from the segment. Tones and segments are autonomous or independent. Thus, each of the four *ma* words would be understood to be one segment, with different tones that could be superimposed on the segment. This theory is revolutionary because instead of four words seemingly having nothing in common, they now share a common base-- the segment. The tones could be detached from the segment. They were considered to be suprasegmental, or above the segment. Therefore, any segment like *ma* could be manipulated by plucking off the tone and placing another tone on top of the segment to produce another lexical meaning. The framework was now that the segment *ma* could have four tones, not that there were four different segments with differing tones. Tones were no longer one with the segment, no longer inseparable or glued down (Goldsmith, 1976). Mandarin Chinese syllables were further analyzed as being 400 syllables with differing tones, not 1300 different syllables. This alone offered a great reduction to the work of linguists in lexically filing words.

The theory of Autosegmental Phonology was proposed by Goldsmith in his doctoral dissertation in 1976. Goldsmith used his theory to analyze African tone languages. The tonal properties of the word or segment were factored out and treated

separately from the segmental properties: "Goldsmith proposed a two-tiered representation in which tones are associated to tone-bearing segments (usually vowels)" (Spencer, 1991, p. 133). Goldsmith's main point was that a phonological representation of a word or phrase was about more than just the segments. The segments had a relationship with other elements, which he called autosegments, and this relationship could be mapped out specifically: "For example, a sequence of consonant and vowel phonemes, and simultaneously a sequence of tones, together with an indication of which tones are linked to which vowels" would create a proper phonological representation (Spencer, 1991, p. 133).

Goldsmith's theory is considered nonlinear, because of the multiple lines of phonological elements (one is the CV structure and the other is the tone):

Tone is on a separate 'tier' from the segmental and prosodic material, like a musical melody. A tone is only realized on the surface if it is 'associated' with some segment or prosodic entity such as a syllable or the more, on which it is eventually pronounced. These associations are denoted by lines connecting the tiers. (Yip, 2002, p. 180)

John McCarthy took Goldsmith's theory and revolutionized it by first applying it to Semitic languages. In these languages tone is not a factor; however, prosodic features still exist. The meaning of 'prosodic' can be taken as anything that is superimposed on the segment, such as intonation or stress in English. Semitic languages are largely tri-consonantal, meaning every word has a root of three consonants. These languages change the order or sequence of the vowels that go in between the root consonants in order to change tense, aspect, person, or number on verbs and in nouns the vowels used will

determine the plurality and agreement with the verb. The difficulty came in showing this realization. No framework was available to visually show that the vowels were being plucked out of the root and switched with another set of vowels. In these languages the vowels were being superimposed onto the tri-consonantal root.

Arabic is known for its triliteral roots.[8] The three consonants of a root do not change; however the vowels do and these changes carry grammatical meaning. For example, the root *ktb* in Arabic means 'write.' The vowel sequences give the grammatical meanings of example (2):

(2)     a) [k**ata**b]  perfective active     (-a-a-)

          b) [k**uti**b]  perfective passive    (-u-i-)

          c) [**a**kt**u**b]  imperfective active     (a- -u-)

          d) [**u**kt**a**b]  imperfective passive   (u- -a-)

*Figure 8.* Paradigm of *ktb* 'write'

In traditional morphological frameworks it would be extremely difficult to show the grammatical meanings associated with the morphological changes, because they are occurring in a nonlinear framework. The vowels would be analyzed as discontinuous infixes and prefixes. Instead, the root and vowels can be better viewed in a nonlinear framework shown in the figure below.

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[8] A trilateral root is a set of three consonants between which are inserted vowels to denote grammatical functions (Spencer, 1991).
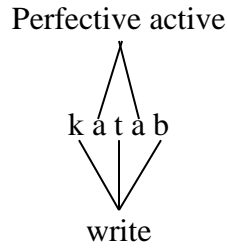
Perfective active

k á t à b

write

*Figure 9.* Separation of Morphemes

McCarthy further expands the nonlinear framework by denoting specific tiers. The first tier is a prosodic template or a CV tier:

This is a representation of a morpheme or word simply in terms of the string of consonants and vowels which make it up but without any indication of precise identity of those consonants and vowels. Crucial to McCarthy's theory is the idea that separate identifiable exponents of a morphological category, such as the trilateral root or the vowel sequence, are represented on separate planes or dimensions of the representation. These planes are usually called tiers. The other two tiers consist of ordinary phonemic segments, the sequence of root consonants and vowel sequences. These segments are called melody elements. They have to be associated to the C and V slots of the CV template. (Spencer, 1991, p. 134)

The following example would be McCarthy's representation of *katab* (the perfective active).

a

C V C V C

k    t    b

*Figure 10.* Autosegmental Phonology Analysis of *ktb*

The structure and placement of association lines is governed by Goldsmith's (1979)

Well-Formedness Condition, given below:

      a) Every CV skeletal slot must be associated with at least one melody element and

      every melody element must be associated with at least one appropriate C or V

      slot.

      b) Association lines must not cross.

"'Appropriate' means that a consonant melody element links to a C slot and a vowel

element links to a V slot" (Spencer, 1991, p. 134).

      Now that a sufficient overview of Autosegmental Phonology has been given the

examples and experiments detailed in this paper will now be reinterpreted using this

model.  The following figure will show the Autosegmental analysis of one of the *ma*
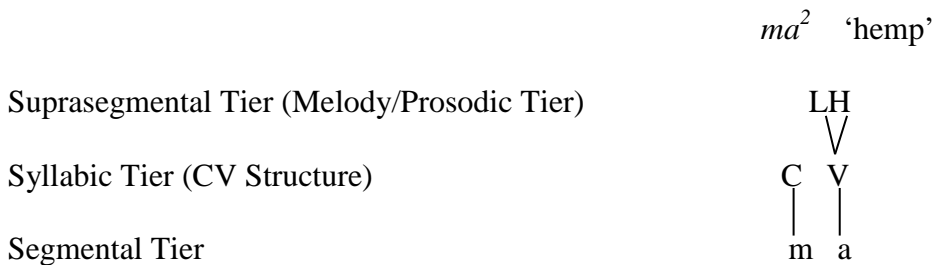
segments.

$$ma^2 \quad \text{'hemp'}$$

Suprasegmental Tier (Melody/Prosodic Tier)             LH

Syllabic Tier (CV Structure)                         C  V

Segmental Tier                                   m  a

*Figure 11*. Autosegmental Analysis of Mandarin Chinese

      In this example three tiers are shown: the suprasegmental containing the tone, the

syllabic containing the CV structure, and the segmental containing the *ma* or the actual

sounds representing the CV structure. This segment carries the rising tone, but it is

separated from the segment and occupies its own tier. One can simply detach the LH tone

and supply another tone. Using a falling tone (HL), for example, the lexical meaning

would simply be 'scold' instead of 'hemp.' Nothing changed except for the

suprasegmental tier. This framework completely revolutionized the world of linguistics

and how linguists viewed prosodic features, such as tone.

Another example is provided to further examine a more complex prosodic feature

through using this framework. Recall the example used earlier of the Mandarin greeting

for *hello*. Tone sandhi rules can be explained using other frameworks. An example using

Generative Phonology when was given in the T3 rule in this form: 3→2/__3. However, it

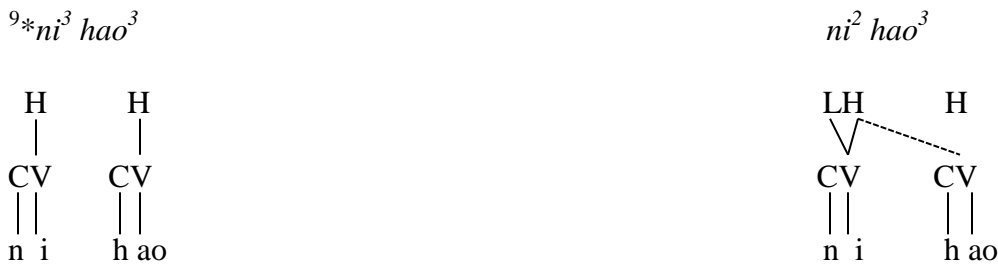can also be explained through Autosegmental Phonology. Below is this example:

[9]*$ni^3\ hao^3$                                                      $ni^2\ hao^3$

```
  H       H                              LH        H
  |       |                               \/·······
 CV      CV                              CV        CV
 ||      ||                              ||        ||
 n i     h ao                           n i        h ao
```

*Figure 12.* Autosegmental Analysis of Mandarin Chinese Tone Sandhi

Notice that the UR is on the left-hand side and the SR is on the right-hand side of

the figure. What becomes apparent is that the tones are separable. The segmental

structure does not have to change when the tone sandhi rule is applied. The tones are

acting of their own will, in their own sphere, completely autonomous of the other two

tiers. The tone sandhi rules are better understood through this structure because in

previous frameworks tone sandhi rules could only be dealt with by looking at each

individual segment, as though the tone depended on the segment or that the segment had

some intrinsic reason for causing the tones to go through a change. This framework helps

us further understand that tones are autonomous. Spencer (1991) states, "scientific

---

[9] Note: The asterisk indicates an incorrect diagram or before tone sandhi rule is enacted (the Underlying Representation of 33).

discovery and the appraisal of empirical facts depends in large part on the theoretical apparatus at the disposal of the scientific community" (p. 133).

## 6. Conclusion

Tone is the lowering and rising of pitches that can in some languages change the lexical meaning of segments. This was crucially seen in Mandarin Chinese through the example of the *ma* segment. It was further deduced that tones function in processes as well, such as tone sandhi. This was effectively seen through the Mandarin example of the famous greeting of *hello*.

A new approach to prosodic features was given: Autosegmental Phonology, a framework that breaks linguistic data into three tiers. The history of tonal theory was viewed in relation to Autosegmental Phonology and it was understood that tones were once seen as inseparable, inherent parts of the segment.

Three experiments, two dealing with tone sandhi and one with loanword phonology, were conducted and the results gathered to further validate the statement of tonal autonomy. It was found that tones are indeed autonomous and that the Autosegmental Phonology framework is adequate in its analysis of the linguistic data. It was further found that not only were the tones themselves autonomous, but that their processes were too. Tones are completely functional on their own. It is as though they are complete, living organisms in their own ecosystem. It was further found that not only are the tones functional, but that they can adapt to new environments, much like living organisms being transported to a new environment the tones mimicked the prosodic feature of stress in the new environment of English.

## 7. Future Research

So now the question becomes: what next? This relatively new theoretical model, Autosegmental Phonology, offers a new way of thinking about tones and segments. With this new view of prosodic features and phonological processes new questions arise, such as the question of *why*. Why are the speakers choosing to use tonal processes, such as tone sandhi, instead of other common processes such as vowel differentiation or lengthening? Or, why are the speakers choosing to use tone sandhi with certain loanwords and not others? Is there a systematic process that is governing this seemingly random distribution of tone sandhi processes?

The newest theoretical model to take the stage in linguistics is Optimality Theory. This theory works with the idea of subconscious constraints and rankings, or in other words answers the question of *why* (Kager, 1999). Autosegmental Phonology definitively answers the questions of *what* and *how*, but Optimality Theory takes another viewpoint to give a fuller picture of the relationship between tone and segment. In Optimality Theory the central theoretical concept is one of constraints and rankings. These constraints and rankings tell us why a speaker chooses Option A over Option B (Kager, 1999). This theory could potentially unravel some of the mystery behind the research already presented in this paper and is a valid approach for further research.

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