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The Phonetic Representations of Nasality in Taiwanese Words*

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Abstract

The purpose of this study is to investigate nasality behavior triggered by the suffix *a* when it is attached to a monosyllabic stem; that is, monosyllabic stem + *a*, such as *mi.a* ‘cotton’, *t^{h}ŋ.a* ‘candy’, *kim.a* ‘gold’, and *p^{h}ĩ.a* ‘nose’. Following the application of the autosegmental model (Goldsmith, 1976) used in previous studies, this paper attempts to offer a possible phonetic representation of the nasality nature. In this study, nasality of nasalized vowels in Taiwanese floats above its nasality bearing vowels and may spread bidirectionally within the domain of a phonological word. The spectrogram of the four words validates the rightward nasality spreading. In addition, a simple test reveals that the leftward nasality spreading may occur. Consequently, the floating nasality may possess the nature of bidirectional spreading. The phonetic realizations of the four words as a result would be transcribed as [mi$^{\tilde{i}\tilde{a}}$ã] ‘cotton’, [t^{h}ŋ$^{ŋ\tilde{a}}$ã] ‘candy’, [kim$^{m\tilde{a}}$ã] ‘gold’ and [p$^{\tilde{h}\tilde{i}\tilde{a}}$ã] ‘nose’, respectively.

Keywords: Taiwanese, autosegmental phonology, nasality, nasality bearing unit, bidirectional spreading rule

* This present study is a revised version of part of my dissertation (Lin, 2006).

The Phonetic Representations of Nasality in Taiwanese Words

台語鼻音性的語音表徵

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摘　要

本研究延用自主音段音韻學(Goldsmith, 1976)架構，分析台語帶鼻音的後綴詞 (例：*mi.a*「棉仔」，*t*^{h}*ŋ.a*「糖仔」，*kim.a*「金仔」和 *p*^{h}*ĩ.a*「鼻仔」)，並藉由 F1 的聲學變化及一個簡要實驗驗證，進一步釐清台語鼻音性的語音變化現象。研究結果指出：鼻(化)母音的鼻音性懸浮於母音(鼻音承載單位)之上，並可能具雙向擴散功能。因此，「棉仔」、「糖仔」、「金仔」和「鼻仔」在運用可能的鼻音雙向擴散規則之後，其語音表徵可能形態爲 [mĩi^{ã}ã]， [t^{h}ŋ$^{ŋ̃}$ã]， [kim$^{m̃}$ã] 和 [p̃^{h}ĩ^{ã}ã]。

關鍵詞：台語、自主音段音韻學、鼻音性、鼻音承載單位、雙向擴散規則

1. Introduction

The purpose of this study is to investigate nasality behavior triggered by the suffix *a*; that is, monosyllabic stem + *a*, such as *mi.a* 'cotton棉仔', *t^hŋ.a* 'candy糖仔', *kim.a* 'gold金仔', and *p^hĩ.a* 'nose鼻仔'.[1] Following the application of the autosegmental model (Goldsmith, 1976) used in previous studies, this paper attempts to offer a possible phonetic representation of the nasality nature.

Autosegmental Phonology, also known as non-linear phonology, treats phonological representations as multi-dimensional rather than a linear display of feature matrices. In particular, some phonological features (regarded as independent segments or autosegments) can be taken away from their segments and arranged on separate autonomous tiers, so that rules applied to one tier may not apply to another. These autosegments are linked to each other by association lines to indicate interrelationship among them. As Goldsmith stresses, "Autosegmental phonology is an attempt to supply a more adequate understanding of the phonetic side of the linguistic representation" (1976, p. 16).

Since phonological features are positioned on different tiers other than the segmental tier, they may remain in their respective tiers even after their associated segments are deleted. This multi-dimensional perspective contrasts with that of Chomsky and Halle's (1968) SPE (*The Sound Pattern of English*) model. The SPE model is a linear phonological perspective which

[1] In this paper, the tones of the sample words are not transcribed because of their irrelevance to the analysis here. The dot indicates the morpheme boundary of suffixed words. The tilde ˜ indicates the nasalization property.

stipulates that all phonological features are included in the segments. Phonological specifications, including suprasegmental properties (e.g., nasality, syllable, tone, or stress), together with segments are arranged in a linear sequence, and this way of phonological representations results in an unsatisfactory condition. The problem in SPE, however, is that when segments are deleted, their entire feature matrices are also deleted (Goldsmith, 1976, 1990). The autosegmental model yet is not a "rival" to the SPE model; it is considered to be a development within the SPE theory (Roca, 1994). Nasality is handled separately as autosegment in the multi-dimensional theory, and this is because of their unique phonological behavior. Nasality owns the property of stability; also, nasality associates to its nasality bearing unit (NBU), which is a vowel. The stability property of nasality arises from the process in which the nasality feature is taken away from the manner property and acts as an autosegment, so it is retained even after its connected root node is deleted (Piggott,1987). In addition, nasality owns a unique feature whereby it may spread bidirectionally (Goldsmith, 1976). That is, nasality can be autosegmentalized and placed on the nasality tier (or nasal tier), associated with the nasality bearing vowel, and then it would spread bidirectionally within its domain.

Taiwanese has eighteen consonants, six primary vowels, and its syllable structure is (C)V(C) which includes V, CV, VC, and CVC. Apart from the glottal stop /ʔ/, all other consonants occur syllable-initially; on the other hand, only seven consonants /m/, /n/, /ŋ/,

/p/, /t/, /k/, /ʔ/ occur syllable-finally. Besides, there are two syllabic consonants: [m̩] and [ŋ̩]; they possess the [+syllabic] feature, forming the nucleus of syllables in words like *m̩* 'do not 不要' and *t*^{h}*ŋ̩* 'sugar 糖'. Taiwanese has six primary vowel phonemes including /i/, /u/, /e/, /o/, /ɔ/ and /a/ (Luo, 1931). In some studies, four additional nasal vowels /ĩ/, /ẽ/, /ɔ̃/, /ã/ are included in the vowel inventory, bringing the number of vowel phonemes to ten (Chung, 1996; Lin, 1989; Wang, 1995).

The nasality behavior in Taiwanese is explicitly characterized by Lin (1989), in which she differentiates the nasalized (or nasal) vowels from the nasal consonants, "The nasal feature of a nasalized vowel and a nasal consonant in Taiwanese should have different properties, which I claim are because of their different underlying representations, floating versus linked respectively" (p. 323). In other words, the nasal feature of a nasalized vowel spreads nasality bidirectionally, whereas the nasal feature of a nasal consonant only spreads nasality to its following vowel. In this study, I follow Lin's model: the nasal feature of nasalized vowels is marked as the tilde ~ floating above the vowels, while the nasal feature of nasal consonants is marked as *N* linked with the consonants. The reason for using the single-valued feature *N* (neither ±N nor [±nasal]) is that oral segments play no role in the phonological process of nasality, so *N* is present if there is a nasal segment, otherwise *N* is absent if there is no nasal segment (Ewen & van der Hulst, 2001).

In conclusion, the phonemic representation of nasality in

Taiwanese is shown in Figure 1.

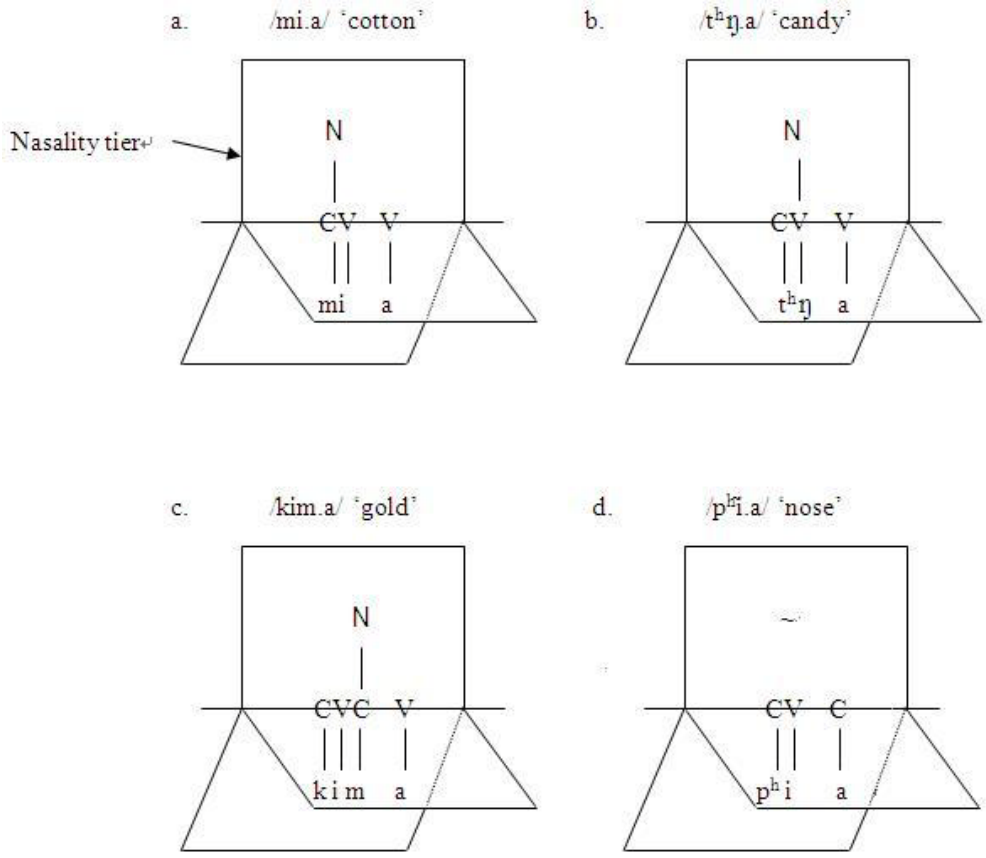


Figure 1. Phonemic representations of nasality before spreading.

As revealed in Figure 1, the nasal feature *N* is treated as an autonomous element, placed in the nasality tier, and linked to the onset /m/ in (a), connected with the nucleus /ŋ/ in (b) (the syllabic consonant /ŋ/ functions like a consonant, though it is situated on the nucleus position of a syllable), and associated with the coda /m/ in (c). In (d), the nasal feature ~ is autosegmentalized as well but floating above rather than connecting with the vowel /i/.

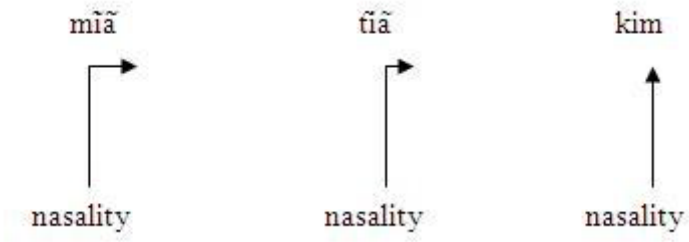
2. Literature review

As regards the behavior of nasality, researchers differ in the identification of the nasality-bearing unit and the direction of nasality spreading. Tung (1988) proposes two types of nasalization processes; namely, progressive nasalization and regressive nasalization. He clarifies that the former has priority over the latter. Moreover, he states that the two ways of nasalization are incompatible in a syllable, i.e., if progressive nasalization is activated, then regressive nasalization becomes inoperative and vice versa. However, Wang (1995) points out that Tung's proposal of unidirectional nasalization fails to explain some forms that require bidirectional account. Wang states, "Actually, in some cases both progressive nasalization and regressive nasalization apply" (p. 74). To solve this problem, Tung (1992) in his later work offers another hypothesis which attributes phonetic nasality of consonants to two different sources. Tung states that the nasalization of an initial consonant would depend on the contrast of the nasal / oral nucleus, and the nasalization of the final consonant would depend on the tonal checked / unchecked contrast. Nevertheless, he admits that the two-source hypothesis would be difficult to defend.

Lin (1989) states that "the nasal feature of a nasalized vowel and a nasal consonant in Taiwanese should have different properties, which we claim are because of their different underlying representations, floating versus linked respectively" (p. 323). In other words, Lin considers the nasal feature of a nasalized vowel to be an autosegmentally floating element which spreads to the vowels and voiced consonants within the

domain of a phonological word; for example, /liãu/ → [nĩãũ] ‘cat 貓’ ([n] is treated as the allophone of /l/) and /i.a/ → [ĩ-ĩã] ‘baby 嬰仔’. On the other hand, the nasal consonant in the coda position has the linkage with nasality, so it does not spread leftward to generate the ill-formed output as in [*kĩm] ‘bright, gold 金’.

Li (1992) adopts the autosegmental model for the analysis and states that the nasality links to three different nasality bearing units: onset, rime (including glide), and coda. After the linkage, the nasality spreads from left to right, and the scheme of this proposed analysis is depicted below (p. 424):



As presented in (1), the nasality of the word [mĩã] ‘life 命’ initially links with the onset [m-] and then spreads rightward. Likewise, in the word [tĩã] ‘cooking vessel 鼎’, the nasality associates with [ia] and spreads rightward. Finally, as the word [kim] ‘gold’ shows, the nasality connects with the coda [m] and spreads rightward as well (i.e., when the coda is connected with the suffix *a*). Though the nasality links with three different elements, the direction of spreading is the same, which is from left to right.

Wang (1995) formulates an autosegmental account and treats nasal element as an autosegment where it is presented in the nasal tier. According to his proposal, the

nasality element in the nasal tier is primarily associated with the coda of the rime. In principle, nasality is allowed to spread bidirectionally from the coda but the leftward spreading is blocked by the non-nasal element of the nucleus. The autosegmental representations for (2) words, /ban/ ‘slow 慢’, /ma/ ‘scold 罵’, /mɔʔ/ ‘hold 摟’, /mŋ̍/ ‘door 門’, and /aŋ.a/ ‘little figure 尪仔’ are diagramed in (2). The parentheses are used to indicate the rime; N means nasality and O means oral element (pp. 80, 83).

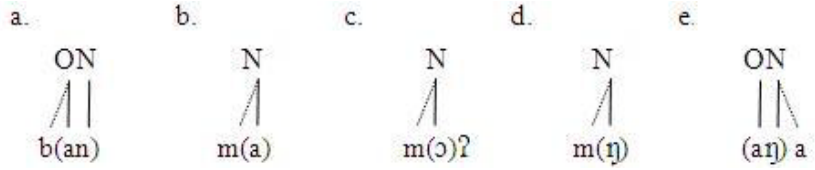


Diagram (2) indicates that the nasal element on the nasal tier first associates with the coda consonant of the rime (2a). If there is no coda, the nasality links to the nucleus (2b-2d). After the establishment of the associations, the nasal elements are motivated to spread bidirectionally to the adjacent nasal bearing units which include vowels, voiced stops and the voiceless consonant /h/. The leftward spreading is blocked by the oral element and the rightward spreading is allowed to cross the morpheme boundary and derives the form [aŋ.ã] (2e).

Chung (1996) claims that nasality in Southern Min is governed by domain-based rules. According to him, the nature of nasality is characterized by the following aspects. First, the nasal consonants

[m], [n] and [ŋ] are presumed to be allophones of the voiced stops /b/, /l/ and /g/, respectively. Second, only the vowels /i/, /u/, /e/, /o/, /ɔ/, /a/, the voiced stops /b/, /l/, /g/, the voiceless fricative /h/, and the glottal stop /ʔ/ can be nasalized, whereas the voiceless obstruents /p/, /t/, /k/, /p^h/, /t^h/, /k^h/, /s/, /ts/, /ts^h/ cannot be nasalized. Third, the nasality features of nasalized vowels and that of nasal consonants in the coda position are quite similar. Lastly, the nasality feature is morphemic, and it floats in underlying representation.

As for the derivation of a nasalized form, Chung proposes three stages: (1) domain definition; (2) nasal spreading; and (3) percolation. The first stage, domain definition, indicates that onset and nucleus constitute one domain, and coda defines another domain. After that, in the stage of nasal spreading, the floating nasality feature is underlyingly associated with the right-most domain, and it is followed by the bidirectional spreading to the designated domains in other syllables. However, there is the so-called "One Nasal Constraint" which means that only one domain per syllable can receive nasality and such constraint must be applied. Finally, the nasality feature is percolated to all segments in the designated domain.

Furthermore, Chung employs Chiang's (1992) proposal of prosodic framework to manifest the process of nasality spreading. He states that "… within a prosodic word, the nasal of a domain spreads to the adjacent domain *if and only if* the domains are of different syllables" (p. 193). The derivations of the two phonological words /ẽ.a/ 'infant 嬰仔' and /kam.a/ 'tangerine

柑仔’ are shown in the following (pp. 193-194):

（3）

	a.	b.
Suffixation	(e) a | [nasal]	ka(b) a | [nasal]
End-spreading		ka(b) ba | [nasal]
Domain definition	(e) (a) | [nasal]	ka(b) (ba) | [nasal]
Nasal spreading	(e) (a) | [nasal]	
Percolation		ka(b) (ba) | [nasal]
Surface	[ẽ.ã]	[kam.mã]

In (3), the right-most domain of the two stems in (3a) and (3b) is associated with the nasality feature. Next, after the addition of the suffix, the coda of the stem as well as the nasality feature spread to the onset position of the following syllable *a*. In the stage of domain definition, domains in other syllables are determined, after which rightward nasal spreading takes place. Finally, the nasality percolates all elements within the designated domain, and the phonetic outputs of [ẽ.ã] and

[kam.mã] are derived.

Ang (1996) claims that the spreading of nasality can be conceived to start from the most sonorous peak and end at the least sonorous segments in both directions. In short, the nasality spreads bidirectionally from the nuclear vowel to the surrounding segments (a nucleus is analyzed as GVG in which G indicates a glide and V the nuclear vowel). Moreover, he argues that the main point for nasality spreading predominantly relies on the position where a nasal segment is situated rather than on the nature of the segment itself. For example, when the nasal consonant /ŋ/ occupies the nucleus position, the linked nasality can spread leftward to the onset consonant, as in /lŋ/ → [nŋ] 'two 二'. On the contrary, when the nasal /ŋ/ occupies the coda position, the nasal consonant /ŋ/ stops spreading leftward (e.g., /lɔŋ/ → *[nɔŋ] 'farming 農').

In summary, the feature of nasality spreads across morpheme boundary within a prosodic word, characterizing the nasality nature of the rightward spreading. However, the unidirectional assumption does not fulfill the requirement of some words that need the nasality to spread bidirectionally. As to the nasality bearing unit, the proposed hypothesis varies among the researchers. If it is assumed that there are three nasality-bearing units, further explanation seems to be needed as to what the motivation is to establish three separate sources of nasality instead of just one.

Moreover, it appears that some points discussed in the literature may require further exploration. First, it is claimed that voiceless obstruents cannot be nasalized

(Chung, 1996; Lin, 1989). By virtue of the claim, the voiceless obstruent /p^{h}/ in *p^{h}ĩ.a* ‘nose’ and the voiceless obstruent /s/ in *sẽ.a* ‘raw iron 生鐵’ cannot be nasalized; however, the voiceless obstruent /h/ in *hĩ.a* ‘ear 耳仔’ is claimed to be nasalized. Why can the obstruent /h/ be nasalized whereas the obstruents /p^{h}/ and /s/ cannot? Second, the nucleus /i/ in the word *mi* ‘noodle 麵’ is claimed to transmit the nasality to the onset consonant /m/ (or /b/) (Lin, 1989; Wang, 1995), but in reality it is the nasal /m/ that carries nasality over to the nucleus /i/. Finally, the sounds [m], [n] and [ŋ] are claimed to be allophones of the voiced stops /b/, /l/ and /g/ (Ang, 1996; Chung, 1996; Lin, 1989; Wang, 1995), yet the two sets exist different phonetic properties. The phoneme-allophone relationship requires further clarification.

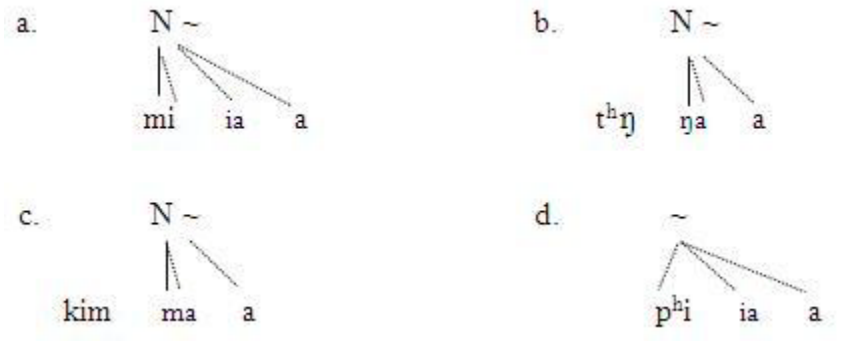
In this present study, vowels are regarded as the nasality-bearing units, and this study attempts to explore the following questions: In the nasality tier, what is the nature of the nasality that would be expected from the addition of the suffix *a*? Is the spreading direction of the nasality a rightward spreading, a leftward spreading, or a bidirectional spreading?

3. Analysis

As has been stated in the theoretical framework, nasality of nasalized vowels in Taiwanese floats above its nasality bearing vowels and spreads bidirectionally within the domain of a phonological word; on the other hand, nasality of nasal consonants links with its consonants and only spreads to its succeeding vowels. The proposed nasality behaviors of the four words *mi.a* ‘cotton’, *t^{h}ŋ.a* ‘candy’, *kim.a* ‘gold’, and *p^{h}ĩ.a*

'nose' are schematized in (4).

(4)



In the proposed spreading pattern, (4a) shows that the nasal feature of [m] spreads its nasality *N* to its following vowel [i], thus, makes the vowel [i] nasalized as [ĩ]. Next, the nasality of the nasalized vowel [~] is taken away from the segment and is placed on the nasality tier. Afterwards, the nasality on the nasality tier starts to spread bidirectionally to its adjacent segments. However, the leftward spreading is blocked since the nasal stop [m] already holds a nasal feature. The rightward spreading continues, and the nasality spreads to the transition sound [^{ia}] [2] and crosses it to nasalize the suffix [a]. Finally, the surface form of [mi$^{\tilde{i}\tilde{a}}$ã] is generated.

In (4b) and (4c), the spreading principle is consistent with that in (4a). Although [ŋ̍] in (4b) is a syllabic nasal and is positioned on the syllable nucleus, it still acts as a consonant. In (4d), it is shown that the nasality is autosegmentalized in

[2] This transition sound [^{ia}] is adopted from Lin's (2007, 2012a, 2012b) framework, which claims that the boundary between two morphemes is occupied by a transition sound (or a formant transition) generated from its adjacent segments. Without the transition sound, the nasality cannot cross the morpheme boundary and nasalize the suffix.

the nasality tier and floats above the nasality bearing vowel [i]. The nasality then spreads leftward to the onset position [p^h] and spreads rightward to the transition sound [^{ia}] and the suffix [a], and finally the phonetic manifestation of the pronounced form [$\tilde{p}^{h}\tilde{i}^{ia}\tilde{a}$] is produced. In the following sections, nasality behavior of five sample words will further be discussed.

A 68-year-old female native speaker was recruited for the recording and her predominant languages used in daily life were both Taiwanese and Mandarin. The recording was conducted in her house and the task for her was to identify five pictures of *box*, *cotton*, *candy*, *gold*, and *nose*. The sampling rate used for recording was 44100Hz. After the voice samples for the five words were collected, they were edited by Praat software (http://www.praat.org) for further acoustic analysis.

According to Ladefoged (2001, 2003), the most obvious acoustic fact about nasalized vowels is that their first formant (F1) tends to disappear and the bandwidth of F1 becomes broader. Based on the statement, it is necessary to examine whether the F1 (approximately 1,000Hz for the sound [a]) of the suffix tends to disappear. The logic is that once the F1 of the suffix becomes weaker, it indicates that the suffix *a* is nasalized; if the suffix *a* is nasalized, then the rightward spreading of nasality from the source is justified.

3.1 First formant (F1)

In the following figures, the oral sample word *ab.a* ‘box’ is first displayed in Figure 2 for comparison and the four nasalized sample words are shown from Figures 3 to 6.

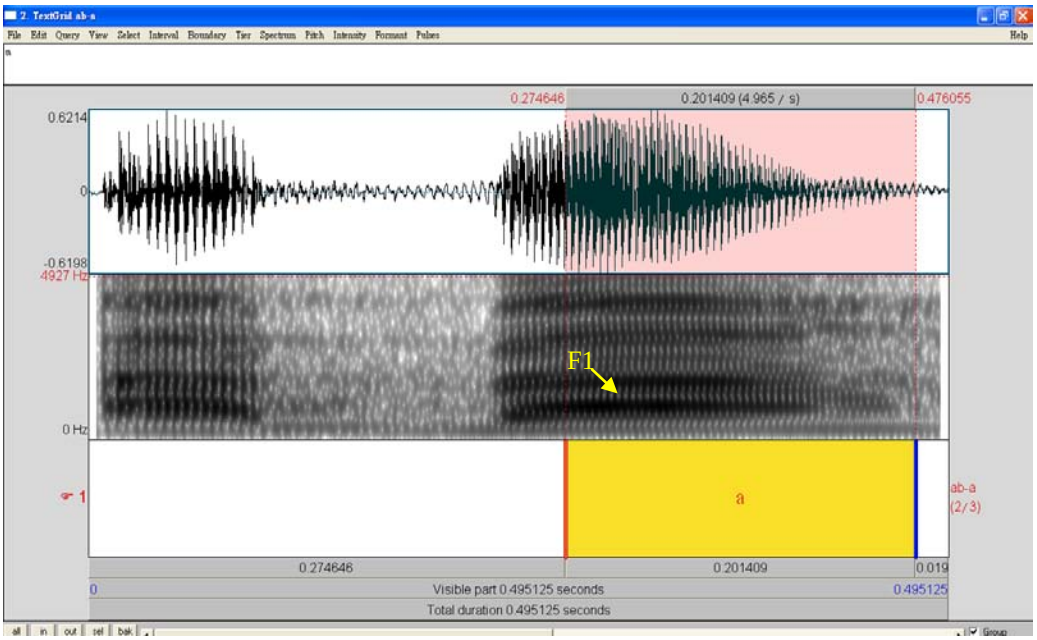


Figure 2. The spectrogram of the word *ab.a* 'box'.

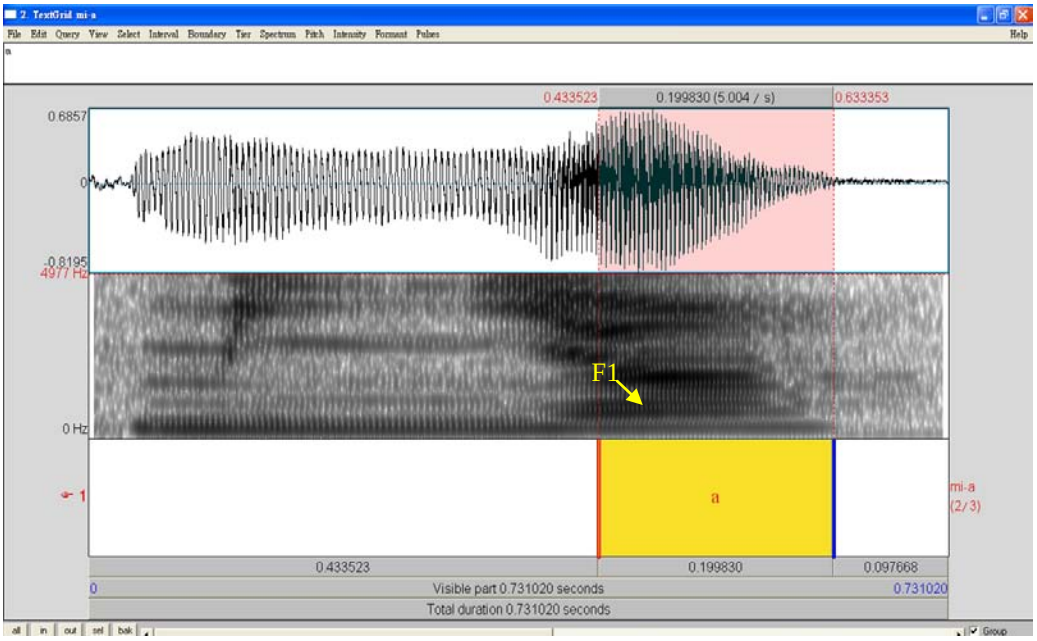


Figure 3. The spectrogram of the word *mi.a* 'cotton'

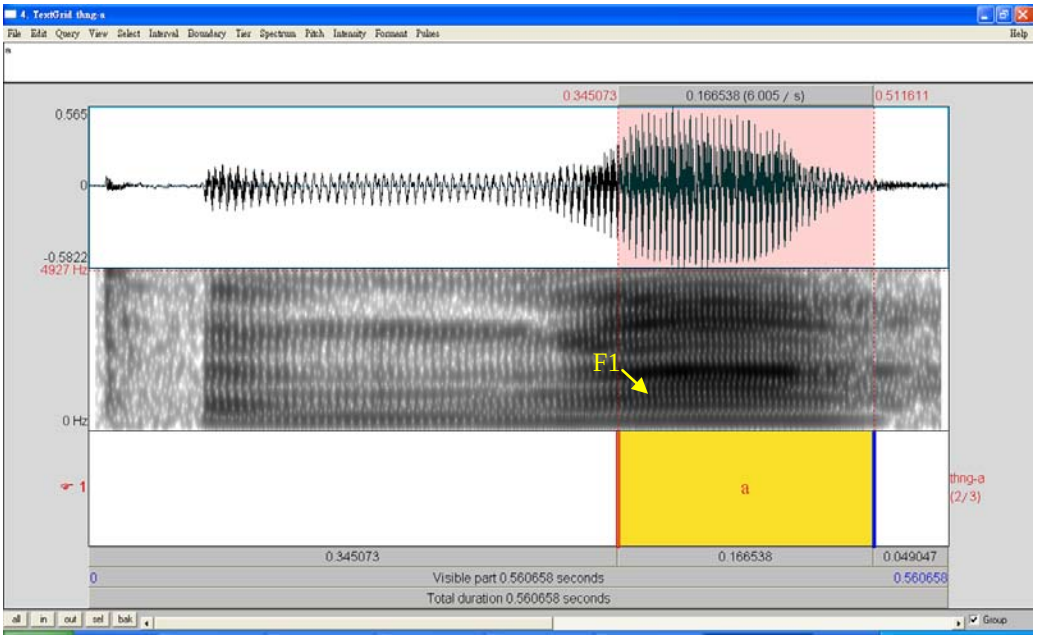


Figure 4. The spectrogram of the word $t^{h}ŋ.a$ ‘candy’.

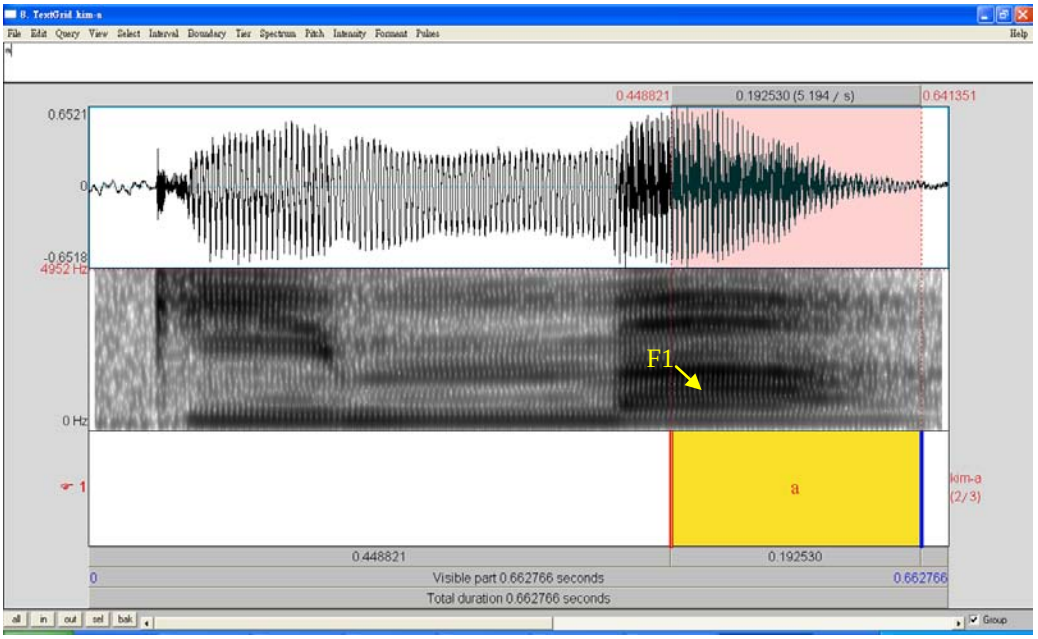


Figure 5. The spectrogram of the word *kim.a* ‘gold’.

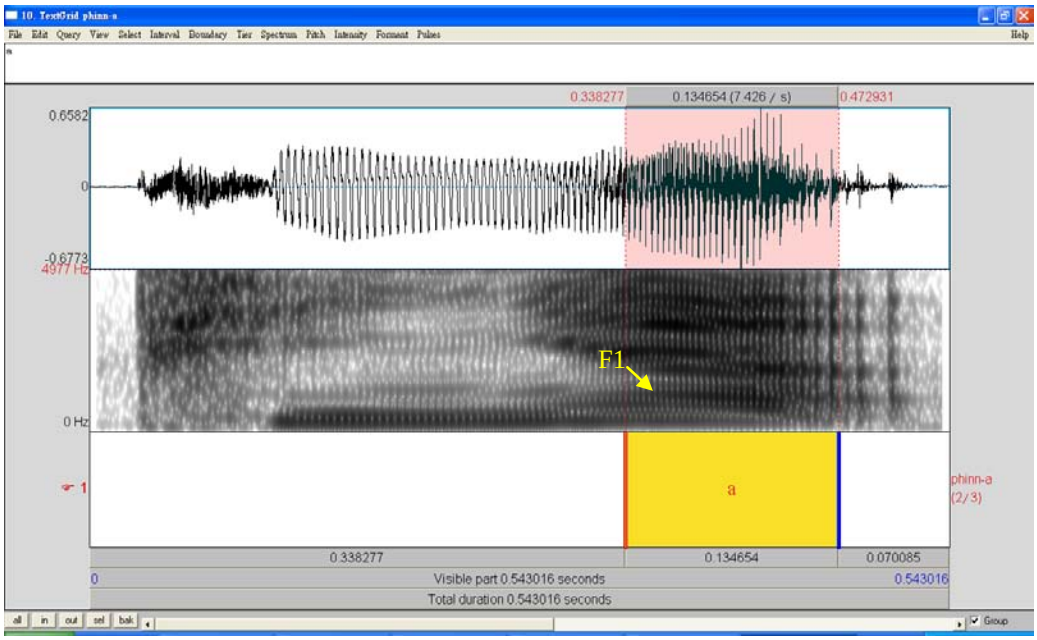


Figure 6. The spectrogram of the word p^hĩ.*a* ‘nose’.

In Figure 2, the suffix *a* is an oral vowel and its F1 reveals that its color is darker and its shape can easier be traced. Conversely, from Figures 3 to 6, the respective F1 seems to be fainter and vaguer than the F1 in Figure 2. This result implies that the suffix *a* in the four sample words is nasalized.

By examining the fading of F1, it is adequate to conclude that the suffix in the four sample words is nasalized. Therefore, the phonetic realizations of the words *mi.a* ‘cotton’, t^hŋ̍.*a* ‘candy’, *kim.a* ‘gold’ and p^hĩ.*a* ‘nose’ can be transcribed as [mĩi^{iã}ã] ‘cotton’, [t^{h}ŋ̍$^{ŋ̍ã}$ã] ‘candy’, [kim^{mã}ã] ‘gold’ and [p^{h}ĩ^{iã}ã] ‘nose’, respectively.

3.2 A simple test

The leftward spreading of nasality can be identified by observing whether or not the aspirated consonant /p^h/ in the word

p^{h}*ĩ.a* ‘nose’ can be nasalized as [p̃^{h}]. Unfortunately, the spectrograph analysis fails to offer an effective way for detecting the nasalization of [p̃^{h}]; thus, a brief test is described as below.

In the test, a cardboard is placed between the nose and the mouth so that airflow coming out from the oral cavity will not affect the airflow from the nasal cavity. Next, a tissue paper is held under the nostrils, so that if air comes out from the nose, the tissue paper can sense it. After the cardboard and the tissue paper are settled, three words are to be tested. The three words are: the oral word *i.a* ‘daughter’s aunt 姨仔’, the nasal word *ĩ.a* ‘glutinous rice ball 圓仔’, and the target word *p*^{h}*ĩ.a* ‘nose’. The three words are pronounced one after another, and if the tissue paper in *ĩ.a* vibrates more than it does in *i.a*, then the extra vibration can be attributed to the nasalized vowel /ĩ/ because more air flows out from the nasal cavity when this word is pronounced. Similarly, if the tissue paper in *p*^{h}*ĩ.a* shakes more than it does in *ĩ.a*, then the extra vibration is due to the aspirated /p^{h}/, because more air is released through the nasal cavity as this target word is produced.

In light of the observation, a brief result is tentatively given: In the test, the tissue paper vibrated the most when the word *p*^{h}*ĩ.a* ‘nose’ was produced. The result of the test implies that the initial consonant of /p^{h}/ is nasalized as [p̃^{h}] when the target word *p*^{h}*ĩ.a* ‘nose’ is articulated, which means -- the leftward spreading of nasality may be valid.

4. Conclusion

In summary, the spectrogram of the four words validates the rightward nasality spreading. In

addition, the simple test reveals that the leftward nasality spreading may occur. Consequently, the nasality of nasalized vowels may possess the nature of bidirectional spreading. Although this result reformulates Lin's proposal (1989), it may argue against the three statements: (1) Voiceless obstruents cannot be nasalized. (2) The nucleus /i/ in the word *mi* 'noodle' is claimed to transmit the nasality to the onset consonant /b/. (3) The sounds [m], [n] and [ŋ] are claimed to be allophones of the voiced stops /b/, /l/ and /g/.

Since the behavior of nasality varies from that of other oral segments, it is normally removed from a nasal vowel and is placed on the nasality tier as an autosegment. Thus, the nasal vowels as in /ĩ/, /ẽ/, /ɔ̃/ and /ã/ in the autosegmental perspective can be analyzed as a combination of a vowel phoneme and a nasal autosegment. Under this framework, it is reasonable to treat nasal vowels as non-phonemic units because they are still not the smallest units even though they contrast with oral vowels in minimal pairs. In this way, the inventory of Taiwanese vowels can be simplified as only six phonemes (/i/, /u/, /e/, /o/, /ɔ/ and /a/) rather than ten phonemes (/i/, /u/, /e/, /o/, /ɔ/, /a/, /ĩ/, /ẽ/, /ɔ̃/ and /ã/).

After applying the bidirectional spreading rule, the phonetic representations of the four words may eventually be illustrated as the geometrical structures in Figure 7.

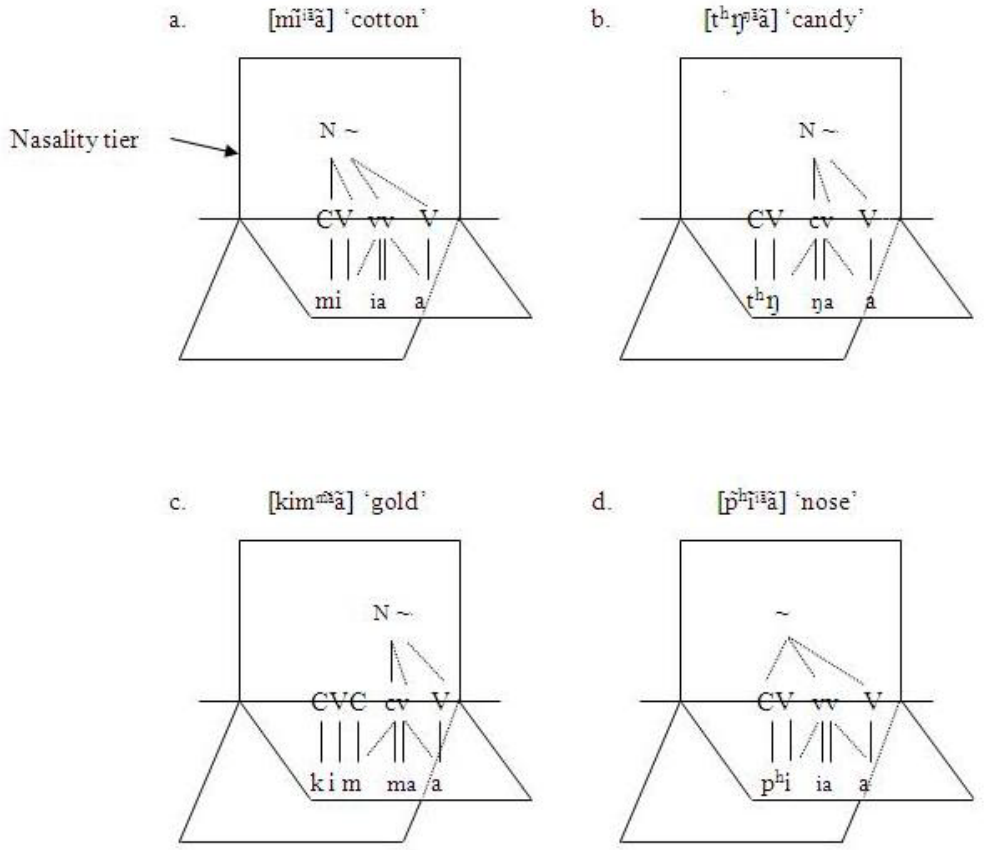


Figure 7. Phonetic representations of nasality after spreading.

Li (1986) indicates that nasal vowels commonly rhyme with oral vowels in Taiwanese oral literature (such as folk songs, popular songs and nursery rhymes). The rhyming examples include: /i/ rhymes with /ĩ/, /e/ rhymes with /ẽ/, /a/ rhymes with /ã/, /iu/ with /iũ/, /ui/ with /uĩ/, /ia/ with /iã/, and /ai/ with /aĩ/. Li concludes,

> Perhaps the most outstanding feature in Taiwanese rhyming is that oral vowels are permitted to rhyme with their corresponding nasalized vowels despite the fact they are in phonemic contrast. This implies that nasalization might be only a secondary phonetic feature for most Taiwanese

> speakers... This seems to indicate that, instead of treating the nasalized vowels /ĩ, ẽ, ã, ɔ̃, uĩ, uã, iã, iũ/ in Taiwanese as segments separate from their corresponding oral vowels, we should simply treat the nasality in these vowels as an autosegment. (p. 458)

As stated by Li, Taiwanese rhyming system may provide certain evidence to assure the autonomous property of nasality in nasal vowels.

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