

# VELAR SYLLABIC NASAL AND ITS PHONOLOGICAL INTERPRETATION IN TAIWAN SOUTHERN MIN

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## ABSTRACT

This paper examines phonetic realizations of phonemic syllabic nasal /ŋ/ in Taiwan Southern Min. Motivated by the observation that /ŋ/ is often realized as [əŋ], two main research questions are asked: How frequent are [əŋ] and [ŋ] realizations respectively, and what are their distributions? These questions lead to discussion on the interpretation of the \*NV and \*VN constraints in this language, since forms like /mŋ/ are often realized as [məŋ]/[məŋ]. Examination of /ŋ/ tokens in a spontaneous speech corpus shows that /ŋ/ is realized with a vowel portion 95% of the time. The [ŋ] realization is only consistently observed following /h/, and shows up slightly more following velar stops than following other sounds. Articulatory accounts are used to argue that this distribution supports the view that /ŋ/ is an underlying form, keeping the \*NV and \*VN true in the underlying level, and explains the [əŋ] realizations as a side effect of tongue movement.

**Keywords:** syllabic nasal, glottal fricative, nasal, phonotactics, homorganicity

## 1. INTRODUCTION

This study examines the velar syllabic nasal /ŋ/ in Taiwan Southern Min (henceforth Taiwanese). Taiwanese is described as having phonemic syllabic nasals, /m̩/ and /ŋ/ (e.g. [8, 2, 7, 9]). Voiceless obstruents and nasals can precede /ŋ/, while /m/ is always onsetless, but with a very high token frequency, as it is a negative marker in Taiwanese. This study focuses on the realization of /ŋ/ due to its more varied distribution of occurrences.

In addition to descriptions in grammars and dictionaries, there are also phonotactic motivations for assuming that the syllabic nasal /ŋ/ is behaving as one single unit rather than a vowel and a velar nasal coda in Taiwanese. First, nasal onsets only appear with phonemic nasal vowels (e.g., /mã/ is attested but /ma/ is not) [11], which can be formalized as a \*NV constraint. Second, nasal vowels never have

codas (e.g., /pit/ is attested but /pīt/ is not), which can be formalized as a \*VC constraint. The latter restriction is potentially related to the fact that nasal vowels were introduced into Southern Min via sound change from vowels with a nasal coda (i.e., VN → Ṽ) [10, 15], and since there was no complex coda, nasal vowels are now only attested in open syllables.

Given these constraints, the attestedness of sequences like /mŋ/ may suggest that /ŋ/ is phonologically a nasal vocalic unit. Otherwise, if /mŋ/ is phonologically /məŋ/, it either violates \*NV if it is /məŋ/, or violates \*VC if it is /məŋ/. The violations would not arise if /mŋ/ has the phonological status of a nasal vowel, since NṼ is licit.

Informal observations reveal that a schwa-like vowel is very often inserted between the onset and the velar nasal /ŋ/. Motivated by the observations, this study has two main goals. The first goal is to examine how often /ŋ/ is realized as [ŋ] and [əŋ] respectively. The second goal is to reveal the distributions of these realizations across different contexts.

It is possible that syllabic nasals are consistently realized with a schwa regardless of phonological contexts. Existence of such consistency may be used as an argument to posit an /əŋ/ underlying form or to posit an obligatory phonetic realization rule. This is the CONSISTENT SCHWA-NASAL hypothesis.

It is also possible that the realization is variable and sensitive to contexts. One type of sensitivity that may surface is articulatory. For example, when the onset is alveolar, the transition from the alveolar gesture to the velar gesture in /ŋ/ may create an obligatory vocoid articulation. On the other hand, when the onset is a labial or glottal sound, which does not require a tongue gesture, or a velar sound, which is homorganic with the velar nasal, /ŋ/ may be more likely to be realized a real syllabic nasal since no such transition into a velar gesture from the onset is needed. In other words, the [əŋ] realization is an articulatory by-product, and /ŋ/ can still be seen as the underlying form. This is the ARTICULATORY EFFECT hypothesis.

There is also a possibility that the present-day description of syllabic nasals in Taiwanese was once

accurate, but a sound change from /ŋ/ to /əŋ/ is either ongoing, or is completed with some remnant effect that shows up as a difference between speakers from different generations. This is the SOUND CHANGE hypothesis, which predicts that old speakers are more likely to have [ŋ] realizations, and when they do have a [əŋ] realization, the vowel is more likely to be shorter.

English, a language where syllabic nasals [ŋ] and [ŋ̥] are described in both phonetic and phonological accounts (e.g., [4, 5, 14]), may provide some support for the ARTICULATORY EFFECT hypothesis. A recent study [3] on the distribution of word-final syllabic nasals [ŋ] and [ŋ̥] (as opposed to [əŋ] and [əŋ̥]) shows that in read speech, after a glottal stop [ʔ], [ŋ] shows up 74% of the time, and after a flap [ɾ], [ŋ] shows up 37% of the time. In spontaneous speech, the rate of [ŋ] rises to 89% in both contexts. In all other consonantal contexts, [ŋ] only shows up 3%-17% of the time in both read and spontaneous speech. The predominance of [ŋ] as opposed to [əŋ] following a glottal stop shows a potential effect of a true syllabic nasal being more likely following a segment not requiring a tongue gesture. The relatively higher frequencies of [ŋ] following a flap, on the other hand, may suggest that homorganic onsets are more likely to elicit true syllabic nasals.

In addition to the main research questions, following [3], this study also investigates whether the presence of a vowel correlates with the length of the nasal coda. If the vocoid realization is accompanied with a shortening of the nasal coda, it may suggest that the speaker takes the whole rime as a unit with a fixed length.

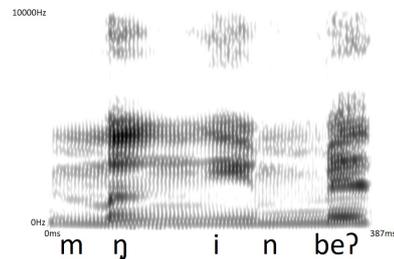
## 2. METHOD

The acoustic data were taken from a corpus of Taiwanese spontaneous speech where the speakers were elicited monologue-like speech in sociolinguistic interviews. The subset for this study contains 16 speakers from the same dialectal region (Taichung), evenly balanced in gender and two age groups: old speakers born before 1960 and young speakers born after 1975. Each speaker contributed around 30 minutes of recording, adding up to around eight hours in total. The annotation for this subset contains syllable-level segmentation and the location and levels of prosodic breaks [13].

For the present study, segmental boundaries for syllables containing syllabic nasals were labeled, mainly to identify portions within a syllable that contained vowel-like formant structure. Figure 1 shows an example of /ŋ/ being realized with a vo-

coid portion.

**Figure 1:** The syllable /mŋ/ in the phrase /mŋ/ in beʔ/ ‘ask them (if they) want’, where a syllabic nasal is realized with an apparent vocoid portion.



Annotation was also done for syllables with the rime /ŋ/ to make vowel quality comparisons with the vowel in [əŋ] realizations for /ŋ/. It also allows for examining the potential effect on inserted vocoid duration between old and young speakers: without comparing vowel duration with at least one other rime type, we cannot conclude whether the observed effect is specific to /əŋ/ or is just a general effect of age on vowel duration.

The occurrence of true syllabic nasals was examined by mixed-effects logistic models with a binary dependent variable indicating whether a specific token was realized without a vocoid. The duration of vocoid portion, when there was any, was examined by mixed-effect linear models. Both types of models were run with R using the lme4 package [1]. For both types of models, subjects were included as a random effect. The fixed effects included AGE, PLACE (onsets' place of articulation), MANNER (onsets' manner of articulation), NASAL (onsets' nasality), and ProsBr (whether the target syllable occurs before a prosodic break). For the analysis of nasal coda duration, VOCOID, the presence and absence of a vocoid realization was added as a fixed effect. After a full model with all the fixed effects and their interactions was run, main effects and the associated interactions that did not improve the overall fit of the model were taken out one by one. After this procedure, we use the lsmeans package [6] to conduct pairwise comparisons with the final model between cells, with the built-in p-value adjustment using the Tukey method.

## 3. RESULTS

### 3.1. Distribution of true syllabic nasals

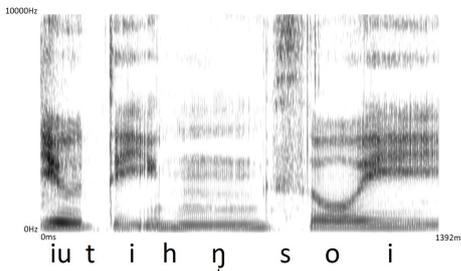
A total of 835 occurrences of /ŋ/ were identified in the corpus. Their realizations were broken down into three types. A true syllabic velar nasal [ŋ], a ve-

lar nasal with a vocoid realization [əŋ], and a vowel without a coda [ə]. The distribution of realization types across different consonantal contexts is shown in Table 1. Only 4.8% of these tokens are realized as a true syllabic nasal.

**Table 1:** Distribution of realization types across different onsets

context	ŋ	əŋ	ə
m	0 (0.0%)	46 (88.5%)	6 (11.5%)
n	0 (0.0%)	176 (94.6%)	10 (5.4%)
p	0 (0.0%)	39 (97.5%)	1 (2.5%)
t	1 (0.5%)	193 (91.9%)	16 (7.6%)
t <sup>h</sup>	2 (15.4%)	9 (69.2%)	2 (15.4%)
k	3 (17.6%)	14 (82.4%)	0 (0.0%)
k <sup>h</sup>	4 (20.0%)	16 (80.0%)	0 (0.0%)
ts	0 (0.0%)	43 (95.6%)	2 (4.4%)
ts <sup>h</sup>	4 (25.0%)	11 (68.8%)	1 (6.2%)
s	6 (2.9%)	184 (91.2%)	12 (5.9%)
h	20 (95.2%)	1 (4.8%)	0 (0.0%)
∅	3 (100%)	0 (100%)	0 (100%)
total	43 (5.2%)	732 (88.7%)	50 (6.1%)

**Figure 2:** Example of a [hŋ] realization in phrase /iu-ti-hŋ sou-i/ ‘kindergarten, so’

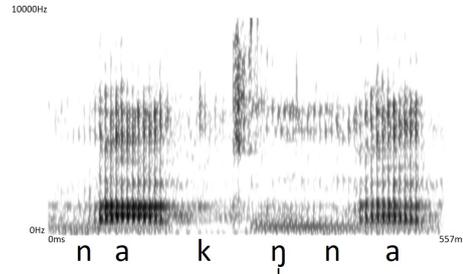


The consonantal contexts with the highest proportion of [ŋ] tokens are the onsetless context, where all three occurrences are realized as [ŋ], and following the glottal fricative [h], where 20 out of 21 occurrences of are realized as [hŋ], one of which is shown in Figure 2. The other contexts where [ŋ] occurs around 15%-25% of the time are following /t<sup>h</sup>/, /k/, /k<sup>h</sup>/ and /ts<sup>h</sup>/. An example of [kŋ] realization is shown in Figure 3.

The final model on the occurrence of true syllabic nasals only contains PLACE and MANNER as fixed effects. Pair-wise cell comparisons show five significant differences, four of which show the expected effect involving glottal fricative /h/ that can be easily observed in Table 1: following an /h/, a true syllabic nasal is more likely than following /ts, ts<sup>h</sup>/ ( $\beta = 5.72, SE = 1.19, z = 4.81, p = .0001$ ), following /s/ ( $\beta = 6.69, SE = 1.15, z = 5.83, p < .0001$ ), follow-

ing /t, t<sup>h</sup>/ ( $\beta = 8.15, SE = 1.22, z = 6.69, p < .0001$ ), following /k, k<sup>h</sup>/ ( $\beta = 4.91, SE = 1.18, z = 4.18, p < .0001$ ). In addition, a true syllabic nasal is more likely following a velar stop /k, k<sup>h</sup>/ than following /t, t<sup>h</sup>/ ( $\beta = 3.23, SE = 0.74, z = 4.42, p < .0001$ ).

**Figure 3:** Example of a [kŋ] realization in phrase /na-kŋ-na-kiau/ ‘carrying while swearing’



### 3.2. Vowel quality & duration of [ɪ] vs. [ə] before [ŋ]

Having established that [əŋ] is a predominant realization of /kŋ/, acoustic measurement is done to confirm the impressionistic transcription of the vocoid realization as [ə], using the [ɪ] vowel as the reference. Mid-point F1 and F2, normalized with the Bark Difference method [12], are shown in Figure 4. Mixed-effects linear models show that [ə] is significantly lower ( $\beta = -0.78, SE = 0.03, t = 22.48, p < .0001$ ) and backer ( $\beta = 1.92, SE = 0.04, t = 48.58, p < .0001$ ) than [ɪ]. Analysis on duration shows that [ə] is shorter than [ɪ] (64.05 ms vs. 85.26 ms,  $\beta = -21.02, SE = 1.26, t = 16.66, p < .0001$ ).

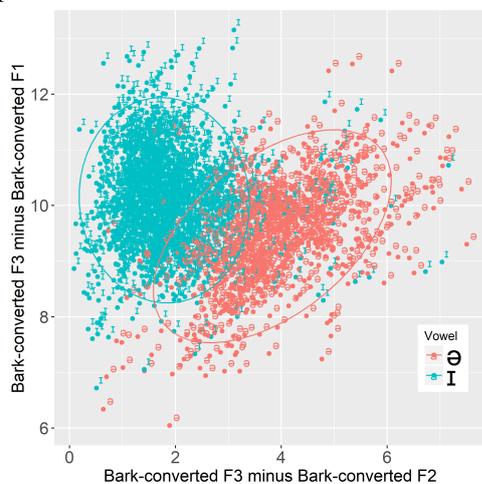
### 3.3. Duration of vocoid portion

The final model on the occurrences of true syllabic nasals contains AGE, PLACE, MANNER, and PROSBR as the fixed effects. Pair-wise cell comparisons show four significant differences. In young speakers’ non-final syllables, the vowel is longer following an fricative than following a stop ( $\beta = 7.98, SE = 2.79, t = 2.86, p < .05$ ) and an affricate ( $\beta = 13.13, SE = 4.98, t = 2.64, p < .05$ ). Following young speakers’ coronal fricative /s/, the vowel is longer before a prosodic boundary than in a phrase-medial position ( $\beta = 15.19, SE = 4.32, t = 3.51, p < .001$ ). Finally, for coronal fricative /s/ in a syllable that is not right before a prosodic boundary, the vowel is longer for young speakers than for old speakers ( $\beta = 17.26, SE = 5.35, t = 3.32, p < .001$ ).

Supplement analysis with /ɪŋ/ syllables does not reveal significant effect of age, as the most informative model only contains place of articulation and syllable finality as fixed effects. It shows the possi-

bility that the age effect might be exclusive for the vocoid portion for /sŋ/ syllables.

**Figure 4:** Quality of vowels in [ɿ] and [əŋ]. Ellipse show 95% confidence interval



### 3.4. Compensatory shortening of coda for [əŋ]?

The final model for coda duration contains four fixed effects: Age, MANNER, PROSBR, and crucially, VOCOID. Analysis with lsmeans shows that the coda is significantly shorter in [əŋ] than in [ɿ] for old speakers' fricatives in phrase-final position ( $\beta = -155.41$ ,  $SE = 34.62$ ,  $t = -4.49$ ,  $p < .0001$ ), and both groups of speakers fricatives in phrase-medial position (young:  $\beta = -90.55$ ,  $SE = 16.38$ ,  $t = -5.52$ ,  $p < .0001$ ; old:  $\beta = -87.86$ ,  $SE = 19.57$ ,  $t = -4.49$ ,  $p < .0001$ ). These results suggest a compensatory shortening effect.

## 4. DISCUSSION

Consistent with informal observations, the syllabic nasal /ŋ/ in Taiwanese is overwhelmingly realized as [əŋ], which a vowel that is shorter, lower, and backer than [ɿ]. The findings with respect to the hypotheses are summarized in (1).

The CONSISTENT SCHWA-NASAL hypothesis is not supported, as the rate of [əŋ]/[ɿ] realization varies across different phonological contexts. On the other hand, the ARTICULATORY EFFECT hypothesis finds a relatively strong support in this study. The glottal fricative /h/, whose articulation does not require a tongue gesture in the oral tract, is almost exclusively followed by the [ɿ] realization. The velar stops /k, k<sup>h</sup>/, being homorganic with /ŋ/, also show a moderately higher rate of [ɿ] realization than their coronal counterparts.

There is very limited support for the SOUND CHANGE hypothesis, which predicted that old

speakers will either have more [ɿ] tokens or shorter schwas in their [əŋ] realizations. The latter is found only in a very particular context, although the lack of such an effect on the /ŋ/ rime suggests a possibility that this effect only pertains to syllabic nasals.

(1) Findings paired with the hypotheses

- a. CONSISTENT SCHWA-NASAL: Not supported – [əŋ] realizations are not uniformly consistent across contexts
- b. ARTICULATORY EFFECT: Supported – [ɿ] realizations are more likely following /h/ than other sounds, and more likely after velar stops /k, k<sup>h</sup>/ than coronal stops /t, t<sup>h</sup>/
- c. SOUND CHANGE: Very weakly supported – old speakers have shorter [ə] than young speakers following /s/ in phrase-medial syllables

Analysis on coda duration as a function of [ɿ]/[əŋ] realization shows that in certain contexts, presence of a schwa shortens the nasal coda. This compensatory shortening effect suggests that the syllabic nasal, including the often-attested vocoid realization, may be considered a phonological unit in articulation so that having a schwa does not result in additional duration.

These findings can be interpreted as showing that /ŋ/ is an underlying phonological unit as a whole, just like nasal vowels such as /ã/: the sensitivity of the rate of [ɿ]/[əŋ] to articulatory gestures may be a by-product of articulatory effects: the speakers aim for a syllabic nasal, but for some places of articulations, a vocoid portion is difficult to avoid because of transitions of tongue gestures. This effect may be stronger for nasal onsets /m/ and /n/, since voicing already starts during labial and alveolar closure, the transition to a velar closure easily leads to the opening of oral tract with voicing and results in a vocoid portion.

To conclude, this study has provided a preliminary phonetic description of /ŋ/ in Taiwanese. The findings align with an articulatory interpretation of the [əŋ] realization and are used to argued for /ŋ/ being underlyingly a syllabic nasal, despite being frequently realized with a schwa. The findings also make contribution to the very understudied topic of the phonetics of syllabic nasals in general.

## ACKNOWLEDGEMENTS

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