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年齡與韻律對臺灣華語自然語料中鼻音韻尾合流之影響

The Effect of Age and Prosody on Syllable-final Nasal Mergers in Taiwan Mandarin Spontaneous Speech

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本論文係葉宇喬君（R01142002）在國立臺灣大學語言學研究所完成之碩士學位論文，於民國 104 年 7 月 6 日承下列考試委員審查通過及口試及格，特此證明

口試委員：

馮怡蓁 （簽名）
（指導教授）

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摘要

本研究旨在探討臺灣華語中鼻韻尾合流的表現。過去數十年來之研究已確立鼻音韻尾合流存在地域差異，但關於這些合流現象的起源仍未有定論。因此，本研究納入不同世代的發音人來更深入探討此一起源議題。另外，透過自然語料，韻律因素的影響也得以受檢視。本研究共有三十二位男女發音人，年齡層分佈在兩個不同的世代，皆出生於台北或高雄，每位發音人提供約 30 分鐘長的談話。探討的變因有五項，其中包含三個社會變因──性別、年齡、地區──以及兩個語言韻律變因──語句重音、韻律邊界。結果顯示，北部的年輕人最常使用 /in/ → [iŋ]，而南部人大量使用 /iŋ/ → [in]，尤其是南部老年女性，兩條 /i/ 母音後的鼻韻尾合流律之間具有相互競爭的傾向；所有不同社會條件的發音人皆廣泛使用 /əŋ/ → [ən]。至於語言韻律變因，韻律邊界對於三條合流律皆有整體強化效果，而語句重音的效果則較為複雜：它對所有社會條件的 /in/ → [iŋ] 都有強化效果，對年輕人的 /iŋ/ → [in] 也有強化效果，對於年輕人的 /əŋ/ → [ən] 則有抑制的趨勢。本研究結果可進一步推論出這三條合流律處於不同的地位：/in/ → [iŋ] 是出於臺北的創新，其競爭者 /iŋ/ → [in] 則是源於閩語的負遷移。/əŋ/ → [ən] 的起源仍無法確定，但也許是因為它未受其他合流律競爭壓迫，故而使用最為廣泛普遍。韻律邊界對所有合流律都有強化效果，語句重音的效應則可能與合流律發展程度、合流律的社會意涵以及鼻音的有標程度相關。

關鍵字：鼻韻尾合流、語句重音、韻律邊界、自然語料、臺灣華語

ABSTRACT

The present study investigated the performance of syllable-final nasal mergers in Taiwan Mandarin. After decades of research, past studies on this topic have identified regional difference in the application of the mergers, but their origins are still under debate. In this study, generational difference was examined in order to explore such an issue into a deeper core. With the usage of spontaneous speech, the effect of prosodic factors was also under examination. Thirty-two speakers of both genders, of two generations, and from two regions, Taipei and Kaohsiung, were recruited and each speaker contributed around 30-minute-long speech data. Effects of five factors were observed, including three social factors—gender, age and region—and two linguistic factors—prosodic promenince, and prosodic boundary. Results showed that the /in/ → [iŋ] merger was led by the young northerners, whereas the /iŋ/ → [in] merger was dominated by the southerners, especially the old southern females. The two post-/i/ nasal mergers were generally in competition with each other. On the other hand, the /əŋ/ → [ən] merger was widely applied by speakers of all different social factors. As for the effects of linguistic factors, prosodic boundary had an overall strengthening effect for all the three mergers, while prosodic promenince had a more complicated effect: an overall strengthening effect for the /in/ → [iŋ] merger of all social groups, and for the /iŋ/ → [in] merger of the young groups, and a restraining trend for the /əŋ/ → [ən] merger of the young groups. Our results further implicated the different status of the three mergers: the /in/ → [iŋ] merger was an innovation of Taipei origin, while its competitor, the /iŋ/ → [in] merger, was a negative Min transfer. The origin of the /əŋ/ → [ən] merger was still unclear, but perhaps its lack of competition made it become the most frequently used merger. Although prosodic boundary presented an overall enhancement on all the mergers, the effect of prosodic promenince seemed to interact with rule progression, rule connotation and markedness of nasals.

Keywords: syllable-final nasal mergers, prosodic promenince, prosodic boundary, spontaneous speech, Taiwan Mandarin

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CHAPTER 1 INTRODUCTION

1.1 Linguistic background

Taiwan is a society with multiple languages, mainly including Mandarin, Min[1], Hakka, and more than ten different indigenous languages. These languages entered Taiwan during different time periods[2]. Unlike the aboriginal languages that have been residing in Taiwan for more than thousands of years, Min and Hakka arrived at Taiwan only hundreds of years ago. With the demographic advantage of the Min population, Min language has been the lingua franca in Taiwan for a long time before the government imposed a Mandarin-only policy since 1956 (Huang, 1993). In contrast, Mandarin is a relative newcomer to Taiwan. Despite its late arrival, Mandarin has rapidly become the most commonly used language in formal situations due to the government's mandatory promotion (Ang, 1997; Ang, 2002).

Nowadays, most people living in Taiwan are capable of speaking Mandarin, with different degrees of accents coming from their own substrate mother tongues if the languages are different from Mandarin. According to the "Taiwan Social Change Survey: Year 4 of Round 6 (2013TSCS)" (Fu *et al.*, 2014) sponsored by the Ministry of Science and Technology, Taiwan, Republic of China, Min is the largest ethnic group (76.2%) in Taiwan based on residents' self-identity, followed by Hakka (9.2%), Mainlanders (6.6%) and Austro-Polynesian aborigines (1.1%).[3] Figure 1.1 demonstrates the ethnic composition of Taiwan residents surveyed in 2013.

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[1] Min languages consist of a large group of different dialects, such as Northern Min, Southern Min, etc. Since Taiwan Southern Min is the most popular Min language in Taiwan, it is abbreviated as Min in the current study.

[2] The ancestors of the indigenous languages were reported to immigrate into Taiwan around 15,000 years ago, before the end of the last ice age (M.-l. Lin, 2010).

[3] The terminologies for ethnic identities in the 2013TSCS survey were 'Taiwan Southern Min', 'Taiwan Hakka', 'Taiwan Aborigines', 'people from different provinces of Mainland (China)', 'Taiwan Mainlanders', 'people from Kinmen or Matsu Islands', 'people from Southeast Asia countries',

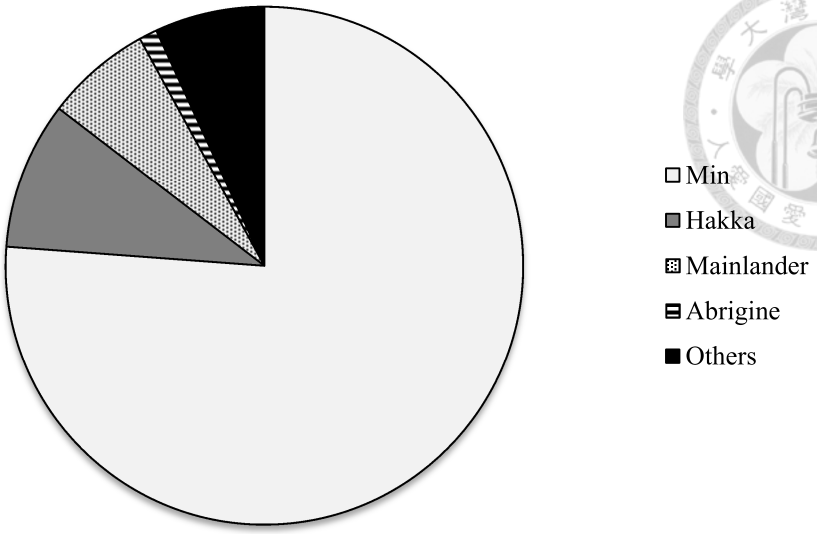

Figure 1.1 The distribution of the self-identified ethnic groups of Taiwan residents surveyed in 2013. Data were from the 2013TSCS survey (Fu *et al.*, 2014) with 1952 valid samples.

With the fact that the Min ethnic group dominates the population in Taiwan, it is not surprising that Min is used much more frequently than other languages. Based on the data of 2013TSCS (Fu *et al.*, 2014) (see Figure 1.2), Min languages are still the most domestically used (44.2 %) even in the year of 2013, ten years after another similar survey conducted in 2003. As a result, Min possibly contributes the largest substrate influence to Mandarin spoken in Taiwan. In fact, it has long been reported that Min has a profound influence on the phonology of Taiwan Mandarin. Ing's (1985) report, for example, described various aspects of the divergences of Taiwan Mandarin from Standard Mandarin taught in school due to Min and different dialects or accents of Mandarin, including onsets, rhymes, and tones.

However, the accents of Mandarin spoken in Taiwan are not highly homogeneous in the society all over the island owing to different levels of Min fluency. Phonological systems of Min and Mandarin are competing with each other

and others. Here we combined 'people from different provinces of Mainland (China)' and 'Taiwan Mainlanders' into a single group, which is 'Mainlanders'.

for bilingual speakers based on complex factors, such as frequency of language usage, language competence, age of onset in learning a language, etc. As we can see in Figure 1.2, Mandarin is the one with the largest growth in the domestic usage throughout the ten years (from 23.4% to 31.4%), implying a more common usage of Mandarin among the younger generation. The domestic usage population of Min seems to be relativley stable (from 45.3% to 44.2%), whereas that of Hakka and other languages has decreased throughout the time.

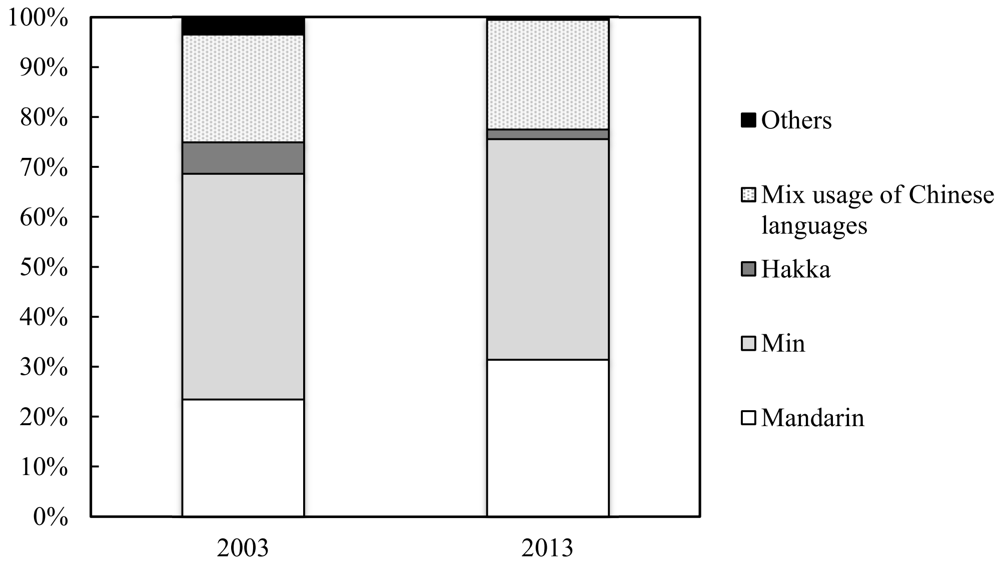

Figure 1.2 The most often used language at home. Data were from the 2013TSCS survey (Fu *et al.*, 2014). There were 2016 valid samples in the year of 2003 and 1952 valid samples in the year of 2013. Mix usage of Chinese languages stands for bilingual usage of Min and Mandarin (19.5%), or Hakka and Mandarin (1.5%), or trilingual usage of Min, Hakka and Mandarin (0.8%) in the year of 2013.

Besides the aforementioned survey data, Ang (1992) has also pointed out the change of status of language usage in Taiwan throughout recent decades. Before the year of 1945, Mandarin was hardly heard in Taiwan. Min dominated the other languages in the society, while Hakka and the aboriginal languages were also frequently used in their own regions at that time. Min was still the most dominant language in most parts of Taiwan before 1960s, but Mandarin gradually suppressed

Min and other languages after half a century of ruling by the Nationalist government. Such a change of language usage in society due to governmental enforcement led to different Mandarin proficiency levels, and thus different accents, among different generations. The older generation speaks Mandarin with a stronger influence on pronunciation from the substrate languages. Such an influence among the younger generation is weaker since they do not use substrate languages as frequently as the older generation.

Apart from the aforementioned generation difference, the frequency of usage of languages also differs across regions. According to the "Census of population and housing 2010" (DGBAS, 2011), the usage of Mandarin decreases and that of Min increases as one goes further south in the western part of Taiwan. The average percentages of domestic usage of Mandarin for the northern, the central, and the southern regions are 91.8%, 78.5%, and 73.8%, respectively, while those of Min are 73.3%, 88.7%, and 91.9%, respectively. These findings all suggest that Taiwan is not a linguistically homogeneous society. Both age and region are possible independent variables that may shape one's accent.

1.2 Motivation

The influence of Min on the phonology of Taiwan Mandarin is a topic with a long history. The first thing that comes into our mind may be deretroflexion originated from obvious mismatch between sibilant sounds of the two languages. However, other less obvious phenomona can also be found, such as syllable-final nasal mergers. Compared to the highly stigmatized deretroflexion in Taiwan Mandarin, the nasal mergers seem to have obtained a relatively neutral judgment from native speakers. Although Ing (1985) has reported a strongly negative implication of both deretroflexion and the nasal mergers, there is still other indirect evidence that helps distinguish the difference of the deretroflexion and the nasal mergers in terms of social connotations. According to the perception test in Fon *et al.* (2011), the connotations to variant forms of syllable-final nasals were very diverse for different groups of people. Such an inconsistent judgment among people may imply that the variants of syllable-final nasals are less stigmatized than the variants of retroflex sibilants since some of the nasal variants have even obtained positive evaluation, but the deretroflexion has never been regarded as a positive sound change. Therefore, nasal mergers are more unconscious and opaque sound changes in progress, and worthy to be concerned with effort.

There are two syllable-final nasals in Mandarin, /n/ and /ŋ/, which are allowed to be preceded by the five vowels in the system (i.e., /i/, /ə/, /a/, /u/, and /y/). Nonetheless, only the first three vowels result in monophthongal realizations regardless of the following nasals (Duanmu, 2000). It has been reported that the two nasals tend to be neutralized under certain conditions, but disagreement upon the direction of sound changes remains. Most reseachers agree that /əŋ/ tends to be realized as [ən][4] (Chen, 1991; Hsu, 2006; Hsu & Tse, 2007; C.-w. Hung, 2006; Kubler, 1985; C. C. Lin, 2002; Tse, 1992; J. H.-T. Yang, 2010; Yueh, 1992), but they disagree upon the direction of nasal merger after vowel /i/. Some argued that /iŋ/ tends to be realized as [in] (C.-w. Hung, 2006; Kubler, 1985; Tse, 1992; J. H.-T. Yang, 2010; Yueh, 1992), while others suggested that /in/ tends to be realized as [iŋ] (Chen, 1991; Hsu, 2006; Hsu & Tse, 2007; C. C. Lin, 2002). The 'merging directions' of the nasals after vowel /i/ reported in the previous studies were contradictory to each other

[4] The vowel labialization of /əŋ/ (əŋ/ → [ɔŋ]) after labial onsets (/p/, /p^h/, /m/, or /f/) in Taiwan Mandarin was also found in previous studies (e.g., Ing, 1985; Kubler, 1985). It has been reported to frequently block the nasal merger /əŋ/ → [ən] (e.g., J. H.-T. Yang, 2010). This phenomena was also found in the current study. However, with only limited amount of tokens initiated with labial onsets, such an issue was ignored here.

among the two groups of researchers. Such a contradiction implies that there are some factors that may lead to different kinds of nasal mergers. Apart from the majority of research, there is still one study that proposed that /n/ and /ŋ/ are highly fluid after vowels /i/, /ə/, and /a/ (Ing, 1985).

The divergent proposals of the merging directions mentioned above may be attributed to several possible reasons. First of all, previous studies differ in their research materials and experimental designs. Ing (1985) and Kubler (1985) primarily based the study on their own observations towards the language use of the society, while most of the other early studies utilized read speech of controlled tokens to discuss the nasal mergers (e.g., Fon *et al.*, 2011; Hsu & Tse, 2007; C. C. Lin, 2002; J. H.-T. Yang, 2010). In contrast, only Su (2012) attempted to use data of interviewed spontaneous speech, which provides a more natural and realistic speech flow. As for the target syllables under investigation, some researchers did not include the full set of all possible syllables with both kinds of nasal endings (e.g., C.-w. Hung, 2006; Su, 2012), and thus the problem is still not fully explored in their studies. Therefore, this study would like to combine the benefits suggested by the previous studies using spontaneous speech, to investigate all possible syllable combinations.

Besides, the linguistic backgrounds and the place of origins of the speakers were not well controlled or were only partially controlled in most of the earlier studies. Since Fon *et al.* (2011) pointed out the existence of a regional spit in terms of the merging directions for /in/ and /iŋ/, there are difficulties in interpretation for many of the earlier studies with regard to regional differences. Only studies that recruited speakers from the same region (Hsu, 2006; Hsu & Tse, 2007; C.-w. Hung, 2006) can be used to support the regional spit without trouble. Studies without a careful control of speakers' origins would be more difficult to interpret.

In addition, the factors being examined were also very diverse. Most research were sociolinguistic studies that focused on extra-linguistic variables such as gender, age, social class, etc. Few studies paid attention to linguistic factors that are carried in spontaneous speech. Studies have shown that prosodic factors such as prosodic prominence may have an influence on the realizations of phonemes (e.g., Chuang, 2009; Duanmu, 2000; J. Wang, 1996). The effect of such linguistic factors has yet to be considered with regard to the nasal mergers.

Given the aforementioned reasons, we would like to investigate the nasal mergers more thoroughly, by examining the full set of syllables with several linguistic and social factors.

1.3 Aims of study

In order to understand the possible mechanism and regular patterns hidden behind the nasal mergers, we refer to the inspiration provided by previous works and attempt to explore the topic from a different perspective. Precisely speaking, three research goals are to be achieved.

The first goal is to investigate the realization of syllable-final nasals in Mandarin more systematically, by using all possible tokens containing the three monophthongal vowels paired with the two nasal codas (i.e., /in/, /iŋ/, /ən/, /əŋ/, /an/, and /aŋ/) in a spontaneous speech corpus. Most of the past studies adopted read speech of well-designed tokens, which may lead to departure from the reality of language. With the application of spontaneous speech, the frequencies of content and function words are more like the original composition as in natural languages, since no artificial adjustment was made for token selection. At the same time, the extra attention towards intentionally elicited read speech can also be eliminated, making the pronunciation more natural. Although Su (2012) also has used data from spontaneous speech to investigate the issue, only tokens of /iŋ/ and /əŋ/ were included in her study. A more thorough investigation upon spontaneous speech with all possible vowel-nasal combination is needed.

The second research goal is to examine social factors more completely by using corpus data with a stricter control over speakers' backgrounds. Although Su (2012), Hsu & Tse (2007), and Chen (1991) also had control over social factors, their factors were limited to either region (Su, 2012) or age (Hsu & Tse, 2007; Chen, 1991) and had not attempted to utilize both. This study thus included speakers from distinctive regions and of different age groups to specify the role of Min on the nasal mergers, as both factors covary with Min and Mandarin proficiency. As mentioned earlier, Taipei residents and youngsters mainly use Mandarin more in their daily life compared to the southerners and the elder. Therefore, the influence of Min may be hidden behind these social factors. Also, gender is an important social factor that cannot be discarded since we are unable to guarantee the uniformity of rule application among different genders. With the combination of the three social variables, we are able to understand the nasal mergers to a greater extent.

The last goal of our study is to include linguistic factors which have not been examined in any of the previous works. Prosodic prominence has been incorporated in examining the realization of different phonemes in Mandarin (e.g., Chuang, 2009; Duanmu, 2000; J. Wang, 1996) and in other languages (e.g., Beckman & Edwards, 1994; Cole *et al*., 2007). Prosodic boundaries have also been reported to have strengthening effects, such as in durational cues (Horne *et al*., 1995; Krivokapi, 2007) or phrase initial strengthening (Cho, 2003; Kraehenmann & Lahiri, 2008). Previous studies regarding prosodic factors mainly focused on realizations of phonetic levels.

As a first attempt, this study would like to see how prosodic prominence and prosodic boundaries modify the usage of nasal variants, which are more like phonological rule applications.

1.4 Significance

Building on the foundation laid down by previous research on nasal mergers, this study endeavored to examine this topic one step further by looking into a full set of vowel-nasal combinations with the main vowel remaining in monophthongal vowel realization and their association with some social factors using spontaneous speech. It is hoped that a more general picture could be depicted via a more thorough examination using more natural speech.

This study incorporated two different prosodic factors to investigate a sound change with relatively neutral connotations compared to deretroflexion. As speakers are less self-conscious about their own pronunciation, one can more easily study the effect of linguistic factors on the realization of nasal mergers. With the usage of both prosodic prominence and prosodic boundaries at the same time, the result of this study may help improve the existing prosodic theory in a way that we can further investigate how the two dimensions of linguistic factors function differently on the same phonological rule.

1.5 Organization

The following chapters are structured as follows. Literature regarding syllable-final nasal mergers in Taiwan Mandarin and other relevant prosodic issues is discussed in Chapter 2. Details of research methods, from data collection to data processing, are introduced in Chapter 3. Results and statistical analyses are presented in Chapter 4. Discussion and conclusion are provided in Chapter 5 and Chapter 6, respectively.

CHAPTER 2 LITERATURE REVIEW

This chapter provides the overview of relevant studies. Section 2.1 reviews studies on the topics pertaining to syllable-final nasal mergers in Taiwan Mandarin. Discrepancies among researchers in terms of merging directions are discussed together with social factors. Section 2.2 reviews studies on prosodic factors. Both prosodic prominence and prosodic phrasing are the focus of the current study.

2.1 Previous works regarding syllable-final nasal mergers

As early as 1985, Ing observed the instability and interchangeability of the syllable-final nasals in Taiwan Mandarin (i.e., /n/ and /ŋ/ might be pronounced as both [n] and [ŋ] when preceded by vowel /i/, /ə/ or /a/), and attributed the mispronunciation to the effect of Min and a number of Chinese dialects on Mandarin. In the same year, Kubler reported the replacement of [iŋ] and [əŋ] by [in] and [ən], respectively, in Taiwan Mandarin due to the lack of [iŋ] and [əŋ] in Min[5]. In spite of the inconsistent observations towards merging performance of the syllable-final nasals, the two studies ascribed their observations primarily to Min influence and triggered the subsequent wave of research on the topic.

2.1.1 Debate on merger types

Studies after Ing (1985) and Kubler (1985) further investigated the nasal mergers with elicited experimental data, but they did not reach an agreement on the

[5] In Kubler (1985), Min was reported to have only the following vowel finals ending in [ŋ]: [iəŋ], [ɑŋ], [iɑŋ], [ɔŋ] and [iɔŋ]. According to Yuan *et al*. (2001), there are also five rhymes ending in /ŋ/, namely, /iŋ/, /aŋ/, /iaŋ/, /ɔŋ/ and /iɔŋ/. Although there is a discrepancy between Kubler (1985) and Yuan *et al*. (2001), the symbols in Yuan *et al*. (2001) are phoneme labeling, and records in fieldwork data (e.g., Li, 2009, p.112 & p.120; Yuan *et al*., 2001, p.243) have reported a transitional /ᵊ/ between the /i/ and /ŋ/ of the /iŋ/ rhyme regardless of Chôan, Chiang, or Ē-bn̂g dialects.

merger direction. After Ing (1985), other studies no longer observed the nasal mergers under the condition of vowel /a/. While Tse (1992) found the dominance of /ŋ/ to [n] mergers over /n/ to [ŋ] mergers and agreed with Kubler's (1985) observation, Chen (1991) and C.C. Lin (2002), by contrast, reported an opposite merging direction, /n/ to [ŋ], when the nasal followed the vowel /i/.

Later on, studies focusing on social factors also appeared. Yueh (1992) was the first study that focused on a number of social factors, such as location, gender, and age, but their results showed no significant effect of any social factor. C.-w. Hung's (2006) study of Kaohsiung residents was another research focusing on social factors, including gender, age, social class, ethnicity, and context (level of formality). Results indicated that age, social class, and context did have a significant influence on the variation of /ŋ/. Compared to the younger people (16 to 30 years old) and the older people (above 51 years old), those who aged between 31 and 50 produced the most prestigious forms [ŋ]. Higher social class, and more formal styles and contexts are influential in inhibiting the mergers. Gender is not a determinant factor since male speakers, senior female subjects, and lower-middle class subjects all produced many [n]. J. H.-T. Yang (2010) compared the nasal mergers of Taiwan Mandarin and Mainland Mandarin and reported the difference between the two places. Speakers from Taiwan seemed to show a high level of homogeneity. No regional difference was found in his subjects from Taiwan. The /ŋ/ to [n] merger was found to lead in Taiwan, whereas the /n/ to [ŋ] merger was reported to lead in China.

Yueh (1992), C.-w. Hung (2006) and J. H.-T. Yang (2010) all found the nasal mergers after vowel /i/ and /ə/ to be /ŋ/ to [n] direction, which supported Kubler's point of view again. However, Hsu (Hsu 2006, Hsu & Tse 2007) found /in/ to [iŋ] and /əŋ/ to [ən] mergers, which provided another counter example to argue against Kubler, but none of the social factors (age, gender, and ethnicity) in their work were statistically significant. The debate on merging directions of syllable final nasals could be summarized as follows: most researchers agreed with the merging direction after the vowel /ə/, i.e., /əŋ/ to [ən], but disagreed upon the merging direction after the vowel /i/ (Table 2.1).

Table 2.1 Summary of debates on merging direction.

Merger types	**Studies**
/n/ → [ŋ] /ŋ/ → [n] (interchangeable)	Ing (1985)
/iŋ/ → [in] /əŋ/ → [ən] (same direction)	Kubler (1985) Tse (1992) Yueh (1992) C.-w Hung (2006) J. H.-T. Yang (2010)
/in/ → [iŋ] /əŋ/ → [ən] (opposite direction)	Chen (1991) C. C. Lin (2002) Hsu (2006) Hsu & Tse (2007) R. J.-m. Hung (2007)

2.1.2 Evidence for regional difference

According to the abovementioned works (see Table 2.1), except for Ing (1985), there seemed to be two camps of researchers, who agreed on the merging direction after /ə/, but disagreed on the merging direction after /i/. One possible explanation for such discrepancies lies in regional variations, as subjects from different populations were recruited for these studies. Yueh (1992) was the first study attempting to survey regional difference. J. H.-T. Yang (2010) also recruited speakers form different parts of Taiwan. Unfortunately, no regional variations were found in the two studies. However, later studies such as R. J.-m. Hung (2007) and Fon *et al.* (2011) pointed out that the contradictory results in merging direction were very likely to be caused by regional and methodological differences. Fon *et al.*'s (2011) experiment recruited subjects from Taipei and southwestern Taiwan and suggested the /ŋ/ to [n] mergers in both regions and an additional /in/ to [iŋ] merger in Taipei.

Coming back to view the discrepancies, studies that reported the /in/ to [iŋ] merger were Chen (1991), C. C. Lin (2002) and Hsu (Hsu 2006, Hsu & Tse 2007), which all used speakers from Taipei as their subjects. Such a coincidence further confirmed Fon *et al.*'s observation, i.e., the /in/ to [iŋ] merger was only found in Taipei. All the other studies, except for Ing (1985), only reported /ŋ/ to [n] mergers (C.-w. Hung, 2006; Tse, 1992; J. H.-T. Yang, 2010; Yueh, 1992). Even if Tse (1992), J. H.-T. Yang (2010) and Yueh (1992) enlisted Taipei residents as part of their subjects, the result did not contradict with Fon *et al.* (2011), either. The regional difference between the north and the south was almost established.

Su (2012) further examined the social and contextual factors influencing the variation of /ŋ/, using data from 35 sociolinguistic interviews among college students in Taipei and Tainan. As a first trial using spontaneous speech, Su reproduced the regional difference in a different respect. Although the realization of /n/ was not discussed, regional split and gender difference could be seen from the merging rate of /iŋ/. Southerners and male speakers utilized the variant form [in] more frequently than their counterparts. In order to complement Su's deficiency and to reduplicate Fon *et al.*'s finding, this study used a full set of vowel-nasal combinations with the main vowel remaining in monophthongal vowel realization, so that the performance of nasal mergers in the opposite direction could also be covered. Although the effect of region is not the main focus of the current study, such a factor is still included since regional differences have been well established by recent studies (Fon *et al*., 2011; Su, 2012).

2.1.3 Possible generational difference

Previous studies gave different explanations for the existence of nasal mergers. Some argued that they were due to negative transfer from Min (Ing, 1985; Kubler, 1985), others claimed that the mergers were neutral innovations by young speakers due to assimilation (C. C. Lin, 2002; Tse, 1992; Yueh, 1992), still others pointed out the possibility of a natural sound change inspired by historical rhyme books or dictionaries (Chen, 1991; Hsu & Tse, 2007). Ing (1985) and Kubler (1985) attributed the cause of the nasal mergers to the influence of Min, since it is the most influential substrate language in Taiwan. Tse (1992) and Yueh (1992) claimed that the /ŋ/ to [n] mergers were the innovation favored by the younger generation because most of the younger generation acquired Mandarin as their first language, and both Mandarin monolingual and Mandarin-Min bilingual speakers showed a similar trend, suggesting no obvious effect from Min transfer. The rules could thus be best described as frontness assimilation, as both /i/ and /ə/, as well as /n/, are produced in the front half of the vocal tract. C. C. Lin (2002), on the other hand, also regarded the mergers as an innovation, but his explanation was somewhat different due to the opposite direction of the /in/ → [iŋ] merger. Since both [ŋ] and [i] can be regarded as [+high], and both [n] and [ə] as [–high], he characterized the mergers as an [αhigh] assimilation.

These studies also reported different degrees of progression for different merging rules regardless of merging directions, implying a possible existence of generational difference. The processes of the /ŋ/ to [n] mergers were found to vary from those at the burgeoning stage (17-28% in Tse, 1992), to mergers-in-progress (32-43% in C.-w. Hung, 2006), to changes almost complete (95-97% in J. H.-T. Yang, 2010). As for the /in/ → [iŋ] and /əŋ/ → [ən] mergers, Chen (1991) claimed the merging process to be more advanced for /in/ → [iŋ] than for /əŋ/ → [ən] among three different age groups in his study, while Hsu (Hsu, 2006; Hsu & Tse, 2007) reported in the opposite way. Their older speakers showed lower merging rates for /in/ → [iŋ] than for /əŋ/ → [ən], while no such difference was found for her younger speakers regardless of gender and language background. As a result, Hsu argued that /əŋ/ to [ən] was the leading merger instead. Owing to the divergent findings in previous reports, this study aimed to investigate potential generational difference in more detail.

2.2 The effect of prosody on the application of phonological rules

Prosody, including stress, rhythm, and intonation, has been found to have crucial functions in language use. For example, different stress patterns could be used to convey different meanings or to emphasize different things; rhythm could be used to do chunking or segmentation of sentences or words for newborn babies (e.g., Christophe *et al*., 2014; Wellmann *et al*., 2012); intonation of sentences could also be used to express emotions or tell the difference between statements and questions (e.g., Eady & Cooper, 1986; Ma *et al*., 2006, van Heuven & Haan, 2000). Regardless of the debate on the linguistic or paralinguistic nature of prosody, researchers (e.g., Ladd, 2008) have dedicated to the construction of a reasonable and systematic way of analysis on prosody. The following sections review the functions of prosodic prominence and boundary, and the accompanying influence on phonetic realization.

2.2.1 Prosodic prominence

The function of prominence has been widely explored. Take English for example, stress, as the realization of prominence, can be used to make lexical contrast (e.g., *WHITE house* vs. *white HOUSE*), or to do narrow focus (e.g., *TOM loves Mary* vs. *Tom loves MARY*), etc. Besides, stress has also been reported to influence phonetic realization of words, such as vowel space or consonant gesture. Vowels are pronounced with greater gestural efforts in stressed positions (e.g., Beckman & Edwards, 1994), and consonants remain greater distinction in some dimensions with more stress (e.g., Cole *et al.*, 2007). In contrast, unstressed vowels and consonants are more centralized and lose their original distinctive phonetic features (e.g., van Bergem, 1993; van Son & Pols, 1999).

As for stress in Mandarin, Chao (1968) suggested a three-level distinction, i.e., contrastive stress, normal stress, and weak stress. Contrastive stress refers to words with a contrastive context and is realized with a wider pitch range and longer duration. Weak stress is associated with neutral tone syllables, most of which are grammatical function words, such as *–de* (possessive marker) or *–zi* (noun suffix). The name "neutral" is given because the original tonal range is "flattened to practically zero". Compared to contrastive stress, neutral tone syllables are flatter in pitch range and shorter in duration. At last, any syllable that bears neither contrastive stress nor weak stress belongs to normal stress.

As proposed by Chao (1968), the most relevant phonetic correlates of stress in Mandarin are pitch range and duration, with loudness being less related. Such an idea was further proven by Jin's (1996) acoustic study, reporting pitch to be even more related to stress than duration. Following the idea of Chao, Pan-Mandarin ToBI developed by Peng *et al.* (2005) provided a systematic tool for stress labeling. There are four levels of stress, S0 to S3, in total. Their definitions are shown in Table 2.2.

Table 2.2 Levels of stress in Pan-Mandarin ToBI (Peng *et al.*, 2005).

Stress	**Description**
S3	Syllables with a fully realized lexical tone.
S2	Syllables with substantial tone reduction.
S1	Syllables that have lost their lexical tonal specification.
S0	Syllables with a lexically-defined neutral tone.

Peng *et al.* divided the weak stress of Chao into two levels (S0 and S1), depending on whether a syllable is lexically specified. Notice that only tonal realizations were taken as the sole criterion for labeling stress levels. However, Shen's (1993) perceptual experiment found that listeners were able to recognize stress locations even without F_0 information, suggesting none of the cues (pitch, duration and loudness) were indispensable. Taking a step further, Chuang (2009) improved the criteria for stress labeling in her study with cues from multiple dimensions (see Table 2.3).

Table 2.3 Modified criteria for stress in Pan-Mandarin ToBI (Chuang, 2009).

Stress	**Tone**	**Amp.**	**Duration**	**Segmental information**
S3	tone expanded/raised	loud	lengthened	target accurately reached
S2	default	default	default	default
S1	loss of original tonal shape	soft	shortened	target neutralized
S0	lexically neutral tone	soft	shortened	target neutralized

2.2.2 Prosodic boundary

Prosody also functions as an aid for chunking, breaking a stream of speech into smaller prosodic phrases. Due to some similarities, such phrases are often confused with syntactic phrases. There were studies reporting that prosodic phrases and boundaries should be defined by syntactic projection and juncture (Hayes, 1989; Selkirk, 1986), however, Ladd (2008) regarded their proposal only as a hypothesis rather than an approved definition. Regardless of the high correlation between prosodic and syntactic phrasing, prosodic trees differ from syntactic ones in that they should be non-recursive (Halliday 1966; Huddleston, 1965; Matthews 1966; Nespor & Vogel, 1986; Selkirk, 1984), entailing the special fixed depth property of prosodic trees (Ladd, 2008).

Although the theory of prosody is still under construction, it has been proven that prosodic boundary has something to do with changes of acoustic signals, such as articulatory strengthening (Fougeron & Keating, 1997) and declination reset (Ladd, 1988). In order to quantify prosodic boundaries for further exploration of their essence, studies have proposed an impressionistic way to label different strengths of word and phrase boundaries and named it as "break indices". Such method became part of the major prosodic labeling system known as ToBI (Beckman *et al*., 2005; Brugos *et al.*, 2006; Pitrelli *et al.*, 1994; Silverman *et al.*, 1992).

In Pan-Mandarin ToBI (Peng *et al.*, 2005), there are six levels of break indices, B0 to B5. Their definition is shown in Table 2.4. Notice that Peng *et al.* also mentioned the difficulty of distinguish B4/B5 and B2/B3 due to their subtle difference in definition. Even trained labelers showed a low rate of consistency for these two pairs of tagging. Since both B4 and B5 refer to a breath group boundary, and both B3 and B2 refer to a phrase boundary, it is not surprising to see the trouble of distinction, which mainly depends on length or existence of pauses.

Table 2.4 Levels of break indices in Pan-Mandarin ToBI (Peng *et al.*, 2005).

BI	Definition
B5	Prosodic group boundary: a breath group boundary accompanied by a prolonged pause.
B4	Breath group boundary: reset of pitch between sentences or phrases.
B3	Major phrase boundary.
B2	Minor phrase boundary: must be followed by at least S2.
B1	Regular syllable boundary: the 'default' case within a polysyllabic word.
B0	Reduced syllable boundary, i.e., contraction: require S0 or S1 on left or right.

Most studies focused on the effect of prosodic boundaries on durational cues (e.g., Horne *et al*., 1995; Krivokapi, 2007; S.-F. Wang, 2013), and fewer investigated their influence on phonetic realizations of vowels or consonants. There are some studies showing a strengthening effect of prosodic boundaries, especially phrase initial strengthening (e.g., Cho, 2003; Kraehenmann & Lahiri, 2008). Although their findings are mainly about subtle phonetic differences in VOT rather than phonological changes of phonemes, such findings still shed light on the possible influence of prosodic boundaries on segments near boundaries. Therefore, this study would like to look into the effect of prosodic boundary on syllable-final nasal mergers since syllable-final nasals may possibly be influenced by prosodic boundaries due to their close relationship regarding position. It would be thus interesting to extend the finding from a phonetic level to a phonological level.

CHAPTER 3 METHODS

This chapter describes the methods of conducting the present study. Section 3.1 provides the process of data collection. Section 3.2 introduces social factors that speakers stand for. Section 3.3 describes basic labeling, including segmentation of syllables and classification of target syllables. Section 3.4 presents the criteria and examples of prosodic labeling.

3.1 Data collection of corpus

This study utilized part of the speech data from the Mandarin-Min bilingual corpus constructed by Fon (2004). The social variables in the corpus, including age at the time of recording, and the place one grew up, were all strictly controlled, providing us with a good source for comparison between different regions and age groups. Besides, the ethnicity of speakers' parents was confined to Min only, so that the influence from other languages could be minimalized. Only the Mandarin part of the corpus was utilized in this study.

3.2 Background of speakers

The data of 32 speakers in the corpus were included for analyses. Each of the speakers contributed around 30 minutes of interviewed spontaneous speech. The speakers were equally divided into 8 groups according to their gender, age, and place of upbringing. All of the three social factors were 2-leveled, resulting in a 2×2×2 combination, in which each of the 8 cells contained 4 participants. Table 3.1 shows the distribution of the subjects. The number of the speakers was equally distributed in gender. Half of the speakers were aged between 20 and 35 years old, while the other half were between 50 and 65 years old at the time of recording. Half of them lived solely in Taipei City/County at least between ages of 3 and 18, whereas the other half lived in Kaohsiung City/County.[6]

Table 3.1 The number of subjects in different social conditions.

Place of origin		Taipei		Kaohsiung	
Age		Young	Old	Young	Old
Gender	male	4	4	4	4
	female	4	4	4	4

3.3 Labeling of target words

The recordings were first transcribed in Chinese characters, later romanized in Hanyu Pinyin, and then labeled using *Praat* (Boersma & Weenink, 2008). Each syllable that contained /in/, /iŋ/, /ən/, /əŋ/, /an/, or /aŋ/ was first identified, and its phonetic realization (described in the next section), stress level, and prosodic break index were labeled by two native speakers of Taiwan Mandarin, one of whom was the author of the current study. Each of the two labelers was responsible for half of the data. In order to increase inter-labeler reliability, the standard for labeling was frequently discussed at initial stages. Ambiguous cases were selected and checked by both labelers in order to improve the consistency of the labeling standard, and the standard was applied throughout the whole process of labeling.

3.3.1 Labeling of realization

Based on the auditory perception of the labelers together with the auxiliary of acoustic signals, all target syllables were assigned into one of the following categories:

[6] Taipei County has become New Taipei City and Kaohsiung County has merged with Kaohsiung City since the 25th of December, 2010.

[Vm], [Vɱ], [Vn], [Vɲ], [Vŋ], [Ṽ], [N̩], [V], and [V̥]. Despite the fact that there are only two types of syllable-final nasals in Mandarin, which are /Vn/ and /Vŋ/, we did observe five different realizations of nasals in terms of places of articulation due to the inevitable assimilation or coarticulation caused by following syllables. All tokens were assigned one of the two nasals of default places, [Vn] and [Vŋ], the best we could. They were assigned other labels only when none of the two nasals suited them any longer. Besides, we also found several variants due to fast paces of speech flow. Sometimes the nasal was merged into the vowel, resulting in a nasalized vowel (assigned into [Ṽ]); sometimes the vowel was deleted, causing a syllabic nasal (assigned into [N̩]); sometimes the nasal was completely deleted, remaining a pure oral vowel (assigned into [V]); sometimes the vowel quality changed, making the vowel be realized as breathy or creaky (assigned into [V̥]). Apart from the aforementioned reasons, there were still other reasons accounting for all the variant forms, such as speech errors, careless speech styles, or any unpredictable causes due to random sampling from spontaneous speech.

3.3.2 Labeling of intention

The categorizing principles mentioned in Section 3.3.1 focused basically on signals of the nasal part; as a result, the realization of a great number of tokens was inevitably affected by coarticulation and lost its representativeness and explanatory ability. In order to rescue some of the tokens back into use, we took signals of the vowel part into account to judge speakers' intended nasal target if possible. This kind of rescue functioned the best for /an/ and /aŋ/ pair because the phonetic realizations of the vowel /a/ before different nasal codas had greater distinction (i.e., [an] vs. [ɑŋ]) compared to /i/ and /ə/.

Figure 3.1 shows an example of nasal realization and intention labeling. Syllables were transcribed in the first tier, acoustic/perceptional realizations of nasals were labeled in the second tier, while the intentions of speakers towards nasals were tagged in the third tier if they were judged to be different from those in the second tier. The realization of *nan2* was [am]. Since the [m] final of *nan2* was caused by assimilation or coarticulation of the following syllable, and there seemed to be no intention of pronouncing [ɑŋ], we assigned [an] on the intention tier to rescue it back into valid analysis. The intention of speakers was mainly judged according to the acoustic/perceptional realizations of vowels since vowel differences resulting form different nasal targets could also be accounted for their intention of pronouncing a certain nasal.

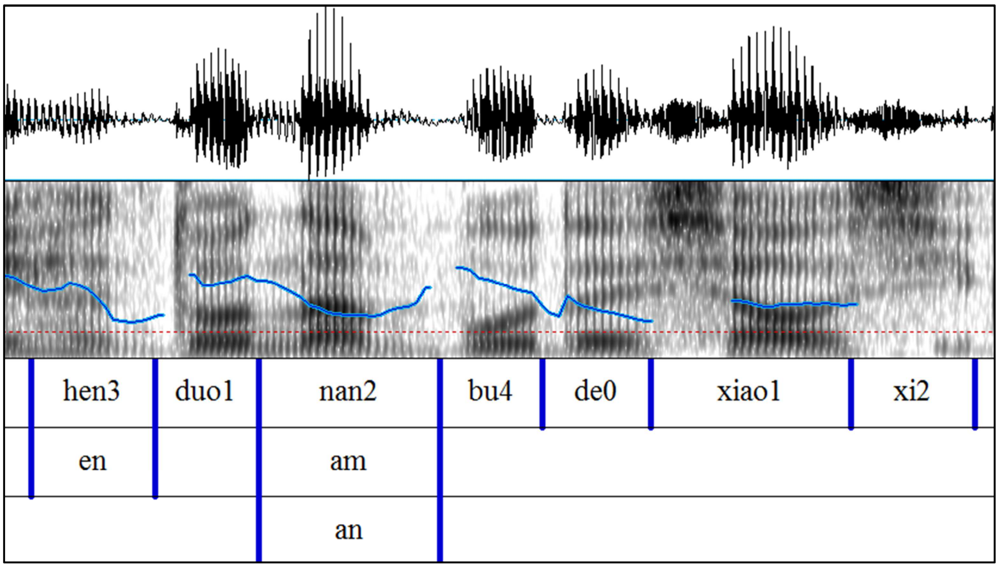

Figure 3.1 An example of nasal realization (tier 2) and intention (tier 3) labeling.
hen3-duo1 nan2-bu4 de0 xiao1-xi2
"lots of news from the south"

3.4 Prosodic labeling

There are two prosodic factors being examined in our study, i.e., prosodic prominence and prosodic phrasing. Different levels of prominence and phrasing were labeled utilizing stress and break indices of a modified Pan-Mandarin ToBI system (Peng *et al.*, 2005).

3.4.1 Stress labeling

Peng *et al*. (2005) have designed the Pan-Mandarin ToBI system for labeling different Mandarin varieties. Here we adopted the modified version from Chuang (2009) to label the prominence levels for each syllable. In the original version, the criteria that differentiate distinctive levels of prominence are generally based on tonal realizations or pitch contours. The modified version, however, was improved with more relevant variables, such as duration, amplitude, and segmental information, which made it easier to adapt to the various situations in spontaneous speech. There are four levels of prominence in total, from S0 to S3. S3 represents the prominent condition, S0 and S1 are the reduced ones, and S2 stands for the default condition. The modified set of criteria is provided in Table 2.3.

Examples of stress labeling are shown in Figure 3.2. *she4* and *gao1* were labeled with S3 since they accorded with multiple criteria provided in Table 2.3, with louder amplitude, longer duration, and targets accurately reached. Although the *gao1* had relatively low pitch, we still labeled it with S3 because of the long and clear closure of its initial plosive, making it sound like a kind of emphasis. *bi3* was relatively weaker than other syllables, and thus received S1 since it was not a syllable with lexically neutral tone. *de0* automatically received S0 due to the requirement of neutral tone.

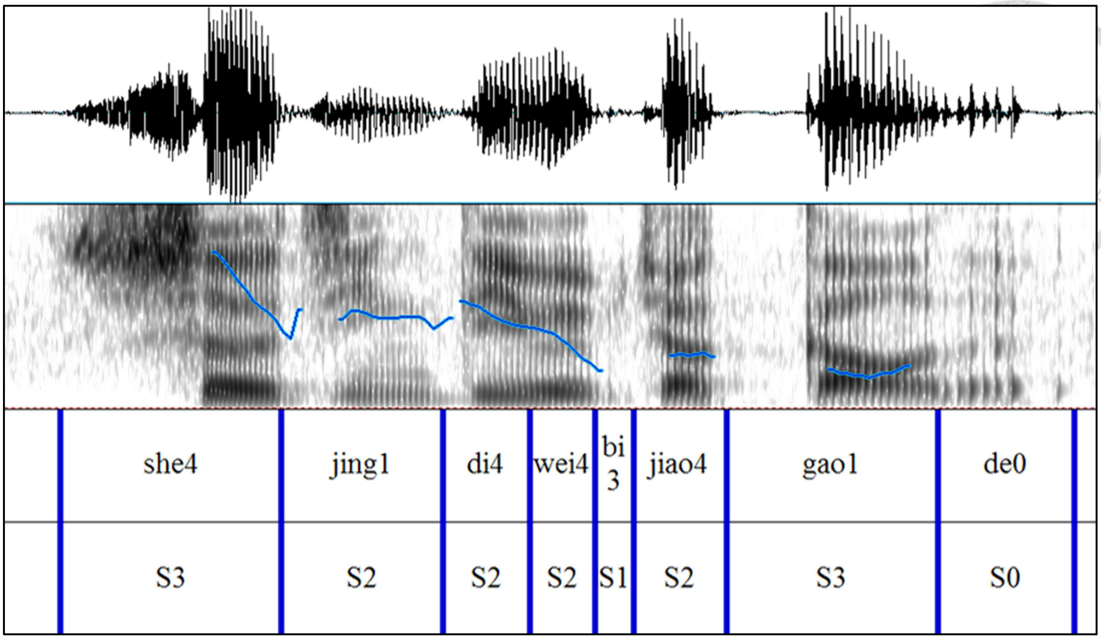

Figure 3.2 An example of stress labeling.
she4-jing1 di4-wei4 bi3-jiao4 gao1 de0
"those that were higher in social class"

3.4.2 Break labeling

A modified Pan-Mandarin ToBI (Peng *et al*., 2005) was also used to label prosodic break indices. In the original version, there are six ordinary levels (see Table 2.4), but there are no levels designed for disfluency, which occurred very often in spontaneous speech. In order to improve its feasibility, we referred to the P diacritic of English ToBI (Beckman *et al*., 2005) and combined some of the ordinary levels in the original version. The modified version of break indices is shown in Table 3.2. There are four ordinary levels, from B0 to B3, and two additional levels with diacritics for compromising disfluency of spontaneous speech. B3 and B2 indicate the existence of prosodic boundaries, B1 is the default syllable boundary, and B0 stands for the reduce one.

Table 3.2 Modified criteria for levels of prosodic boundary.

Break	Definition
B3	intonation phrase boundary
B2	phonological phrase boundary
B1	regular syllable boundary
B0	reduced syllable boundary
B2P	hesitation
B1P	truncated

Examples of break labeling are shown in Figure 3.3. The boundary between *qu1* and *yu4* was erased and was thus labeled B0. There seemed to be a small break after *zhong4* and it was thus tagged with B2. *heng2* was at the end of a sentence and was perceived with a feeling of ending, so it received B3. All the other syllables were relatively normal and received B1.

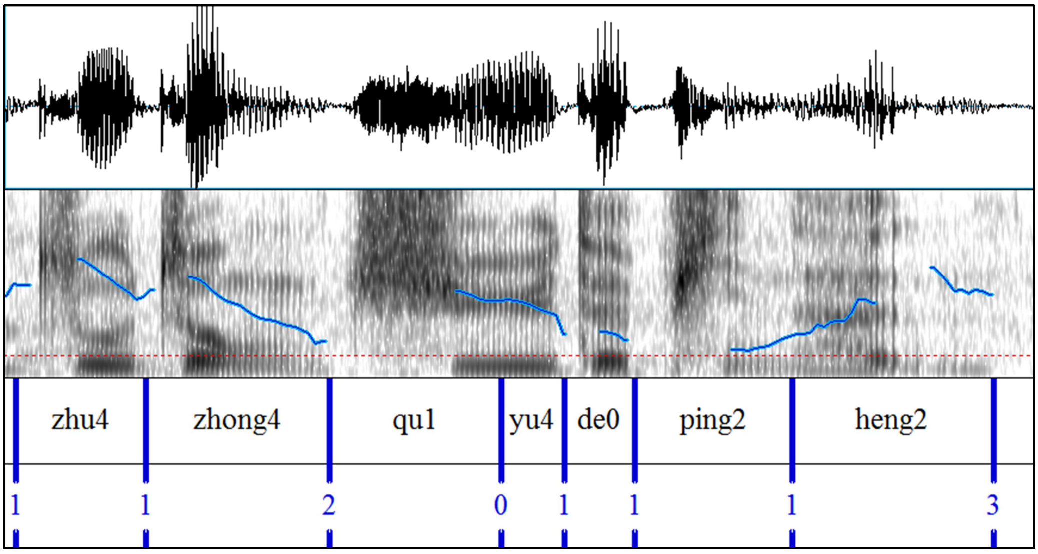

Figure 3.3 An example of break indices labeling.
zhu4-zhong4 qu1-yu4 de0 ping2-heng2
“pay attention to the areal balance”

CHAPTER 4 RESULTS

Data with statistical analyses are presented in this chapter. Overall distribution of relevant syllables is provided in Section 4.1. The examination of social factors is summarized in Section 4.2. The effects and statistic results of two linguistic factors, stress and break, are shown in Sections 4.3 and 4.4, respectively.

4.1 Overall distribution

There are in total 46,324 tokens containing /in/, /iŋ/, /ən/, /əŋ/, /an/, and /aŋ/ vowel-nasal sequence from the recordings of 32 speakers. The summary of recording content is provided in APPENDEX I. Detailed distribution of the underlying vowel-nasal sequence is shown in APPENDIX II, subdivided by age (Young/Old), gender (Male/Female), region (Taipei/Kaohsiung), stress level (S3/S2/S1/S0), and break index (B3/B2/B1/B0/B2P/B1P).

According to previous research, nasal mergers were mainly found in /in/, /iŋ/, and /əŋ/ syllable types; these syllables were thus chosen as the target of analyses (termed as "target" in the rest of the study). On the other hand, /ən/, /an/, and /aŋ/ syllable types were also included and used as references (termed as "reference" in the remaining part). A previous study has shown a lower degree of nasal mergers in spontaneous speech (Su, 2012). It would thus be easier to judge and compare the proportion of nasal mergers with some reference points being settled. Overall token numbers and relative percentages of target syllables and references are shown in Table 4.1. The target syllables composed 22.14% of tokens, whereas the other 77.86% of tokens consisted of the references.

Table 4.1 Distribution of targets and references.

	Syllable type	Token number	Percentage
Target	/in/	3,080	6.68%
	/iŋ/	3,987	8.65%
	/əŋ/	3,143	6.82%
Reference	/ən/	9,502	20.62%
	/an/	16,828	36.52%
	/aŋ/	9,546	20.71%
Total		46,086	100.00%

Some of the data were discarded before analyses due to various reasons, such as bad voice quality or disfluency. The details of data distribution divided by different reasons of exclusion are shown in Table 4.2. The upper part of the table gives a general distribution of the targets, while the lower part provides that of the references. The valid data were those containing both vowels and nasals in some forms in their signals. Only such tokens underwent further investigation since our research goals were based on the realization of nasals. Notice that we also labeled the intention of some tokens as mentioned in Section 3.3.2. As a result, some of the tokens that should have been discarded could be taken back into analyses. However, most of the rescued tokens were /an/ and /aŋ/. Among all valid data, only 6 tokens of /in/, 33 tokens of /iŋ/, and 7 tokens of /əŋ/ were rescued from invalid tokens with the help of intention labeling.

Except for /ən/ syllables (only 88%), valid tokens accounted for approximately 95% of the data, which revealed a highly accordant distribution among syllable types. The exception of /ən/ came from a great amount of *men0*, the plural suffix for personal pronouns, which was often realized as a syllabic nasal since it is a function word with high frequency. However, the low level of prosodic prominence (S0) is also a reasonable explanation of getting lots of syllabic nasals in *men0*. With only a small number of invalid tokens, we discarded them without further statistical analyses.

Table 4.2 Distribution of tokens subdivided by different reasons of discarding.

Target	/in/		/iŋ/		/əŋ/	
	Token number	Percentage	Token number	Percentage	Token number	Percentage
valid	3,000	97.40%	3,835	96.19%	3,031	96.44%
truncation	11	0.36%	15	0.38%	12	0.38%
hesitation	16	0.52%	47	1.18%	51	1.62%
syllabic N	26	0.84%	48	1.20%	25	0.80%
creaky V	4	0.13%	14	0.35%	12	0.38%
breathy V	4	0.13%	21	0.53%	1	0.03%
loss of N	19	0.62%	7	0.17%	11	0.35%
Total	3,080	100.00%	3,987	100.00%	3,143	100.00%

Reference	/ən/		/an/		/aŋ/	
	Token number	Percentage	Token number	Percentage	Token number	Percentage
valid	8,366	88.05%	16,037	95.30%	9,046	94.76%
truncation	92	0.97%	77	0.46%	31	0.32%
hesitation	235	2.47%	228	1.36%	164	1.72%
syllabic N	619	6.52%	9	0.05%	8	0.08%
creaky V	103	1.08%	321	1.91%	209	2.19%
breathy V	24	0.25%	31	0.18%	33	0.35%
loss of N	63	0.66%	125	0.74%	55	0.58%
Total	9,502	100.00%	16,828	100.00%	9,546	100.00%

4.1.1 Examples of discarded tokens

As shown in Table 4.2, several types of tokens were discarded due to different reasons. The following figures are a couple of illustrations for each kind of discarded tokens. Figure 4.1 shows an example of truncated tokens. This kind of tokens was abandoned due to sudden interruption and unclearness at syllable final positions, which made it hard or impossible to identify the realization of nasals.

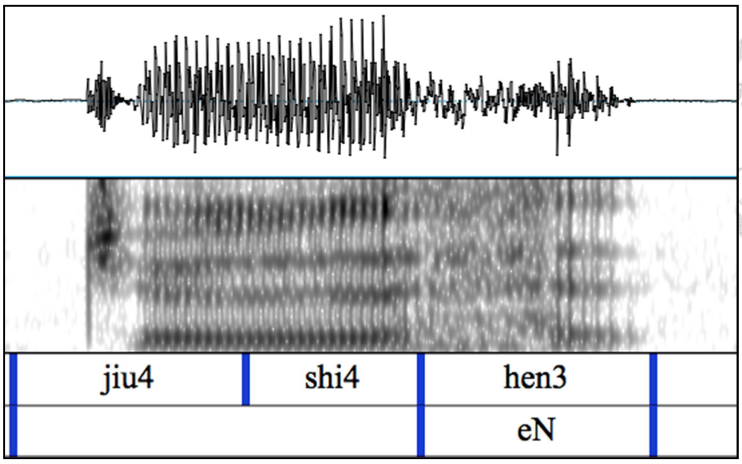

Figure 4.1 An example of truncation.
jiu4-shi4 hen3
"it's just very"

Figure 4.2 is an example of hesitation. Tokens with hesitation may show different patterns of nasal mergers from those of fluent speech. It might thus be inadequate to group these tokens together with the others before we could make sure there was no difference in their performance. With a limited and insufficient number of tokens, we had no choice but to remove them from further analyses.

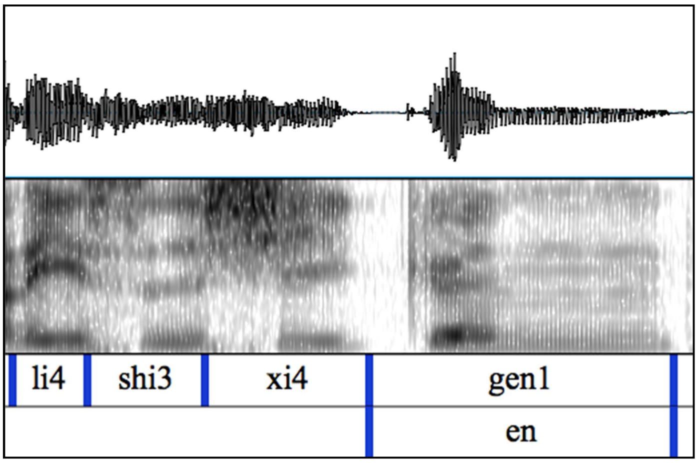

Figure 4.2 An example of hesitation.
li4-shi3 xi4 gen1
"Department of History and"

Figure 4.3 displays an instance of syllabic nasals. Without vowels in the realization, they no longer showed a vowel-nasal sequence. They could be influenced by surrounding syllables of both edges and were thus excluded from the population of investigation.

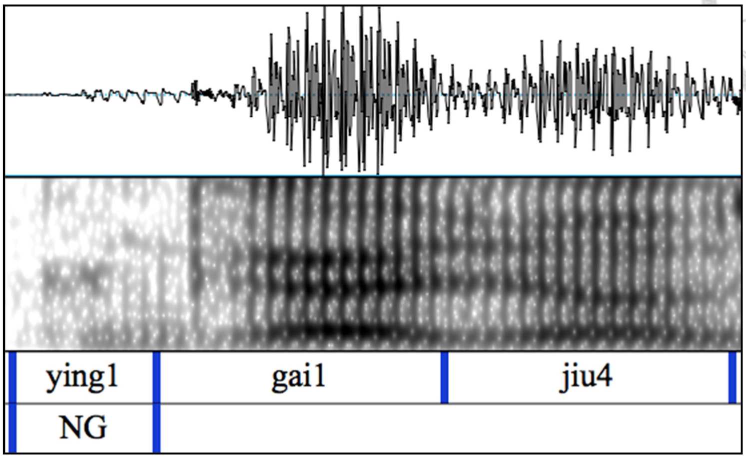

Figure 4.3 An example of syllabic nasals.
ying1-gai1 jiu4
"it should just"

Figure 4.4 and Figure 4.5 present cases of creaky voice and breathy voice, respectively. Owing to their bad voice quality, signals of nasals became harder to recognize. Such tokens were also discarded as a consequence.

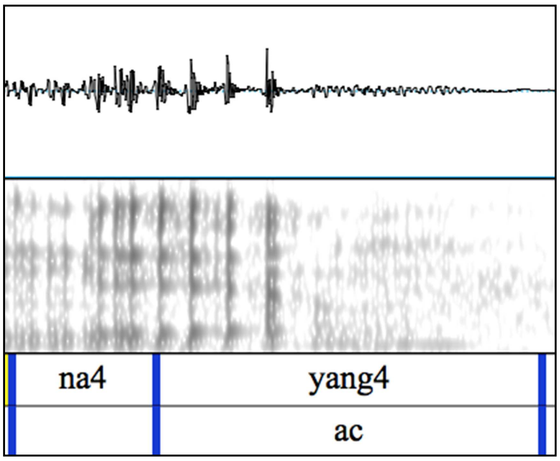

Figure 4.4 An example of creaky voice.
na4-yang4
"that kind"

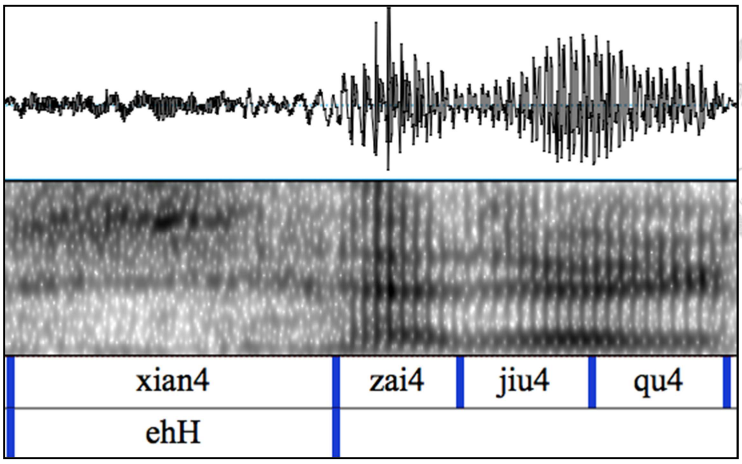

Figure 4.5 An example of breathy voice.
xian4-zai4 jiu4 qu4
"now go to"

Figure 4.6 is a demonstration of tokens without any nasal articulation. These tokens were also discarded since there were no nasals in the signal any longer. Only the oral vowel remained.

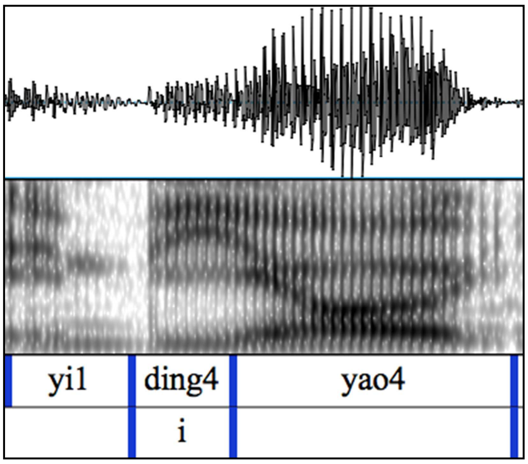

Figure 4.6 An example of nasal loss.
yi1-ding4 yao4
"must"

Taking out the aforementioned variants, one obtained a cohort of 43,315 tokens as our database for further examination, in which 9,866 of them were targets and 33,449 of them were references.

4.1.2 Data for analyses

In the rest of the tokens, there were mainly two types of realizations: one with a relatively complete or obvious sequence of vowel and nasal in the signal, and the other with merely a nasalized vowel with little or no trace of formant transitions caused by nasals. Their relative proportions are shown in Table 4.3. The nasalization rates of the tokens varied from 9.67% to 26.23% for different vowel-nasal sequences.

Table 4.3 Distribution of valid tokens.

Target	/in/		/iŋ/		/əŋ/	
	Token number	Percentage	Token number	Percentage	Token number	Percentage
VN	2,213	73.77%	3,464	90.33%	2,615	86.28%
Ṽ	787	26.23%	371	9.67%	416	13.72%
Total	3,000	100.00%	3,835	100.00%	3,031	100.00%

Reference	/ən/		/an/		/aŋ/	
	Token number	Percentage	Token number	Percentage	Token number	Percentage
VN	7,264	86.83%	13,027	81.23%	7,959	87.98%
Ṽ	1,102	13.17%	3,010	18.77%	1,087	12.02%
Total	8,366	100.00%	16,037	100.00%	9,046	100.00%

4.1.3 Analyses on tokens of nasalized vowels

Nasal weakening or deletion was not a surprising result in spontaneous speech. However, its emergence competed with our research interests. Although it might be a by-product of spontaneous speech, its unequal distribution among different vowel-nasal combinations seemed to contain some information. Before taking them out, it is also worth knowing their distribution regarding social factors. Since all of the social factors are categorical, step-wise binary logistic regressions were carried out for the three types of target syllables. The dependent variable was whether the realizations of the syllables became nasalized vowels without nasal murmurs or not. All independent variables were categorical and were set to be simple contrasts, including Age (Young = 0.5, Old = −0.5), Gender (Male = 0.5, Female = −0.5), and Region (Taipei = 0.5, Kaohsiung = −0.5), and all possible combinations of these variables, resulting in a total of seven predictors.

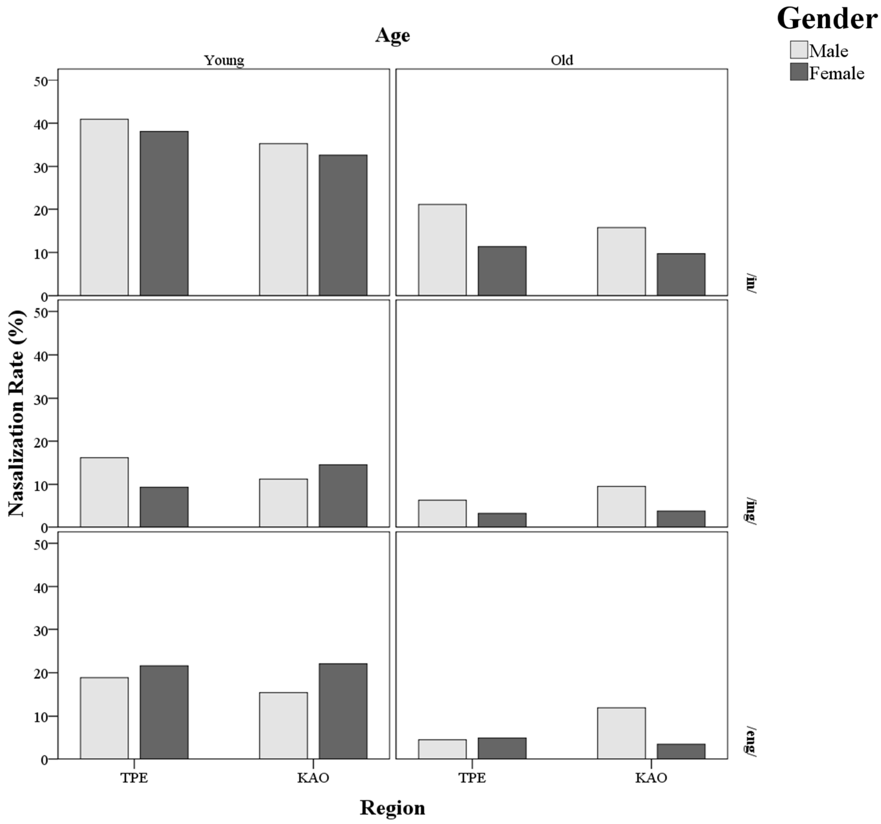

Figure 4.7 Nasalization rates of targets.

The statistic results are presented in Table 4.4. Results showed that the overall model fit test was significant for /in/ → [ĩ] [$\chi^2(4) = 213.562$, $p < .001$], for /iŋ/ → [ĩ] [$\chi^2(4) = 80.024$, $p < .001$], and for /əŋ/ → [ə̃] [$\chi^2(4) = 139.709$, $p < .001$].

For all targets of /in/, /iŋ/, and /əŋ/, the main effect of Age was the first predictor that entered each of the three models; switching from Old to Young group would increase the odds of applying nasalization by a factor of 3.595, 2.684, or 3.938, respectively. There are still other successful predictors for each type of targets as shown in Table 4.4. By including the four predictors for each case in Table 4.4, the model would correctly classify 73.8%, 90.3%, and 86.3% of the cases, respectively.

Although the nasalized tokens showed slightly different trends among different syllable types, we still had to eliminate them from further analyses since they had no more explanatory power for our research questions, which focused on the merging direction of syllable-final nasals.

Table 4.4 Statistics of step-wise binary logistic regression of nasalization rates.

(a) /in/ → [ĩ]	B	S.E.	Wald	df	*p*	Exp(B)
Region	.261	.086	9.139	1	.003	1.299
Gender	.387	.096	16.290	1	.000	1.473
Age	1.279	.096	178.691	1	.000	3.595
Age × Gender	−.538	.192	7.879	1	.005	.584
Constant	−1.187	.048	611.564	1	.000	.305

(b) /iŋ/ → [ĩ]	B	S.E.	Wald	df	*p*	Exp(B)
Gender	.536	.133	16.339	1	.000	1.710
Age	.987	.133	54.988	1	.000	2.684
Age × Gender	−.753	.266	8.046	1	.005	.471
Age × Gender × Region	1.651	.453	13.284	1	.000	5.211
Constant	−2.430	.068	1.284E3	1	.000	.088

(c) /əŋ/ → [ə̃]	B	S.E.	Wald	df	*p*	Exp(B)
Age	1.371	.140	96.208	1	.000	3.938
Gender × Region	−.713	.280	6.511	1	.011	.490
Age × Gender	−.849	.222	14.616	1	.000	.428
Age × Gender × Region	1.879	.559	11.302	1	.001	6.550
Constant	−2.125	.071	889.848	1	.000	.119

4.2 Effects of social factors on nasal mergers

After removing tokens of nasalized vowels, we obtained a homogeneous set of tokens composed of vowels and nasals, where 8,296 of them were targets, while 28,250 of them were references. We could subdivide these tokens into six groups.

Detailed subgrouping criteria are presented in Table 4.5. In spontaneous speech, it is inevitable to encounter assimilation, especially regressive assimilation in our case. Such assimilation would prevent us from understanding the real performance of nasal mergers. As a result, some strategies were needed to tease the two competing rules apart from each other, namely, nasal mergers and assimilation. The former is of our interest, whereas the latter is not. Subgrouping of the tokens was based on places of articulation of nasal realization and that of the successive onset. If they were homorganic, we could not be sure of whether assimilation actually existed. In contrast, if they were not homorganic, we could be sure that no influence from assimilation was involved.

Table 4.5 Subgrouping of VN tokens.

Nasal condition	**Nasal realizations**	**Not followed by homorganic onset of the next syllable**	**Followed by homorganic onset of the next syllable**
Remained in underlying form	/n/ → [n] /ŋ/ → [ŋ]	No rules applied (Category I)	No rules or Assimilation applied (Category II)
Changed into the opposite category	/n/ → [ŋ] /ŋ/ → [n]	Mergers applied (Category III)	Mergers or Assimilation applied (Category IV)
Changed into other places of articulation	/n/ → [m], [ɱ], [ɲ] /ŋ/ → [m], [ɱ], [ɲ]	Speech error (Category V)	Assimilation applied (Category VI)

According to Table 4.5, nasal mergers could occur in two cells. One was for pure nasal mergers (Category III), and the other might include possible competition from assimilation (Category IV). If we only took Category III to compute application rates of nasal mergers, it would be a relatively conservative estimation. If we took both Category III and IV to stand for token numbers of nasal mergers, it would be an overestimation. The real merging rates were somewhere between the two aforementioned versions. In order to resolve such dilemma, the following calculation was used.

If one assume that nasal mergers and regressive application were orthogonal processes, and that the application rate of a nasal merger was x and the token numbers of each cell was n_i. The application rate should be equal to all tokens of Category III plus some tokens of Category IV (the proportion was x) over the entire token number:

$$x = \frac{n_3 + xn_4}{\Sigma n_i}$$

$$x\Sigma n_i = n_3 + xn_4$$

$$x(\Sigma n_i - n_4) = n_3$$

$$x = \frac{n_3}{\Sigma n_i - n_4}$$

After calculation, an estimate value of merger application rate was obtained. Such a value could be used to represent a more accurate rate of nasal mergers. Although all tokens in Category IV were subtracted from the denominator of the final formula, this value was still a valid representative for tokens of all six cells since it was an equivalent result from the original assumption with all tokens. The application rates of the three nasal mergers in the following analyses were based on this corrected formula. The total numbers of /in/, /iŋ/, and /əŋ/ after taking out all tokens in Category IV and relative details were presented in Table 4.6.

Table 4.6 Token distributions according to the categories in Table 4.5.

Targets	**Tokens being taken out** (Category IV)	**Remaining tokens** (Category I, II, III, V & VI)	**Tokens underwent mergers** (Category III)
/in/	789	1,424	207
/iŋ/	587	2,877	329
/əŋ/	635	1,980	454

4.2.1 Individual differences

The application rates of the mergers for each speaker were shown in Figure 4.8. Large individual differences were found within each social group. Take Taipei young males for example, three out of four speakers had the /in/ → [iŋ] merger but hardly used the /iŋ/ → [in] merger, whereas the last one performed the two mergers in a totally opposite direction. With such a huge individual difference among nearly all social conditions, it is thus inadequate to use the averaged merging rates of all the speakers to represent each of the social conditions because the averaged values are no longer meaningful. Therefore, the data should be interpreted at two different levels: one is to see how popular a merger is within a certain social condition, i.e., the proportion of population that applies the merger. The other is to see how high the

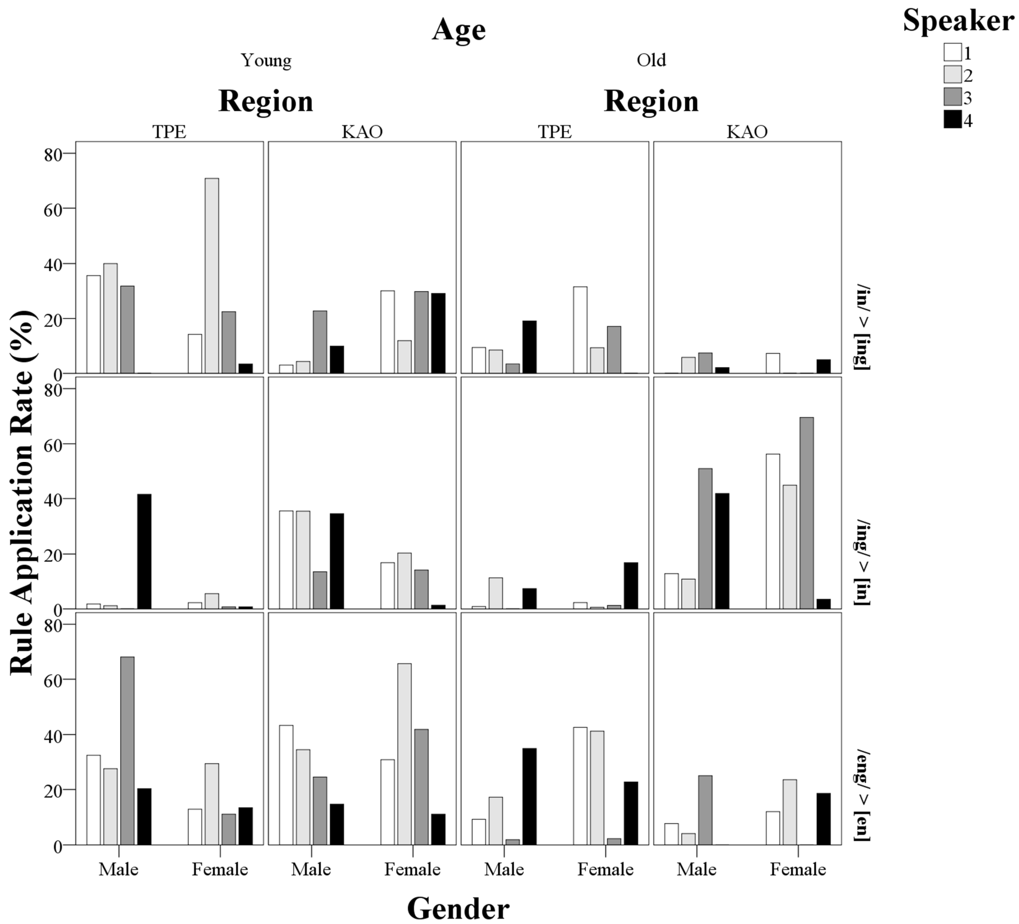

Figure 4.8 Application rates of nasal mergers divided by each speaker.

merging rates are among the population that does utilize mergers within a certain social condition, i.e., the averaged merging rates after taking out the people that do not use certain mergers.

In order to decide which people did not have which mergers, an operational definition for speech error rates should be set. If we use the same formula above to calculate for the references (i.e., /ən/, /an/, and /aŋ/), we get a set of rates that could stand for speech errors (i.e., /ən/, /an/, and /aŋ/ were pronounced as [əŋ], [aŋ], and [an], respectively) in spontaneous speech since previous studies have not shown obvious evidence of nasal mergers of these kinds. The error rates of each speaker that calculated with the formula are shown in Figure 4.9. The range of the error rates is from 0% to 8.8%.

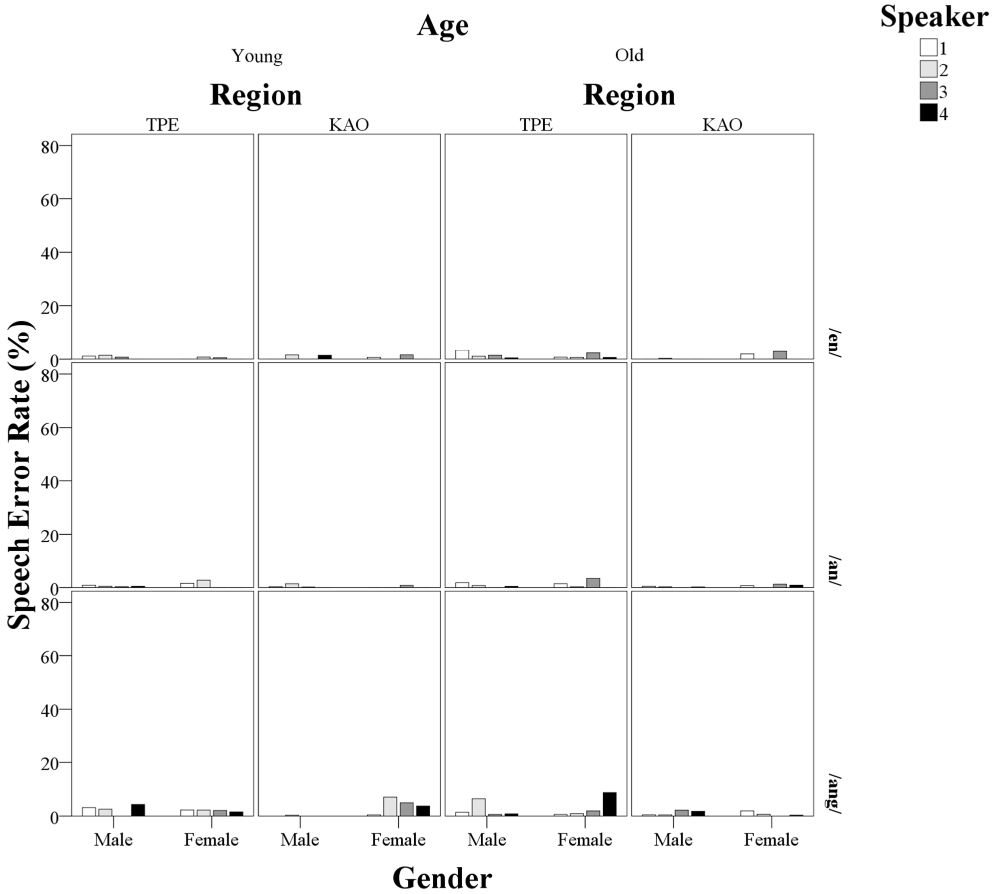

Figure 4.9 Speech error rates of references divided by each speaker.

Taking the speech error rates of references as an auxiliary standard, we arbitrarily set 5% as a threshold to determine whether a speaker has a merger or not. Merging rates lower than 5% would be regarded as having no merger application at all. Even if the merging rates of some mergers for some speakers were only a little bit higher than 5%, they were still counted as speakers with those mergers, but with relatively low merging rates. No matter how the threshold was set would not influence the results very much. The only difference was to interpret a speaker as one with no mergers at all, or one with extremely low merging rates. Although there is a difference between the two interpretations, we would like to view them as interchangeable explanations in such a marginal case.

Table 4.7 is a summary of merger application among all social conditions. According to the number of people with mergers, /in/ → [iŋ] was slightly more popular among the northerners (12 northerners vs. 10 southerners), /iŋ/ → [in] was more popular among the southerners (5 northerners vs. 14 southerners), while /əŋ/ → [ən] was equally popular (14 northerners vs. 13 southerners).

Table 4.7 The number of speakers that applied mergers.

	Young				Old			
	Taipei		Kaohsiung		Taipei		Kaohsiung	
	Male	Female	Male	Female	Male	Female	Male	Female
/in/ → [iŋ]	1,2,3	1,2,3	3,4	All	1,2,4	1,2,3	2,3	1,4
/iŋ/ → [in]	4	2	All	1,2,3	2,4	4	All	1,2,3
/əŋ/ → [ən]	All	All	All	All	1,2,4	1,2,4	1,3	1,2,4

4.2.2 Nasal merging rates of the speakers who applied mergers

With the aforementioned criterion, speakers with merging rates lower than 5% would be excluded from further analyses. After taking out the tokens from speakers with little or no mergers (432 of /in/ from 10 persons, 1503 of /iŋ/ from 13 persons, and 350 of /əŋ/ from 5 persons), the numbers of the remaining tokens were 992 of /in/, 1374 of /iŋ/, and 1630 of /əŋ/, in which 198, 310, and 445 of the /in/, /iŋ/, and /əŋ/ tokens, respectively, underwent nasal mergers. The merging rates of the speakers who applied mergers are shown in Figure 4.10. The rates of a specific social factor were calculated from tokens of all speakers with mergers under certain social factor.

For the /in/ → [iŋ] merger, the young speakers generally applied more mergers than their older counterparts. Among the young, northerners applied more mergers than Kaohsiung females than Kaohsiung males: 36% for Taipei males, 35% for Taipei females, 18% for Kaohsiung males, and 27% for Kaohsiung females. As for the old, northerners generally applied more mergers than southerners: 13% for Taipei males, 17% for Taipei females, 7% for Kaohsiung males, and 6% for Kaohsiung females.

For the /iŋ/ → [in] merger, the southerners generally applied more mergers than the northerners except for young males. Among Kaohsiung speakers, merger rates were quite similar except for the old females: 28% for the young males, 16% the young females, 23% for the old males, and 53% for the old females. In northern groups, young males applied more mergers than the others: 42% for the young males, 6% for the young females, 9% for the old males, and 17% for the old females.

For the /əŋ/ → [ən] merger, all groups applied mergers at similar levels: 32% for Taipei young males, 17% for Taipei young females, 29% for Kaohsiung young males, 39% for Kaohsiung young females, 23% for Taipei old males, 38% for Taipei old females, 18% for Kaohsiung old males, and 18% for Kaohsiung old females.

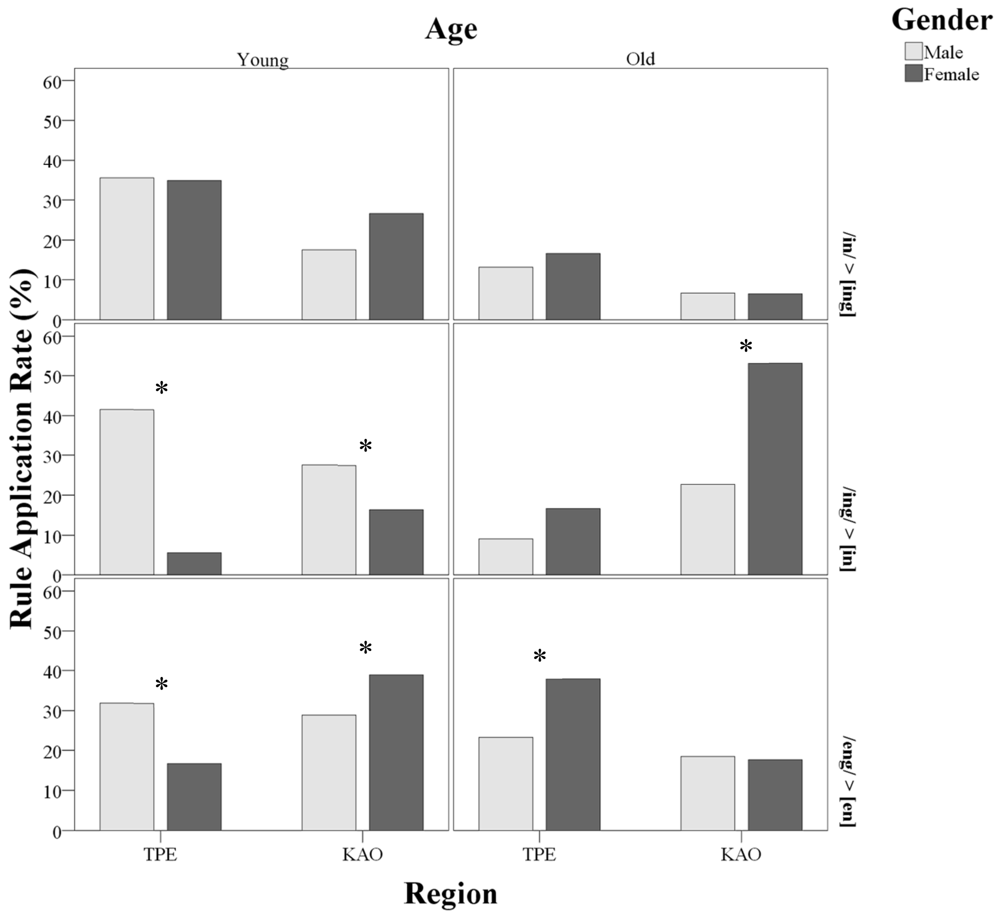

Figure 4.10 Application rates of nasal mergers divided by different social factors.

Three stepwise logistic regression models were conducted to predict the probability of the nasal merger occurrences from Age, Region, and Gender. Since the form of the data here was very similar to that in previous analysis of nasalized vowels in Section 4.1.3, we could have similar setting for variables. The dependent variable was whether the realizations of the nasals changed from the underlying place of articulation to the opposite category or not (i.e., from /n/ to [ŋ] or from /ŋ/ to [n]). Results showed that the overall model fit test was significant for /in/ → [iŋ] [$\chi^2(2)$ = 67.070, p < .001], for /iŋ/ → [in] [$\chi^2(4)$ = 114.334, p < .001], and for /əŋ/ → [ən] [$\chi^2(2)$ = 54.240, p < .001].

For /in/ → [iŋ], among the factors, only Region and Age were successful predictors, as listed in Table 4.8(a). Switching from Kaohsiung to Taipei and from old to young speakers would increase the odds of merging by a factor of 1.939 and 3.492, respectively. By including the two predictors, the model would correctly classify 80.0% of the cases.

For /iŋ/ → [in], the main effects of Region, and the interaction effects of Gender × Region, Age × Gender, and Age × Region were successful predictors (Table 4.8(b)). Switching from Kaohsiung to Taipei would decrease the odds by a factor of .443. As for the interaction effects, switching from Kaohsiung females to Taipei males, from old females to young males, and from old southerners to young northerners would increase the odds by a factor of 2.553, 8.955, and 4.349, respectively. Chi square tests were done between different genders among all the other social factors. Significant difference was found in the young northerners [$\chi^2(1) = 34.402$, $p < .001$], the young southerners [$\chi^2(1) = 8.879$, $p = .003$], and the old southerners [$\chi^2(1) = 37.793$, $p < .001$] (significance was marked by * in Figure 4.10). By including the four predictors, the model would correctly classify 77.9% of the cases.

As for to /əŋ/ → [ən], the interaction effects including Age × Region, and Age × Gender × Region were successful predictors (Table 4.8(c)). Switching from old southerners to young northerners would decrease the odds by a factor of .343, whereas switching from Kaohsiung old females to Taipei young males would increase the odds by a factor of 9.804. Chi square tests were also done between different genders among all the other social factors. Significant difference was found in the young northerners [$\chi^2(1) = 15.922$, $p < .001$], the young southerners [$\chi^2(1) = 5.283$, $p = .022$], and the old northerners [$\chi^2(1) = 9.187$, $p = .002$] (significance was marked by

* in Figure 4.10). By including the two predictors, the model would correctly classify 72.7% of the cases.

Table 4.8 Statistics of step-wise binary logistic regression (social factors).

(a) /in/ → [iŋ]	B	S.E.	Wald	df	*p*	Exp(B)
Region	.662	.172	14.896	1	.000	1.939
Age	1.251	.173	52.098	1	.000	3.492
Constant	−1.524	.089	290.283	1	.000	.218

(b) /iŋ/ → [in]	B	S.E.	Wald	df	*p*	Exp(B)
Region	−.813	.176	21.383	1	.000	.443
Gender × Region	.937	.287	10.660	1	.001	2.553
Age × Gender	2.192	.276	63.290	1	.000	8.955
Age × Region	1.470	.276	28.347	1	.000	4.349
Constant	−1.309	.085	239.658	1	.000	.270

(c) /əŋ/ → [ən]	B	S.E.	Wald	df	p	Exp(B)
Age × Region	−1.070	.232	21.374	1	.000	.343
Age × Gender × Region	2.283	.457	24.989	1	.000	9.804
Constant	−1.014	.058	309.330	1	.000	.363

4.3 Effects of stress on nasal mergers

Before we ran the analyses of linguistic factors, it was very important to check the crosstab distribution of the target syllables by the two factors, stress levels and break indices of the syllables. Only cells that had enough tokens were included in our statistical analyses. Table 4.9 is the new crosstabs of tokens with VN sequence only. All the other discarded tokens are not included in the table.

Table 4.9 Crosstabs of numbers of targets divided by stress and break.

Taipei Young Male

/in/	B3	B2	B1	B0	Total
S3	4	3	9	0	16
S2	1	7	74	7	89
S1	0	0	0	2	2
S0	0	0	0	0	0
Total	5	10	83	9	107
/iŋ/	B3	B2	B1	B0	Total
S3	2	0	11	0	13
S2	5	6	30	9	50
S1	0	0	2	0	2
S0	0	0	0	0	0
Total	7	6	43	9	65
/əŋ/	B3	B2	B1	B0	Total
S3	6	3	24	4	37
S2	9	23	98	27	157
S1	0	1	6	3	10
S0	0	0	0	0	0
Total	15	27	128	34	204

Taipei Young Female

/in/	B3	B2	B1	B0	Total
S3	5	7	45	2	59
S2	3	13	44	12	72
S1	0	0	1	0	1
S0	0	0	0	0	0
Total	8	20	90	14	132
/iŋ/	B3	B2	B1	B0	Total
S3	3	5	40	1	49
S2	7	6	45	1	59
S1	0	0	1	0	1
S0	0	0	0	0	0
Total	10	11	86	2	109
/əŋ/	B3	B2	B1	B0	Total
S3	13	9	79	0	101
S2	10	22	145	9	186
S1	0	1	10	2	13
S0	0	0	0	0	0
Total	23	32	234	11	300

Kaohsiung Young Male

/in/	B3	B2	B1	B0	Total
S3	5	3	15	1	24
S2	2	4	37	7	50
S1	0	0	0	0	0
S0	0	0	0	0	0
Total	7	7	52	8	74
/iŋ/	B3	B2	B1	B0	Total
S3	8	7	63	1	79
S2	15	11	147	19	192
S1	1	0	1	3	5
S0	0	0	0	0	0
Total	24	18	211	23	276
/əŋ/	B3	B2	B1	B0	Total
S3	3	3	36	2	44
S2	13	31	106	15	165
S1	0	2	15	6	23
S0	0	0	0	0	0
Total	16	36	157	23	232

Kaohsiung Young Female

/in/	B3	B2	B1	B0	Total
S3	5	3	30	0	38
S2	4	4	104	4	116
S1	0	0	0	0	0
S0	0	0	0	0	0
Total	9	7	134	4	154
/iŋ/	B3	B2	B1	B0	Total
S3	3	2	35	1	41
S2	12	10	138	15	175
S1	0	1	8	1	10
S0	0	0	0	0	0
Total	15	13	181	17	226
/əŋ/	B3	B2	B1	B0	Total
S3	3	4	30	0	37
S2	5	24	118	4	151
S1	0	5	35	11	51
S0	0	0	0	0	0
Total	8	33	183	15	239

Taipei Old Male

/in/	B3	B2	B1	B0	Total
S3	3	6	24	2	35
S2	14	8	109	2	133
S1	0	0	0	0	0
S0	0	0	0	0	0
Total	17	14	133	4	168
/iŋ/	B3	B2	B1	B0	Total
S3	1	1	28	0	30
S2	26	13	128	0	167
S1	0	0	1	0	1
S0	0	0	0	0	0
Total	27	14	157	0	198
/əŋ/	B3	B2	B1	B0	Total
S3	0	3	6	5	14
S2	15	12	115	7	149
S1	0	0	0	0	0
S0	0	0	0	0	0
Total	15	15	121	12	163

Taipei Old Female

/in/	B3	B2	B1	B0	Total
S3	1	3	33	0	37
S2	16	13	77	1	107
S1	0	0	0	0	0
S0	0	0	0	0	0
Total	17	16	110	1	144
/iŋ/	B3	B2	B1	B0	Total
S3	0	0	7	0	7
S2	1	3	19	0	23
S1	0	0	0	0	0
S0	0	0	0	0	0
Total	1	3	26	0	30
/əŋ/	B3	B2	B1	B0	Total
S3	1	7	34	0	42
S2	11	28	134	2	175
S1	0	1	1	0	2
S0	0	0	0	0	0
Total	12	36	169	2	219

Kaohsiung Old Male

/in/	B3	B2	B1	B0	Total
S3	0	2	15	0	17
S2	4	3	83	13	103
S1	0	0	0	0	0
S0	0	0	0	0	0
Total	4	5	98	13	120
/iŋ/	B3	B2	B1	B0	Total
S3	4	4	26	1	35
S2	42	38	209	28	317
S1	1	0	3	1	5
S0	0	0	0	0	0
Total	47	42	238	30	357
/əŋ/	B3	B2	B1	B0	Total
S3	0	0	11	0	11
S2	8	4	76	4	92
S1	0	0	0	0	0
S0	0	0	0	0	0
Total	8	4	87	4	103

Kaohsiung Old Female

/in/	B3	B2	B1	B0	Total
S3	0	3	19	0	22
S2	5	13	50	3	71
S1	0	0	0	0	0
S0	0	0	0	0	0
Total	5	16	69	3	93
/iŋ/	B3	B2	B1	B0	Total
S3	0	0	15	0	15
S2	7	9	78	2	96
S1	0	0	2	0	2
S0	0	0	0	0	0
Total	7	9	95	2	113
/əŋ/	B3	B2	B1	B0	Total
S3	1	4	42	0	47
S2	6	12	100	4	122
S1	0	0	1	0	1
S0	0	0	0	0	0
Total	7	16	143	4	170

Since we adopted similar statistic methods to those in Section 4.2, the formula suggested in Section 4.2 for the estimation of nasal merging rates was also applied here. The numbers of targets shown in the crosstabs also did not include the tokens of Category IV (the definition was provided in Table 4.5), so that we could make sure a sufficient number of tokens in each cell for further analyses even with exclusion of some tokens from the calculation. Besides, the tokens of people with little or no mergers were also excluded, as mentioned in Section 4.2.1.

In order to investigate the effect of syllable prominence on the nasal mergers, cells of different stress levels with sufficient tokens were needed for representativeness at each stress level. According to Table 4.9, only under the condition of the break index B1 could we find enough tokens in two different stress levels (i.e., S3 and S2). As a result, only tokens of S3/B1 and S2/B1 were used in the further analyses on the effect of different stress levels. There were in total 768 /in/, 1019 /iŋ/, and 1154 /əŋ/ after the subtraction of Category IV of Table 4.5. The numbers of tokens that surely underwent nasal mergers were 145, 211, and 232, respectively. Application rates of nasal mergers divided by different social factors and stress levels are shown in Figure 4.11.

Three stepwise logistic regression models were conducted to predict the probability of the nasal merger occurrences from Age, Region, Gender, and Stress. Results showed that the overall model fit test was significant for /in/ → [iŋ] [$\chi^2(3) = 73.500$, $p < .001$], for /iŋ/ → [in] [$\chi^2(6) = 86.289$, $p < .001$], and for /əŋ/ → [ən] [$\chi^2(2) = 18.280$, $p < .001$]. Since the focus of the current section is the effect of stress, the following results mainly paid attention to stress-related factors.

For /in/ → [iŋ], the main effects of Region, Age, and Stress were successful predictors (Table 4.10(a)). The first two main effects were similar to the results in the

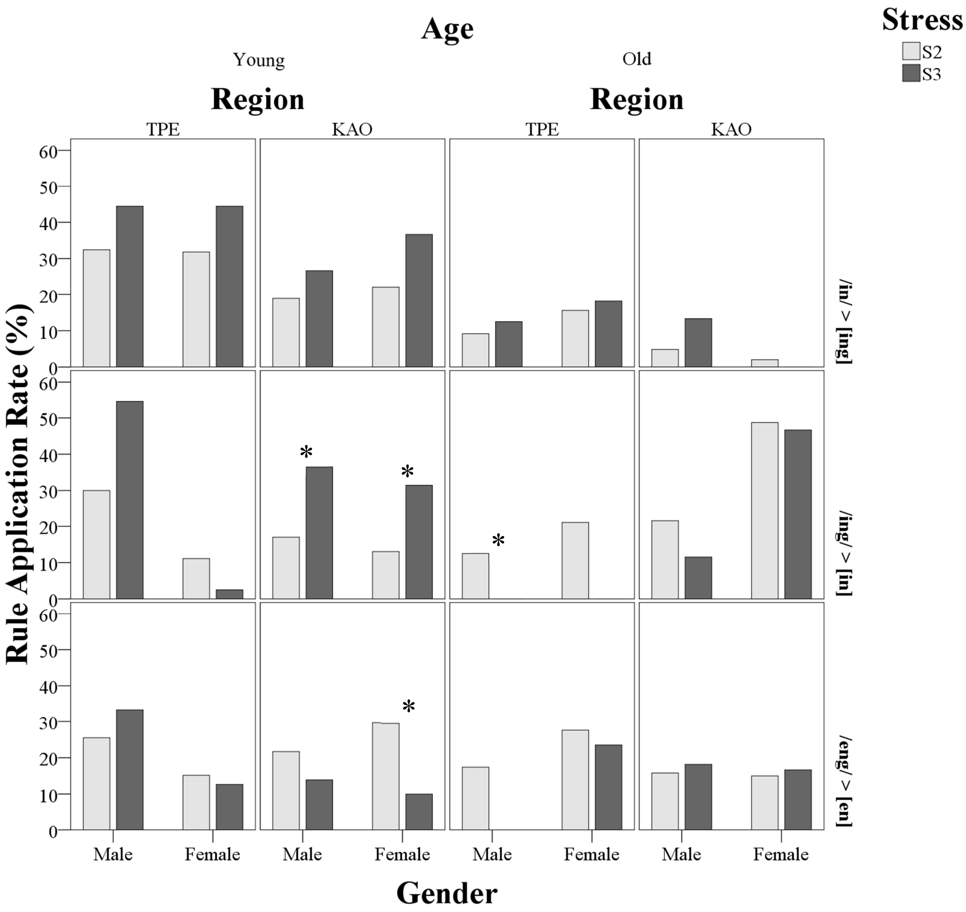

Figure 4.11 Application rates of nasal mergers divided by different social factors and stress levels.

previous section. As for the Stress effect, switching from a lower level to a higher level of stress would increase the odds by a factor of 1.645. By including the three predictors, the model would correctly classify 81.1% of the cases.

For /iŋ/ → [in], the main effects of Region, and the interaction effects of Gender × Region, Age × Gender, Age × Region, Region × Stress , and Age × Stress were successful predictors (Table 4.10(b)). The social ones were the same as those in Section 4.2.The interaction effect of Age × Stress indicated that switching from a lower stress level of the old to a higher stress level of the young would increase the odds by a factor of 3.317. Chi square tests were done between different stress levels among all social factors. Significant difference was found in Kaohsiung young males

[$\chi^2(1) = 9.511$, $p = .002$], Kaohsiung young females [$\chi^2(1) = 6.763$, $p = .009$], and Taipei old males [$\chi^2(1) = 3.900$, $p = .048$] (significance was marked by * in Figure 4.11). By including the six predictors, the model would correctly classify 79.1% of the cases.

As for to /əŋ/ → [ən], only Age × Gender × Region and Age × Region × Stress were successful predictors (Table 4.10(c)). The interaction of Age × Region × Stress suggested that switching from a lower stress level of the old southerners to a higher stress level of the young northerners would increase the odds by a factor of 3.981. Chi square tests were also done between different stress levels among all social factors. Only Kaohsiung young females were found to be significant [$\chi^2(1) = 4.845$, $p = .028$] (significance was marked by * in Figure 4.11). By including the two predictors, the model would correctly classify 79.9% of the cases.

Table 4.10 Statistics of step-wise binary logistic regression (stress).

(a) /in/ → [iŋ]	B	S.E.	Wald	df	*p*	Exp(B)
Region	.703	.202	12.158	1	.000	2.021
Age	1.511	.211	51.352	1	.000	4.533
Stress	.498	.210	5.623	1	.018	1.645
Constant	−1.519	.115	173.367	1	.000	.219

(b) /iŋ/ → [in]	B	S.E.	Wald	df	*p*	Exp(B)
Region	−.962	.230	17.549	1	.000	.382
Gender × Region	1.094	.340	10.336	1	.001	2.985
Age × Gender	1.868	.335	31.017	1	.000	6.478
Age × Region	1.130	.361	9.812	1	.002	3.094
Region × Stress	−.964	.408	5.599	1	.018	.381
Age × Stress	1.199	.364	10.871	1	.001	3.317
Constant	−1.458	.102	202.678	1	.000	.233

(c) /əŋ/ → [ən]	B	S.E.	Wald	df	*p*	Exp(B)
Age × Gender × Region	2.129	.594	12.864	1	.000	8.409
Age × Region × Stress	1.382	.603	5.242	1	.022	3.981
Constant	−1.401	.076	343.515	1	.000	.246

4.4 Effects of break on nasal mergers

Similar to the analyses on the effect of syllable prominence, the investigation on the influence of prosodic boundary also required a sufficient number of tokens. According to Table 4.8, we only had enough tokens for analyses when the stress level was S2. Besides, the tokens of B0 and B1 and those of B2 and B3 needed to be combined together in order to reach enough tokens so that a better representativeness of boundary effect could be reached. There were a total of 741 /in/, 1079 /iŋ/, and 1197 /əŋ/ after the subtraction of Category IV of Table 4.5. The numbers of tokens that surely underwent nasal mergers were 131, 238, and 318, respectively. Application rates of nasal mergers divided by different social factors and break indices are shown in Figure 4.12.

As in previous analyses, three stepwise logistic regression models were conducted to predict the probability of the nasal merger occurrences from Age, Region, Gender, and Break. Results showed that the overall model fit test was significant for /in/ → [iŋ] [$\chi^2(3) = 48.628$, $p < .001$], for /iŋ/ → [in] [$\chi^2(7) = 124.778$, $p < .001$], and for /əŋ/ → [ən] [$\chi^2(5) = 123.132$, $p < .001$].

For /in/ → [iŋ], among the factors, the main effect of Region, Age, and Break were successful predictors (Table 4.11(a)). All successful social predictors were found to be the same as in Section 4.2. The main effect of Break showed that switching from a word boundary to a prosodic boundary would increase the odds by a factor of 2.375. By including the three predictors, the model would correctly classify 82.3% of the cases.

For /iŋ/ → [in], the main effect of Region and the interaction effects of Age × Gender, and Age × Region were successful social predictors (Table 4.11(b)). Compared to the results of Section 4.2, the only difference was that Gender × Region

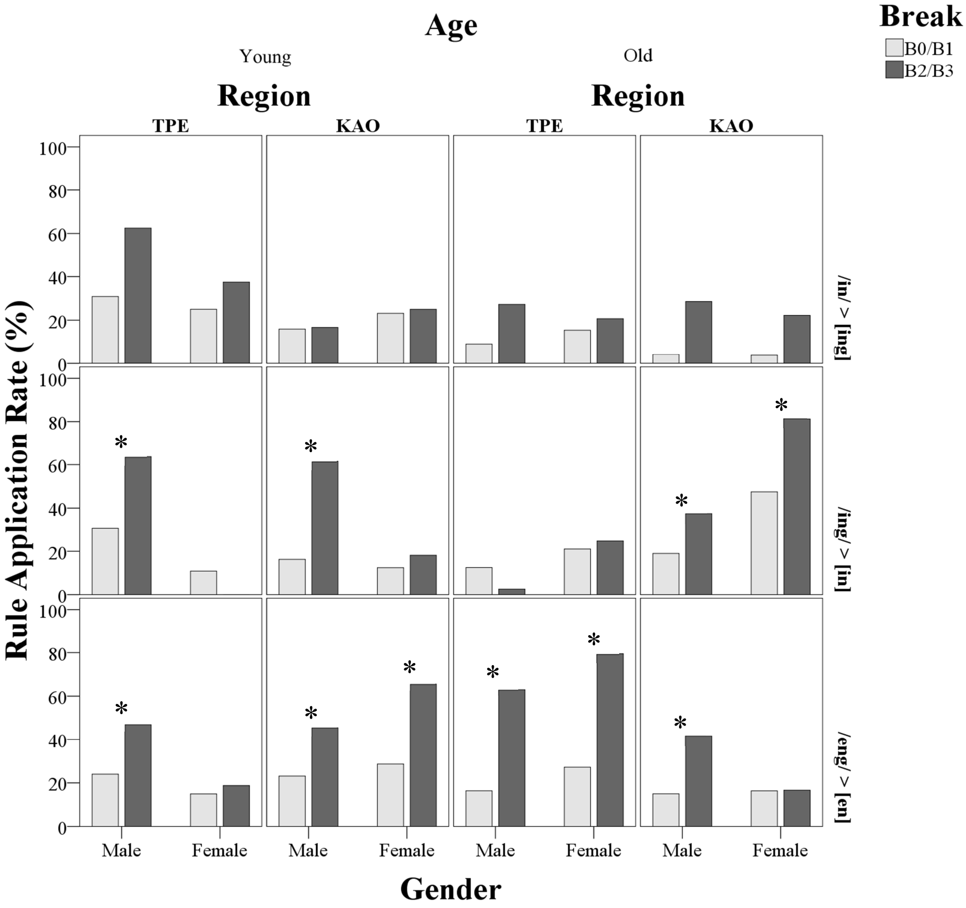

Figure 4.12 Application rates of nasal mergers divided by different social factors and break indices.

was no longer significant here. Besides, there were four more predictors that contained Break, which were Break, Break × Region, Break × Gender × Region, and Age × Break × Gender. These predictors indicated that switching from a word boundary to a prosodic boundary, and from a word boundary of the old females to a prosodic boundary of the young males would increase the odds by a factor of 1.828, and 20.032, respectively, while switching from a word boundary of the southerners to a prosodic boundary of the northerners, and from a word boundary of the Kaohsiung females to a prosodic boundary of the Taipei males would decrease the odds by a factor of .286, or .196, respectively. Chi square tests were done between different boundary strengths among all social factors. Significant difference was found in Taipei young males [$\chi^2(1) = 3.934$, $p = .047$], Kaohsiung young males [$\chi^2(1) = 26.510$, $p < .001$], Kaohsiung old males [$\chi^2(1) = 11.349$, $p = .001$], and Kaohsiung old females [$\chi^2(1) = 6.099$, $p = .014$] (significance was marked by * in Figure 4.12). By including the seven predictors, the model would correctly classify 79.4% of the cases.

As for /əŋ/ → [ən], the interaction effects of Age × Region, and Age × Gender × Region were successful social predictors (Table 4.11(c)), which were the same as the results of Section 4.2. There were three additional predictors with Break, i.e., Break, Age × Break × Region, and Age × Break × Gender × Region. According to the

Table 4.11 Statistics of step-wise binary logistic regression (break).

(a) /in/ → [iŋ]	B	S.E.	Wald	df	*p*	Exp(B)
Region	.564	.207	7.410	1	.006	1.758
Age	1.185	.209	32.267	1	.000	3.272
Break	.865	.249	12.065	1	.001	2.375
Constant	−1.341	.126	112.478	1	.000	.262

(b) /iŋ/ → [in]	B	S.E.	Wald	df	*p*	Exp(B)
Region	−.900	.252	12.710	1	.000	.407
Age × Gender	3.045	.417	53.264	1	.000	21.006
Age × Region	1.769	.330	28.755	1	.000	5.867
Break	.603	.248	5.908	1	.015	1.828
Break × Region	−1.252	.521	5.782	1	.016	.286
Break × Gender × Region	−1.631	.692	5.556	1	.018	.196
Age × Break × Gender	2.997	.836	12.867	1	.000	20.032
Constant	−1.126	.125	80.524	1	.000	.324

(c) /əŋ/ → [ən]	B	S.E.	Wald	df	*p*	Exp(B)
Age × Region	−1.747	.338	26.792	1	.000	.174
Age × Gender × Region	2.981	.660	20.399	1	.000	19.699
Break	1.217	.167	52.901	1	.000	3.377
Age × Break × Region	−2.078	.675	9.478	1	.002	.125
Age × Break × Gender × Region	2.729	1.320	4.277	1	.039	15.324
Constant	−.740	.084	78.318	1	.000	.477

statistics, switching from a word boundary to a prosodic boundary and from a word boundary of Kaohsiung old females to a prosodic boundary of Taipei young males would increase the odds by a factor of 3.377, or 15.324, respectively, and switching from a word boundary of old southerners to a prosodic boundary of young northerners would decrease the odds by a factor of .125. Chi square tests were also done between different boundary strengths among all social factors. Significant difference was found in Taipei young males [$\chi^2(1) = 6.520$, $p = .011$], Kaohsiung young males [$\chi^2(1) = 7.788$, $p = .005$], Kaohsiung young females [$\chi^2(1) = 13.834$, $p < .001$], Taipei old males [$\chi^2(1) = 25.686$, $p < .001$], Taipei old females [$\chi^2(1) = 34.869$, $p < .001$], and Kaohsiung old males [$\chi^2(1) = 4.926$, $p = .026$] (significance was marked by * in Figure 4.12). By including the five predictors, the model would correctly classify 76.4% of the cases.

CHAPTER 5 DISCUSSION

In this chapter, the functions of social and linguistic factors are to be discussed. In Section 5.1, the realizations of nasal codas are discussed. In Section 5.2, the comparison of the three nasal mergers regarding the social variables is made. In Section 5.3, attention is paid to the effect of stress levels (or syllable prominence) and break indices (or prosodic boundary).

5.1 The realizations of syllable-final nasals in spontaneous speech

In the current study, there were much more categories of nasal codas being labeled, such as [m], [ɱ], [n], [ɲ], and [ŋ]. Different from read speech, it was inevitable to deal with assimilation caused by the surrounding syllables. In order to overcome such an issue, some estimation was made in the current study, with the assumption that assimilation and nasal mergers were orthogonal to each other. This might be the possible reason to account for the lower merging rates in our study than those in Su (2012) since such an issue of assimilation was not taken into account in her study.

Apart from the abundant types of places of articulation for nasals, the current study also reported a number of nasalized vowels without any nasal murmur, taking up 10% to 26% of valid tokens (Table 4.3). Such phenomena had not been widely reported in previous studies. Only R. J.-m. Hung's (2007) study on nasal mergers in Taipei children had reported similar findings. In addition, the younger speakers in the current study generally applied more nasalization than their elder counterparts regardless of the rule types (Figure 4.7). If one combines the results of R. J.-m. Hung and the findings of the current study, it could be predicted that nasalized vowels were very likely to become the next step after the nasal mergers.

It is also possible that the great differences of nasalization rates between the young and the old might be due to physiological reasons since younger subjects generally uttered with faster speech rates and produced more coarticulation (e.g., van Brenk *et al*., 2009), and thus led to more nasalized vowels. However, such a coarticulation effect should not have vowel specificity. In order to clarify which explanation is more plausible, it is necessary to check the data of nasalization rates. In our data of /iŋ/ and /əŋ/ (see Figure 4.7), for example, older speakers had similar nasalization rates among different vowels (6% for /iŋ/ vs. 7% for /əŋ/), whereas younger ones had their rates with larger difference (13% for /iŋ/ vs. 20% for /əŋ/). Such a finding implies the existence of vowel specificity upon nasalization rates, and further increases the validity of the former explanation, i.e., nasalization is very likely to be the next step in sound change after the nasal mergers.

5.2 Effect of social factors on nasal mergers

According to Figure 4.10 and Table 4.8, the general performance of nasal mergers regarding different social factors could be observed. The significance of social factors could be reinforced with the help of Tables 4.9 and 4.10. If certain social predictors repeatedly appeared with different ways of sampling, they were more likely to be representative predictors.

5.2.1 The /in/ → [iŋ] merger

The significant predictors were Region, and Age according to Tables 4.7(a), 4.9(a) and 4.10(a). The young generally applied more mergers than the old across all gender and region, and the northerners applied more mergers compared to the southerners (the young: 36% [NM], 35% [NF], 18% [SM], 27% [SF] vs. the old: 13% [NM], 17% [NF], 7% [SM], 6% [SF]).

Such results of the younger groups from spontaneous speech were nearly in accordance with the read speech finding of Fon *et al*. (2011) (80-90% for the northerners, 60-70% for the southern females, and 25-62% for the southern males), with similar trends in terms of gender and region difference, but the overall merging rates were much lower in the current study, which is in contrast with Fon *et al*.'s argument that the merger was the closest to complete phonoligization. This kind of discrepancy is very likely due to genre or methodology difference between Fon *et al*. and the current study.

In addition, the current study showed lower merger application rates for elder groups, which indirectly supported the hypothesis that the /in/ → [iŋ] merger was an innovation. Besides, it was a merger dominated by the northerners no matter in terms of numbers of people who had the merger (12 northerners vs. 10 southerners (4 of them had extremely low merging rates)) or in terms of the overall merging rates. Therefore, it is reasonable to argue that the /in/ → [iŋ] merger is a rule of Taipei or northern origin.

5.2.2 The /iŋ/ → [in] merger

Statistic evidence from Tables 4.7(b), 4.9(b), and 4.10(b) showed successful predictors of Region, Gender × Region (not significant in Table 4.11(b)), Age × Gender, and Age × Region. The significant interaction of Age × Gender was the strongest among all predictors. For the young groups, males applied more mergers than females, whereas the trend was in the opposite direction for the old groups. The significance of Age × Region indicated that the dominant merging rate of the old southerners over the old northerners and that of the young northerners over the young southerners. The significance of Gender × Region might possibly be due to the average over different age groups since the gender difference was relatively small for the young southerners and the old northerners. Finally, the main effect of Region indicated a regional split across different generations.

The regional split in this rule was generally in accordance with previous studies of younger generation (Fon *et al*., 2011; Su, 2012). Fon *et al*. reported only one instance of the merger in the northern group, relative stable merging rates across different conditions for the southern males (35-45%), and a wide variety of merging rates across different conditions for the southern females (0-45%). Su also reported higher merging rates in the South (69% for Tainan males, and 44% for Tainan females) than in the North (28% for Taipei males, and 12% for Taipei females). Notice that the merging rates of the young northerners in the current study were contributed by only one male and one female, and stood for the merging rates of the people who applied mergers. The merger of Taipei young females was hardly observed, and its emergence here might be a sampling error caused by our operational definition for recruiting data. Notice that it could also be regarded as no merger application at all with such a low merging rate (6%).

On the other hand, although the high merging rate of Taipei young males had not been reported in the previous studies, such a result did not really contradict with previous studies. First of all, Fon *et al*. (2011), Hsu & Tse (2007), and Su (2012) also have found some instance of /iŋ/-to-[in] merger in Taipei, showing that such a rule was still be used by some of the northerners even though it was not so popular in the area. Besides, the lower merging rate of the Taipei males in Su than in the current study might also be due to the difference in calculation methods since Su did not mention individual difference in merger application and directly averaged her data of all speakers.

As for the reasons of merger application, Fon *et al*. suggested that such a rule was attributed to negative Min transfer, and Su further inferred that negative transfer might symbolically index a limit proficiency in the second language. Su also pointed out that the use of the merger was found to be more frequently on the topic of hometown Tainan, implying a link between the variant [in] with regional identity. Such explanation seemed to coincide with the current result that different age groups of the south would generally apply such a merger more than the northerners, especially in terms of the number of people who applied the merger (5 northerners vs. 14 southerners).

Regarding the gender difference, Su followed sociolinguistic literature and stated that females tended to focus more on linguistic varieties associated with 'overt prestige'. The statement generally holds when Su's results were compared to the current data of the young groups. The opposite performance of Kaohsiung old females might possibly be due to the lower educational status among the four Kaohsiung old female speakers, two of whom were only junior high school graduates and one of whom did not have any education background at all. Such results were somehow in accordance with those of C.-w Hung (2006). In her study in Kaohsiung, male speakers favored non-prestigious [n] variant. However, senior female subjects and lower middle-class female subjects also produced many [n] variants.

5.2.3 The /əŋ/ → [ən] merger

Age × Region (not significant in Table 4.10(c)), and Age × Gender × Region were successful predictors according to Table 4.8(c), 4.9(c), and 4.10(c). The interaction effect of Age × Gender × Region pointed to the unique pattern of gender differences in the young northern group. Males applied /əŋ/ → [ən] more often than females in the young northern group (32% vs. 17%), both gender applied at a similar level in the old southern group (18% vs. 18%), whereas in the other two groups, males applied less (young southerners: 29% vs. 39%; old northerners: 23% vs. 38%).

Such a result among young groups contradicted with that of both Fon *et al*. (2011) and Su (2012). Fon *et al*. reported higher merging rates for the northerners (55-75% for *zhuyin* and character conditions and 95-100% for sentence condition), followed by the southern males (55-75% for *zhuyin* and character conditions and 65-75% for sentence condition), and southern females had the lowest merging rates (20-25% for *zhuyin* and character conditions and 65-75% for sentence condition). In Su's study, northern females were reported with the highest merging rate (55%), while southern females with the lowest (24%). The merging rates of the males were somewhere in the middle (33-37%). The performance of the old groups in the current study, on the contrary, was more similar to the patterns of Fon *et al*. and Su. With very different performance among young groups from previous studies, there might be great individual differences among speakers (as shown in Figure 4.8). It was the sampling difference that should be accounted for the contradiction.

Nonetheless, /əŋ/ → [ən] was the most frequently applied merger among the three across all social groups (27% (18-39%) vs. 20% (6-36%) for /in/ → [iŋ], and 23% (6-53%) for /iŋ/ → [in]), and was applied by the largest amount of speakers from all social groups (27 speakers vs. 22 speakers for /in/ → [iŋ], and 19 speakers for /iŋ/

→ [in]). Such a result was consistent with most of the previous studies (Chen, 1991; Fon *et al*., 2011; Hsu, 2006; Hsu & Tse, 2007; C.-w Hung, 2006; Kubler, 1985; C. C. Lin, 2002; Tse, 1992; Yueh, 1992).

Our merging rates of the /iŋ/ → [in] and /əŋ/ → [ən] mergers were more comparable to those of Su (2012) than to those of Fon *et al*. (2011), suggesting a lower merging rate in spontaneous speech than read speech. Besides, the exclusion of the tokens with possible assimilation environments when the merging rates were calculated in the current study further led to even lower rates of mergers than those in Su.

5.2.4 The status and possible origins of the mergers

The three mergers found in previous studies, /in / → [iŋ], /iŋ/ → [in], and /əŋ/ → [ən], were also found in the current study. However, their statuses were quite different. First of all, /in / → [iŋ] and /iŋ/ → [in] were two mergers under competition since they shared the same vowel /i/. Lots of our speakers only dominated in the usage of one of the two mergers (see Figure 4.8). Most Taipei residents dominated the usage of /in / → [iŋ], whereas Kaohsiung seniors dominated the usage of /iŋ/ → [in].

Table 5.1 General usages of the three mergers.

Merger type	Social groups from which most speakers applied the merger	Social groups which dominated the usage of the merger	Possible origins of the merger
/in / → [iŋ]	Taipei youngsters Kaohsiung youngsters Taipei seniors	Taipei youngsters	Innovation
/iŋ/ → [in]	Kaohsiung youngsters Kaohsiung seniors	Kaohsiung seniors	Min transfer
/əŋ/ → [ən]	All groups	No obvious leading groups	Innovation Min transfer Natural sound change

Only the youngsters in Kaohsiung applied both mergers at a comparable degree. On the other hand, there was no competitor for the /əŋ/ → [ən] rule. Therefore, subjects of all social factors consistently operated this merger to a certain degree. The summary of the general usages of the three mergers is presented in Table 5.1.

Previous studies have suggested possible the origin of the mergers found in their research. Some used negative Min Transfer as their explanation (Ing, 1985; Kubler, 1985)[7], others stated as neutral innovations (C.C. Lin, 2002; Tse, 1992; Yueh, 1992), and still others suggested the possibility of a natural sound change (Chen, 1991; Hsu & Tse, 2007). Fon *et al*. (2011) went one step further to regard the /iŋ/ → [in] merger as a Min transfer and the /in / → [iŋ] and /əŋ/ → [ən] mergers as innovations. Our results partially supported the view from Fon *et al*. in that the origins of the /in/ → [iŋ] and /iŋ/ → [in] mergers were innovations and Min transfers, respectively. As for the /əŋ/ → [ən] merger, we were still unsure of its origin since none of the three explanations could be easily excluded from our data.

As mentioned earlier, the /in/ → [iŋ] and /iŋ/ → [in] mergers were competitors to each other. The /iŋ/ → [in] merger was easier to be argued as a negative Min transfer since Min phonology only allowed its /in/ and /iŋ/ sequences to be realized as [in] and [iᵊŋ], respectively. On the contrary, the pronunciation of the /iŋ/ sequence in Mandarin had been emphasize by teachers to produce without a schwa during compulsory education. Therefore, [iŋ] was regarded as the standard form of /iŋ/ in Mandarin, whereas [iᵊŋ] was considered to be a negative Min transfer (Ing, 1985). Since Taipei is the political, economic, and cultural center of Taiwan, and has the largest Mainlander population (W.-s. Yang, 2004), people living in Taipei are more

[7] Although the origin of both the /iŋ/ → [in] and /əŋ/ → [ən] mergers was regarded as the negative Min transfer in Ing (1985) and Kubler (1985), Fon *et al*. (2011) argued that the origin of the /əŋ/ → [ən] merger was only Min-related rather than due to a direct Min transfer. In the current study, we did not distinguish the two terminologies.

likely to learn the [iŋ] form without schwa better than people form other regions in Taiwan. Hsu's (2006) study on phonological leveling in Taipei pointed out little ethnic difference regarding pronunciation of Mandarin. Such a result indirectly proved the special position and performance of the language spoken by Taipei residents. However, this leveling phenomenon was hard to analogize to other regions due to the difference in population composition and social status of cities.

The /in/ → [iŋ] merger originated from Taipei might be due to a more positive connotation of the [iŋ] variant as compared to the negative version [iᵊŋ]. Since Taipei residents were capable of pronouncing the /iŋ/ phoneme without schwa, the /in/ → [iŋ] merger provided more chance for them to show their capability. As a result, the /in/ → [iŋ] merger was very likely to be the innovation of Taipei residents. The positive connotation of the /in/ → [iŋ] merger was also proven by Fon *et al*. (2011). On the other hand, its competitor, the /iŋ/ → [in] merger, was very likely due to the mismatch of pronunciation between Min and Mandarin as explained earlier. Its highly negative connotation in Fon *et al*. could also be interpreted as the evidence of originating from negative Min transfer. With different language environment and educational resources in Kaohsiung, its older speakers applied the /iŋ/ → [in] merger due to the inevitable Min transfer, especially the old females who had even lower educational background. The younger speakers in Kaohsiung not only learned the negative /iŋ/ → [in] merger from their parents, but also the positive /in/ → [iŋ] merger from Taipei since mass media is more common in recent years.

The origin of the /əŋ/ → [ən] merger could be due to innovation with some positive connotations, negative Min transfer, or natural sound change without specific connotations. Its high application rates throughout all social groups is very likely due to the lack of competitors. However, without obvious difference on merging rates among social factors, it is not easy to tease apart all possible reasons. The intermediate connotation of the /əŋ/ → [ən] merger reported in Fon *et al*. showed that its status was different from the other two mergers. Although it is hard to determine the origin of the /əŋ/ → [ən] merger, it is still noteworthy that the pronunciation of Mandarin and Min constantly affected each other. For example, the syllabic /ŋ/ phoneme in Min was originally pronounced as [ŋ̍] after glottal initials (such as /h/ and /ʔ/) and as [ᵊŋ̍] with schwa-like transition after other consonants (Yuan *et al*., 2001, p.243). However, the youngsters often pronounced it as [əŋ] with clear schwa even when the syllable started with /h/ or /ʔ/. Therefore, the interaction between the two languages was much more complicated than what had been discussed so far. More thorough investigation could be done in future studies.

5.3 Effect of linguistic factors on nasal mergers

In this section, the function of stress and break was the main focus. Any similar result to the previous section regarding only social factors was omitted from the discussion here.

5.3.1 The role of stress on nasal mergers

For the /in/ → [iŋ] merger, an overall significance of Stress was found, indicating a very strong enforcement of the merger under more attention throughout all social groups. Such a result could be explained by the rule connotation conducted in Fon *et al*. (2011). Since both the northerners and the southerners deemed the merger as the most positive one, it was not surprising that all speakers would apply the merger with a higher level of stress, which was generally pronounced with more attention.

As for the /iŋ/ → [in] merger, interactions of Region × Stress and Age × Stress was found. The significance of Age × Stress suggested a general trend that stress had a strengthening effect for young speakers, but a weakening or no effect for old speakers. The significance of Region × Stress was a result of average over different age groups, eliminating the strengthening effect of stress in the north. However, such a result could also be due to the lack of tokens in the north, since this was not a popular rule among the northerners. With the fact that the /iŋ/ → [in] merger was a rather old one, the results might have something to do with rule progression. We speculated that speakers of the old generation might not have developed the rule mature enough to interact with language-internal factors, such as stress. On the contrary, the youngsters were more capable of manipulating such a rule with linguistic factors, such as stress. According to our observation among all the mergers, prosodic prominence seemed to have a tendency to enhance the choice of the more marked form of nasals. Since both the northerners and the southerners had negative perspectives towards the /iŋ/ → [in] merger (Fon *et al.*, 2011), [in] was the marked form in the merger, and thus was produced more at a higher stress level.

For the /əŋ/ → [ən] merger, there was only one significant interaction regarding Stress, which was Age × Region × Stress. The function of Stress seemed hard to be summarized. Compared to the young groups, the old groups had no clear trend of stress, except for Taipei males. As for the young groups, there was a trend for the southerners and the northern females to have a restraining effect of stress on the merger and a trend for the northern males to have strengthening effect of stress despite the fact that only data of Kaohsiung females reached significance. Again, the /əŋ/ → [ən] merger was also an old one. Similar to the /iŋ/ → [in] merger, stress seemed not to have a clear effect for old speakers. As for young speakers, [ŋ] was the preferred form at a higher stress level for three out of four groups (only one group reached significance). However, the connotation of the /əŋ/ → [ən] merger in Fon *et al*. (2011) was relatively neutral. Hence, the general markedness of nasals depending on places of articulation might be the possible explanation of the current results. Compared to nasals of other places of articulation, /n/ is frequently reported as the default or the less marked form (e.g., Kiparsky, 1985). It was thus the marked from [ŋ] that was preferred with a higher level of prominence, which once again confirm our assumption that prosodic prominence seemed to have a tendency to enhance the choice of the more marked form of nasals.

To sum up, the /in/ → [iŋ] merger was a positive new rule, and was thus preferred by speakers of all social groups. The /iŋ/ → [in] and /əŋ/ → [ən] mergers were relatively old ones, so the old speakers had not developed the capability of interacting these rules with stress. As for the young speakers, marked forms might be preferred with stronger prominence. For the negative /iŋ/ → [in] merger, [n] was the preferred form due to its negative connotation. As for the non-negative /əŋ/ → [ən] merger, [ŋ] was the preferred form due to its typological markedness, which was also true for the positive /in/ → [iŋ] merger.

5.3.2 The role of break on nasal mergers

There was a significant main effect of Break across all the three mergers, indicating that prosodic boundary had a general enhancement of nasal mergers regardless of the rule type. No social factors were found to interact with Break for the /in/ → [iŋ] merger. However, the interaction effects of social factors with Break were much more complicated for the /iŋ/ → [in] and /əŋ/ → [ən] mergers.

For /iŋ/ → [in], prosodic boundary was found to have stronger strengthening effect for the males of the young groups and for the southerners of the old groups. For /əŋ/ → [ən], prosodic boundary was found to have a weaker strengthening effect for Taipei young females and Kaohsiung old females. The abovementioned patterns were quite irregular. Yet, no groups were found to have significant effect that contradicted the general enhancement of prosodic boundary.

The giant gap of merging rates between the current study and Fon *et al*. (2011) might not only be due to the genre or methodological difference. The general enhancement on nasal mergers provided by prosodic boundary could also be a very powerful factor since all of the stimuli in Fon *et al*. were pronounced with prosodic boundaries (sentence-final or word-final).

The interaction of Break × Stress is also an interesting topic. Limited by the distribution of data in the current study, we were unable to investigate such a question. A larger database is needed for research regarding syllable-final nasals. Such an issue can also be discussed in future studies if we can use tokens with fewer phonotatical restrictions as the targets of this study.

CHAPTER 6 CONCLUSION

The current study was the first attempt to investigate nasal mergers in Mandarin using both linguistic and social factors. We collected tokens more thoroughly with all possible candidates of nasal mergers and make a deeper use of spontaneous speech data with fine-grained linguistic factors.

As a study with fine controls of both age and region, the current study further confirmed the /in/ → [iŋ] merger as an innovation, with the young speakers significantly applied more than old ones. Besides, its higher merging rates in the north than in the south also provided evidence of the rule as one with a northern origin. The older merger, /iŋ/ → [in], was widely used by southerners between different generations, partly supporting Su's (2012) perspective that [in] might convey the regional identity for the southerners. Finally, the /əŋ/ → [ən] merger was the one with very different performance from the previous study in terms of social factors. However, such inconsistency did not prevent it from being the most frequently used merger among the three mergers.

As for the linguistic factors, prosodic boundary presented an overall enhancement on all of the three mergers. The effect of stress was correlated with rule connotation in some cases. Stress had a strengthening effect on nasal mergers of positive connotation, or more marked forms of nasals. There was a general enhancement on the /in/ → [iŋ] merger as a whole. For the case of the /iŋ/ → [in] and /əŋ/ → [ən] mergers, the effect of stress had something to do with rule progression. The old groups did not adjust their merger rates according to different stress levels. However, young speakers used the marked forms more (i.e., [in] and [əŋ]) at a higher level of prosodic prominence.

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APPENDIX I

Region/ Gender/ Age	Speaker	Recording duration	Syllable number	Discussed topics
Taipei/ Male/ Young	CZX	30’11”	8,644	future plan, life experience, family, historical stories
	HSK	33’09”	8,305	food, traveling experience
	JXW	30’28”	5,381	traveling experience, study abroad, TV program, singer, pet
	YYS	31’54”	7,680	school life, career, marriage, dating experience
Taipei/ Female/ Young	CZY	32’34”	6,688	Min usage, suicide issue, mass media, education issue, family issue, blind dating experience
	LRL	30’21”	6,685	Min usage, hobby, school life, part-time job, traveling experience
	XHR	30’54”	8,111	Min usage, childhood, history, marriage
	XHY	32’13”	8,243	education issue, food, TV program, career life
Kaohsiung/ Male/ Young	GWH	30’15”	6,491	school life, political activity, food, hobby
	KCZX	30’38”	7,096	playing band, school life, future plan
	LJH	30’37”	7,553	education issue, culture, school life, singing in a choir
	LZW	30’32”	7,050	car repairing, part-time job, internet, TV program, education issue
Kaohsiung/ Female/ Young	CJH	30’43”	4,825	food, sports, part-time job, music, Taipei/Kaohsiung comparison
	CN	30’37”	7,152	movie, TV program, school life, dorm life
	GYX	35’09”	8,638	family, school life, health, future plan
	WJL	31’19”	8,051	study abroad, teaching experience, TV program, education issue, marriage
Taipei/ Male/ Old	ECZY	30’42”	7,009	childhood, school life, study abroad, wedding, life in the USA, children
	HXF	30’43”	4,915	Min usage, traveling experience, business, temple, real estate, family
	WJH	29’54”	5,548	Japanese culture, pet, school life, traveling experience, golf
	ZFN	30’11”	7,372	history, childhood, social change, school life

Taipei/ Female/ Old	LBY	31’14”	7,606	Min usage, life experience, family issue, traveling experience, food, education issue, children
	XMC	42’25”	10,495	Min usage, family, food, social value, life experience
	XZZ	32’16”	6,729	school life, study abroad, wedding, children, life in the USA
	YHM	30’56”	6,178	food, cooking, children, childhood, traveling experience
Kaohsiung/ Male/ Old	CXY	30’03”	5,877	tourist spots, natural and artificial catastrophe, education issue, career, traveling experience, daily schedule
	LJS	47’30”	11,613	family issue, health problem, mass media
	SSH	30’14”	5,870	TV program, education issue, career, social change, religious issue, music, hometown, school life
	ZXQ	30’46”	4,842	music, Min usage, career, social change, election, children, family issue
Kaohsiung/ Female/ Old	CLAM	30’06”	5,830	life experience, social change, religious value
	CLSZ	30’08”	5,484	social change, religious activities, family, cooking
	CWAH	30’08”	4,031	family, life experience, farming, wedding
	GZBF	31’00”	7,077	childhood, Min usage, respective teachers, Mandarin learning experience

APPENDIX II

Taipei Young Male

/in/	B3	B2	B1	B0	B2P	B1P
S3	4	6	24	1	0	0
S2	2	10	179	128	1	3
S1	0	0	1	20	0	1
S0	0	0	0	0	0	0
/iŋ/	B3	B2	B1	B0	B2P	B1P
S3	11	3	54	10	2	2
S2	32	29	246	100	4	3
S1	1	0	7	11	0	0
S0	0	0	0	0	0	0
/ən/	B3	B2	B1	B0	B2P	B1P
S3	6	9	57	11	3	0
S2	35	83	501	208	21	11
S1	4	2	8	37	0	3
S0	6	31	137	56	6	9
/əŋ/	B3	B2	B1	B0	B2P	B1P
S3	9	4	34	6	2	0
S2	9	37	152	79	4	1
S1	0	1	10	11	0	0
S0	0	0	0	0	0	0
/an/	B3	B2	B1	B0	B2P	B1P
S3	34	28	162	21	3	0
S2	135	178	1004	640	28	15
S1	1	4	16	43	1	3
S0	0	0	0	0	0	0
/aŋ/	B3	B2	B1	B0	B2P	B1P
S3	13	18	89	11	1	0
S2	82	115	584	248	13	9
S1	9	8	16	20	0	2
S0	0	0	0	0	0	0

Taipei Young Female

/in/	B3	B2	B1	B0	B2P	B1P
S3	6	9	68	4	0	0
S2	8	19	158	137	5	0
S1	0	0	1	19	0	0
S0	0	0	0	0	0	0
/iŋ/	B3	B2	B1	B0	B2P	B1P
S3	12	14	112	5	4	0
S2	39	37	335	47	10	3
S1	0	1	5	4	0	1
S0	0	0	0	0	0	0
/ən/	B3	B2	B1	B0	B2P	B1P
S3	8	16	113	5	8	0
S2	46	82	520	88	20	3
S1	0	3	9	14	0	0
S0	3	3	161	13	3	4
/əŋ/	B3	B2	B1	B0	B2P	B1P
S3	13	10	88	1	0	0
S2	13	33	231	39	10	2
S1	1	4	25	17	1	1
S0	0	0	0	0	0	0
/an/	B3	B2	B1	B0	B2P	B1P
S3	50	42	343	30	6	0
S2	104	140	1187	329	24	7
S1	1	3	12	40	0	1
S0	0	0	0	0	0	0
/aŋ/	B3	B2	B1	B0	B2P	B1P
S3	31	24	189	10	0	0
S2	60	114	672	179	17	3
S1	5	2	29	14	0	2
S0	0	0	0	0	0	0

Kaohsiung Young Male

/in/	B3	B2	B1	B0	B2P	B1P
S3	5	5	48	3	1	0
S2	5	8	163	126	1	0
S1	0	1	2	23	0	0
S0	0	0	0	0	0	0
/iŋ/	B3	B2	B1	B0	B2P	B1P
S3	9	7	89	8	1	0
S2	21	17	223	60	5	1
S1	2	0	4	12	0	0
S0	0	0	0	0	0	0
/ən/	B3	B2	B1	B0	B2P	B1P
S3	12	15	80	2	4	0
S2	35	68	476	126	17	4
S1	1	3	34	31	0	0
S0	1	20	114	41	2	1
/əŋ/	B3	B2	B1	B0	B2P	B1P
S3	4	3	51	3	1	0
S2	15	42	164	48	10	1
S1	1	7	34	27	0	0
S0	0	0	0	0	0	0
/an/	B3	B2	B1	B0	B2P	B1P
S3	46	56	270	23	6	2
S2	101	154	1045	456	21	4
S1	2	1	21	67	0	1
S0	0	0	0	0	0	0
/aŋ/	B3	B2	B1	B0	B2P	B1P
S3	9	26	169	14	1	0
S2	102	117	587	189	23	1
S1	6	8	29	18	0	0
S0	0	0	0	0	0	0

Kaohsiung Young Female

/in/	B3	B2	B1	B0	B2P	B1P
S3	5	3	38	0	0	0
S2	5	8	214	103	0	3
S1	1	0	1	12	0	0
S0	0	0	0	0	0	0
/iŋ/	B3	B2	B1	B0	B2P	B1P
S3	9	6	67	2	0	0
S2	22	25	322	52	5	3
S1	0	3	14	16	0	0
S0	0	0	0	0	0	0
/ən/	B3	B2	B1	B0	B2P	B1P
S3	13	14	100	1	3	0
S2	38	97	613	151	11	8
S1	4	3	30	33	0	2
S0	0	11	98	28	3	2
/əŋ/	B3	B2	B1	B0	B2P	B1P
S3	3	4	44	1	0	1
S2	9	43	195	44	8	2
S1	1	8	62	34	0	0
S0	0	0	0	0	0	0
/an/	B3	B2	B1	B0	B2P	B1P
S3	34	20	215	7	5	0
S2	95	172	1007	442	16	16
S1	1	1	25	50	0	2
S0	0	0	0	0	0	0
/aŋ/	B3	B2	B1	B0	B2P	B1P
S3	22	14	95	4	0	0
S2	106	109	553	183	17	4
S1	40	3	22	9	1	1
S0	0	0	0	0	0	0

Taipei Old Male

/in/	B3	B2	B1	B0	B2P	B1P
S3	3	6	36	3	0	0
S2	15	12	240	55	2	1
S1	0	1	1	15	0	0
S0	0	0	0	0	0	0
/iŋ/	B3	B2	B1	B0	B2P	B1P
S3	2	4	54	6	0	0
S2	62	32	264	34	7	0
S1	1	0	8	1	0	0
S0	0	0	0	0	0	0
/ən/	B3	B2	B1	B0	B2P	B1P
S3	0	2	64	5	0	0
S2	37	67	536	69	32	5
S1	0	1	5	8	0	0
S0	4	50	219	26	12	0
/əŋ/	B3	B2	B1	B0	B2P	B1P
S3	0	3	32	8	0	0
S2	18	18	206	28	2	1
S1	0	0	1	1	0	0
S0	0	0	0	0	0	0
/an/	B3	B2	B1	B0	B2P	B1P
S3	11	21	191	26	5	0
S2	145	136	1021	170	17	6
S1	0	0	4	25	0	0
S0	0	0	0	0	0	0
/aŋ/	B3	B2	B1	B0	B2P	B1P
S3	12	13	95	11	1	0
S2	111	75	546	98	19	1
S1	0	1	2	0	0	0
S0	0	0	0	0	0	0

Taipei Old Female

/in/	B3	B2	B1	B0	B2P	B1P
S3	1	4	55	0	0	0
S2	16	20	235	15	1	2
S1	0	0	5	9	0	0
S0	0	0	0	0	0	0
/iŋ/	B3	B2	B1	B0	B2P	B1P
S3	2	0	73	0	1	0
S2	32	52	271	26	0	0
S1	0	0	1	0	0	0
S0	0	0	0	0	0	0
/ən/	B3	B2	B1	B0	B2P	B1P
S3	1	13	142	7	2	0
S2	68	117	750	53	8	10
S1	1	2	7	11	0	1
S0	6	45	280	16	9	5
/əŋ/	B3	B2	B1	B0	B2P	B1P
S3	2	9	56	0	1	0
S2	15	43	269	13	2	1
S1	0	1	1	1	0	0
S0	0	0	0	0	0	0
/an/	B3	B2	B1	B0	B2P	B1P
S3	8	21	282	6	2	0
S2	165	245	1338	137	4	10
S1	0	0	8	14	0	0
S0	0	0	0	0	0	0
/aŋ/	B3	B2	B1	B0	B2P	B1P
S3	7	9	130	1	0	0
S2	109	178	765	60	10	2
S1	1	3	8	5	0	0
S0	0	0	0	0	0	0

Kaohsiung Old Male

/in/	B3	B2	B1	B0	B2P	B1P
S3	1	2	40	0	0	0
S2	13	11	328	65	0	0
S1	0	0	1	11	0	0
S0	0	0	0	0	0	0
/iŋ/	B3	B2	B1	B0	B2P	B1P
S3	4	4	41	1	1	0
S2	49	45	378	58	1	1
S1	4	2	7	11	0	0
S0	0	0	0	0	0	0
/ən/	B3	B2	B1	B0	B2P	B1P
S3	2	3	37	1	0	0
S2	41	87	543	72	20	6
S1	1	2	5	6	0	0
S0	1	45	154	25	16	2
/əŋ/	B3	B2	B1	B0	B2P	B1P
S3	0	1	37	0	0	0
S2	14	41	310	34	7	2
S1	2	1	4	2	0	0
S0	0	0	0	0	0	0
/an/	B3	B2	B1	B0	B2P	B1P
S3	10	23	151	18	2	0
S2	157	222	1268	256	39	5
S1	4	1	3	35	0	1
S0	0	0	0	0	0	0
/aŋ/	B3	B2	B1	B0	B2P	B1P
S3	6	24	94	3	1	0
S2	199	172	630	115	41	3
S1	11	3	2	9	0	1
S0	0	0	0	0	0	0

Kaohsiung Old Female

/in/	B3	B2	B1	B0	B2P	B1P
S3	0	3	32	0	0	0
S2	10	19	156	25	5	1
S1	0	0	2	4	0	0
S0	0	0	0	0	0	0
/iŋ/	B3	B2	B1	B0	B2P	B1P
S3	0	1	35	0	1	0
S2	12	23	203	12	5	1
S1	0	0	5	0	0	0
S0	0	0	0	0	0	0
/ən/	B3	B2	B1	B0	B2P	B1P
S3	1	15	81	5	1	0
S2	24	71	481	33	15	11
S1	0	2	19	8	1	2
S0	3	27	187	13	18	3
/əŋ/	B3	B2	B1	B0	B2P	B1P
S3	1	4	54	2	1	0
S2	6	24	132	8	2	0
S1	0	2	1	1	0	0
S0	0	0	0	0	0	0
/an/	B3	B2	B1	B0	B2P	B1P
S3	6	16	182	4	5	0
S2	88	145	971	105	44	4
S1	1	0	4	21	0	0
S0	0	0	0	0	0	0
/aŋ/	B3	B2	B1	B0	B2P	B1P
S3	5	18	69	1	1	0
S2	77	62	570	49	18	2
S1	4	1	6	5	0	0
S0	0	0	0	0	0	0