

Dingxi Mandarin /n/-/l/ Merger and its Transfer to L2 English

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1 Introduction

In Dingxi, a remote place in Gansu province of China, the alveolar nasal /n/ and the lateral /l/ merge in the local Mandarin dialect. The author, born and raised in Dingxi, observes that himself and local people have difficulties in producing English words with syllable-initial [n-], e.g., *Nike, nice, neighbor, noodle, national* etc.

Similar /n/-/l/ merger is attested in a variety of Mandarin dialects (Sichuan, Hubei, Yunnan, Shanxi, Shandong), as well as in Cantonese, South Min, and other Chinese languages. Literature on the Cantonese /n/-/l/ merger appears in English and some Chinese literature addresses the same phenomenon in Mandarin as well as its transfer to L2 English.

This paper deals primarily the nasality of [n/l]-initial words in Dingxi Mandarin and L2 English using acoustic cues (F2-F1, A1P0, F3, BW1, DeltaA1, Relative RMS), and investigates the realization of the /n/-/l/ merger in various phonological environment in both Dingxi Mandarin and L2 English. To preview the results, both the acoustic and phonological analysis confirm that the /n/-/l/ merger in Dingxi Mandarin transfers to L2 English. Importantly, I introduce a *velum coarticulation hypothesis* that explains these phenomena-- from the reduced nasality of alveolar nasal in Dingxi Mandarin, to the reversed F2-F1 pattern in Dingxi Xi rhymes [i y] comparing with native English speakers, and to the convergence of the F2-F1 value of /n/ and /l/ in Hon rhymes [a o e u]. I also show that the nasality measurement illustrates a convergence of /n/ and /l/ to an acoustic realization that lies between /n/ and /l/, a phenomenon that has not been described previously.

2 Literature Review

2.1 Types of /n/-/l/ Mergers in Chinese Languages

Tian (2009) investigates 32 dialectal records published by local governments in China from 1983 to 2005. He categorizes Chinese /n/-/l/ mergers as three types, Hon-Xi-Rhyme conditional, Yin-Yang-Rhyme conditional, and Unconditional. Xi rhymes start with a high-front vowel [i y] while Hon rhymes begin with a low, middle, or high-back vowel [a o e u]. Yang rhymes end with a nasal coda while Yin rhymes do not.

Languages (Mandarin, Xiang, Cantonese, Hakka)	Hon-Xi-Rhyme Conditional	Yin-Yang-Rhyme Conditional	Unconditional
Gansu Dingxi Mandarin Hunan Xiangtan Mandarin Shanxi Pingli Mandarin	n→l / _Hon		
Anhui Qimen Mandarin		l → n / _Yang n and l interchangeable/_Yin	
Guangxi Ziyuan Xiang		l → n / _Yang	
Hunan Loudi Xiang		l → n / _Yang n→l / _Hon	
Cantonese			n → l
Meizhou Hakka			n → \tilde{l} l → \tilde{l}
Sichuan Daxian Mandarin			l → n

Table 1. Types of /n/-/l/ Mergers in Chinese Languages (Tian, 2009)

Tian claims that for the Hon-Xi-Rhyme conditional type, /n/ becomes /l/ preceding a Hon rhyme [a o e u] while /n/ and /l/ are contrastive before a Xi rhyme [i y], e.g., Hunan Xiangtan, Gansu Dingxi, and Shanxi Pingli Mandarin dialects. For the Yin-Yang-Rhyme conditional type, /l/ becomes /n/ while preceding a Yang rhyme, e.g., Guangxi Ziyuan Xiang /n/ and /l/ merge to /n/ before Yang rhymes while remaining contrastive preceding a Yin rhyme,

Anhui Qimen Mandarin /n/ and /l/ are interchangeable preceding a Yin rhyme and merge to /n/ before Yang rhymes; Hunan Loudi Xiang /n/ and /l/ merge to /n/ before Yang rhymes and to /l/ preceding Hon rhymes. For the Unconditional type, /n/ and /l/ merge unconditionally to one of [n], [l], or [ŋ]. Cantonese /n/ always becomes /l/. Sichuan Daxian Mandarin /l/ always becomes /n/. Meizhou Hakka /n/ and /l/ merge unconditionally to [ŋ]. These types of Chinese /n/-/l/ mergers are summarized in Table 1.

Cheng (2022) cites Tian (2009) for acoustic analysis of the /n/-/l/ merger in Fuzhou Min. However, Cheng's summarization of Tian's arguments regarding vowel height appears to be mistaken. Tian (2009) never mentions vowel height but uses the classic Chinese categorization of Hon/Xi and Yin/Yang rhymes. A Xi rhyme is a high-front vowel [i y] while a Hon rhyme can be a vowel of any height [a o e u]. Although this research heavily depends on Cheng (2022) for acoustic analysis, the original Tian (2009) paper is perhaps more credible and provides a more accurate understanding of the types of /n/-/l/ mergers in Chinese languages.

2.2 Chinese syllable structure and Hon Xi rhymes

Duanmu (2000) proposes a syllable structure of (C)(G)V(N) for Standard Chinese based on the X theory (Hayes 1989). Since glides and high vowels are not contrastive in Standard Chinese, Duanmu suggests that a glide [j w ŋ] is in the prenuclear position while a high vowel [i u y] occupies the nuclear slot, i.e., the onset consonant and the glide before the vowel are temporally compressed into one X slot for the prosodic structure. This temporally compressed structure explains how Chinese languages maintain the syllable isochrony feature (Kao, 1971). However, with the glide in the onset position rather than in the rhyme, it is difficult to explain the /n/-/l/ merger pattern in Table 1.

For a better understanding of the /n/-/l/ merger and the Hon Xi Yin Yang rhyme system, it is essential to have a brief introduction of the ancient Chinese phonology.

The ancient Chinese phonology literature (e.g., Cheng and Qiu (1008) 广韵 Guang Yun ‘Collection of Phonetics’, Ding (1039) 集韵 Ji Yun ‘Handbook of Phonetics’, Sun (1577a) 切字捷要 Qie Zi Jie Yao ‘Phonology of Ancient Chinese’, and Sun (1577b) 韵法直图 Yun Fa Zhi Tu ‘Index of Ancient Chinese Phonetics’) are difficult to read. Wang (1963) explains ancient Chinese Phonology with modern linguistic theory and terminology. He claims that the Fan Qie phonetic notation scheme was developed in the East Han dynasty (25-220) while the Si Hu and Hon Xi rhymes were introduced during the end of Min dynasty in 1570s.

1) Fan Qie 反切 ‘cut and flip’, marks the sound of a target character with the onset of an upper character (亭) and the rhyme of a lower character (年).

田	←	亭	年	切
Tian		Ting	Nian	
‘field’,		‘pavilion’	‘year’	‘cut’

2) Si Hu 四呼 ‘four breaths’ rhymes,

- 开口呼 Kaikou Hu ‘wide-open-mouth rhymes’, [a o e]
- 合口呼 Hekou Hu ‘narrow-open-mouth rhyme’, [u]
- 齐齿呼 Qichi Hu ‘teeth-together rhyme’, [i]
- 撮口呼 Cuokou Hu ‘Rounded-lips rhyme’, [y]

3) Hon and Xi rhymes,

- 洪韵 Hon ‘Big’ rhymes, [a o e u], Kaikou and Hekou Hu
- 细韵 Xi ‘Small’ rhymes, [i y], Qichi and Cuokou Hu

4) Yin and Yang rhymes

- Yin 阴 ‘dark/moon/negative’ rhymes, rhymes without nasal coda
- Yang 阳 ‘bright/sun/positive’ rhymes, rhymes with nasal coda

The Hon Xi rhymes play an important role in both the ancient and modern Chinese linguistic literature. Ding (1039) improves the Fan Qie phonetic notation scheme by introducing the Hon Xi rhyme restriction, i.e., the Hon Xi rhymes of the upper and target characters must match even though the rhyme of the upper character does not show up in the target one. Wang (1963) introduces the rhyme head and tail structure. A rhyme head is one of [i u y] while a rhyme tail is one of [i u n ŋ]. The rhyme head and tail are part of the rhyme. All Chinese literature regarding the /n/-/l/ merger are based on the Hon Xi Yin Yang rhymes plus the rhyme head and tail structure.

While Duanmu's (C)(G)V(N) syllable structure for standard Chinese is more accurate regarding prosodic features, the Hon Xi Yin Yang rhyme system is more efficient for analyzing Chinese phonology. The present study uses Duanmu's approach to explain anticipatory nasalization and the Hon Xi Yin Yang rhyme system to analyze the phonological environment for the /n/-/l/ merger in Dingxi Mandarin.

2.3 Dingxi Mandarin /n/-/l/ merger

Zhang and Deng (2005) investigate recordings of two Dingxi Mandarin speakers and argue that Dingxi alveolar nasal /n/ is articulated as palatal nasal [ɲ] before Xi rhymes [i y] while as lateral [l] before Hon [a o e u] rhymes, which confirms the classification of Dingxi Mandarin as Hon-Xi-Rhyme Conditional in Tian (2009). However, there is no investigation about the nasalization of lateral [l] before Yang rhymes in Zhang and Deng (2005).

Han (2014) examines 10 Dingxi Mandarin-speaking English learners' articulation of 106 English words and concludes that in Dingxi L2 English /n/ and /l/ are contrastive before Xi

rhymes while merge to [l] before Hon rhymes. This pattern in L2 English is consistent with Dingxi Mandarin in Tian (2009) and Zhang and Deng (2005), which is clear evidence of transfer.

2.4 Literature on Acoustics

Johnson (2003) compares nasals and laterals. He gives a tube model with an open end at the nostrils for the alveolar nasal /n/ while a tube model with an open end at the lips for the lateral /l/. Both models have a small pocket of air on top of the tongue that acts as a side branch to the main acoustic tubes. The main tubes define formants, and the side branches define anti formants. The alveolar nasal /n/ has more energy at the low end of the spectrum due to the damping effect of the sinus cavity which shows up as areas of little or no spectral energy on the part of spectrogram above F1, i.e., /n/ is characterized by a low frequency energy around F1 called the “nasal formant” and higher frequency energy attenuated by the sinus cavity. The lateral /l/, without damping effect of the nasal cavity, has its energy more evenly distributed cross formants and less spectrum tilt than /n/.

Cheng et al. (2022) examines six acoustic cues to distinguish /n/ and /l/ in Mandarin, English, and Fuzhou Min.

1. F2-F1 spacing, the frequency difference between F2 and F1.
2. F3 frequency, the frequency of formant 3
3. Relative RMS (root-mean-square) amplitude, the RMS amplitude of the vowel following the consonant minus the RMS amplitude of the initial consonant.
4. Delta A1 ($\Delta A1$), the F1 amplitude of the vowel ($A1v$) minus the F1 amplitude of the consonant ($A1c$).

5. A1-P0, index of nasalization (Styler, 2017). A1 is the amplitude of the first harmonic and P0 is the strongest harmonic below F1.
6. BW1, the bandwidth of F1.

Cheng et al. find that Delta A1, BW1, and A1-P0 discriminate /n/ and /l/ in both Mandarin and English, while F2-F1 spacing and F3 frequency do so only in English, and Relative RMS only for Mandarin. They also claim that none of the six acoustic cues works for Fuzhou Min due to the collapse of the contrast between /n/ and /l/.

This paper investigates the same six acoustic cues as Cheng et al. (2022) to analyze the /n/-l/ merger in Dingxi Mandarin.

3 Hypothesis

The hypothesis is based on personal observation that the alveolar nasal /n/ and lateral /l/ in Dingxi Mandarin merge in certain phonological environment, and this merger transfers to L2 English. A velum coarticulation theory is also introduced to explain the merger and the results of tests.

4 Research Questions

1. Which acoustic cues (F2-F1 spacing, F3 frequency, relative RMS, Delta A1, A1-P0, and bandwidth of F1) distinguish /n/ and /l/ in Dingxi, Beijing Mandarin, and English?
2. In what phonological environment does the /n/-l/ merger happen in Dingxi Mandarin?
3. Does the /n/-l/ merger transfer from L1 Mandarin to L2 English?

4. Is the /n/-/l/ merger a substitution of one with the other, or a convergence of the two consonants in question?
5. What is the linguistic explanation of the /n/-/l/ merger in Dingxi Mandarin?

5 Method

5.1 Nasality Measuring and [n/l] Assessment

Two tests, an acoustic analysis based on the nasality of onset [n/l] and a phonological analysis focusing on onset [n/l] assessment in various phonological environments, were conducted to investigate the /n/-/l/ merger. Both tests examined the same sets of audio materials.

The acoustic analysis is objective. The Nasality Automeasure Script Package (Styler & Scarborough, 2018) and the software Praat (Boersma & Weenink, 2019) were used to measure the nasality cues (F2-F1, A1P0, F3, BW1, DeltaA1, and Relative RMS) of participants' audio recordings. The nasality measurement identifies which acoustic cue distinguish /n/ and /l/ and reveals to what extent the alveolar nasal /n/ and lateral /l/ merge in Dingxi Mandarin.

Comparison between L1 Mandarin and L2 English of acoustic cues shows the transfer of the merger.

The phonological analysis, on the other hand, is subjective. As the acoustic analysis part was conducted first, the author had intensively compared the articulations of [n] and [l] with the Praat software in multiple perspectives, [n] vs [l], Hon vs Xi, Dingxi vs Beijing Mandarin, and L2 vs L1 English. The native English speakers' articulation of [n] and [l] are used as the reference of the [n/l] assessment. For each token (an onset [n/l]), a perception of [n], [l], or [ɺ] is evaluated by the author by listening to the recordings in both normal and slow motion. A strong

nasal sound is assessed as [n], a zero nasal sound is assessed as [l], and a slight nasal sound is assessed as [l̃].

Four wordlists including Hon/Xi and Yin/Yang rhymes are created in Table 2 to 5 in the Word List section. Total 197 Mandarin characters and 198 English words evenly distributed in target environments were integrated in 55 Mandarin (Appendix A) and 54 English (Appendix B) sentences respectively.

5.2 Participants

Thirteen participants from the target group participated in the production task. Participants were college students born and raised in Dingxi. Six male Dingxi Mandarin-speaking English learners and seven female Dingxi Mandarin-speaking English learners participated. They all took the mandatory CET-4 English test, with the average score of 431 (Standard Deviation 38.5) out of the full mark of 710. It is approximately the equivalence of CLB-5 in Canadian Language Benchmarks, i.e., an intermediate level of English proficiency.

In addition, four participants served as a control group: One male Beijing Mandarin-speaking English learner, a college student born and raised in Beijing; One female Beijing Mandarin-speaking English learner, also a college student born and raised in Beijing; One male native English speaker, York University graduate student; and one female native English speaker, York University graduate student.

All recordings were self-produced. Dingxi and Beijing participants recorded themselves with their own cell phones while reading aloud the oral consent and the stimuli in their dormitory

room. Native English participants recorded themselves with laptop computers and headphones in a quiet room and signed the consent on PDF files.

Chinese-speaking participants were asked to read aloud 55 Mandarin and 54 English sentences, two times for each. The entire production task took around 30 minutes. While all the participants' recordings were analyzed in the [n/l] assessment regardless of the audio quality, only four participants' recordings are taken for the acoustic analysis. The other participants in the target Dingxi group were dropped for acoustic analysis for a variety of reasons such as background noise, speaking too fast, or/and talking of other people by side in the college dormitory room.

5.3 Word List

Four wordlists were created regarding Hon/Xi and Yin/Yang rhymes.

- Table 2. Hon Yin Rhymes -- [a o e u] without nasal coda
- Table 3. Xi Yin Rhymes -- [i y] without nasal coda
- Table 4. Hon Yang Rhymes -- [a o e u] with nasal coda
- Table 5. Xi Yang Rhymes -- [i y] with nasal coda

Table 2. Hon Yin Rhymes -- [a o e u] without nasal coda

	Chinese Characters with Onset /n/	English #n	Chinese Characters with Onset /l/	English #l
[a]	那/na/个/kə/ 'that', 纳/na/闷/men/ 'wonder', 纳/na/米/mi/ 'nano', 那/na/么/mə/ 'so', 呐/na/喊/xæ/ 'shout', 喷/swo/呐/na/ 'trumpet'	nark, namib, nacho, nard, narc, nut, tsunami, banana,	拉/la/面/miæ/ 'Ramen', 辣/la/椒/tɕjə/ 'Chili', 蜡/la/烛/ʈʂu/ 'Candles', 腊/la/肉/ʒoʊ/ 'Bacon', 垃/la/圾/tci/ 'Garbage'	Large, lard, luck,

[æ]	南/næ/方/fan/'south', 男/næ/人/zən/'man', 难/næ/过/kuo/'sad', 楠/næ/木/mu/'Phoebe wood', 难/næ/民/mɪn/'refugee'	nap, , national, nab, nah, nappy, snap, international	兰/læ/州/tʃəʊ/'lanzhou', 懒/læ/惰 tuo/'lazy', 破/pʰɔ/烂/læ/'tattered', 蓝/læ/色/sə/'blue', 栏/læ/杆/kan/'railing', 篮/læ/球/tʃ'jɔʊ/'basketball', 泛/fæ/溢/læ/'flood', 展/tʃan/览/læ/馆/kwan/'exhibition hall'	lab, laptop, latitude, latch, lack, ladder
[aɪ]	牛/njɔʊ/奶/nai/'milk', 奶/nai/奶/nai/'grandma', 无/u/奈/nai/'helplessness', 耐/nai/心/ɕɪn/'patience', 奈/nai/何/xə/'helplessness', 耐/nai/克/kʰə/'Nike'	Nike, nice, naïve, knife,	过/kuo/来/lai/'Come here', 无/u/赖/lai/'rogue', 天/tʰjɛn/籁/lai/'sound of nature', 赖/lai/皮/pʰi/'rascal', 癞/lai/蛤/xa/蟆/mo/'toad'	Like, lie, license, lite, liability
[ɔ]	闹/nɔ/钟/tʃʊŋ/'alarm clock', 脑/nɔ/袋/tai/'head', 恼/nɔ/火/xuɔ/'annoyed', 孬/nɔ/种/tʃʊŋ/'coward', 闹/nɔ/心/ɕɪn/'upset', 电/tjɛn/脑/nɔ/'computer'	Naughty, astronaut, norm, north, nordic, normal, norman	老/lɔ/师/si/'Teacher', 劳/lɔ/动/tɔŋ/'labor', 坐/tsuɔ/牢/lɔ/'imprisonment', 刘/ljɔʊ/姥/lɔ/姥/lɔ/'Grandma Liu', 捞/lɔ/鱼/y/'fishing', 海/xai/底/ti/捞/lɔ/'fishing in the sea'	Law, lawyer, lawful, Lock, lord, lost,
[ə]	呢/nə/'nah', 木讷/nə/'stupid', 哪/nə/吒/tʃa/'goddess',	Nepal, Netherland, banana, Angelina, Argentina, Diana, Tina	可/kʰə/乐/lə/'cola', 弥/mi/勒/lə/佛/fə/'Maitreya',	Coke Cola, collar, scholar, Kamala,
[eɪ]	内/neɪ/容/zɔŋ/'content', 气/tʃʰi/馁/neɪ/'discouraged', 国/kuo/内/neɪ/'domestic', 内/neɪ/胆/tæ/'internal container',	Neighbor, Nate, Nathan, native, naked, snake, Canadian	类/leɪ/别/pjɛ/'category', 雷/leɪ/电/tjæ/'lightning', 打/ta/雷/leɪ/'thunder', 擂/leɪ/台/tʰaɪ/'arena', 眼/jɛn/泪/leɪ/'tears'	Lake, laid, blade, escalate, chocolate, relate, relation, slave, translate, violate
[u]	努/nu/力/li/'effort', 怒/nu/火/xuɔ/'rage', 奴/nu/隶/li/'slave', 弩/nu/弓/kɔŋ/'crossbow', 怒/nu/气/tʃʰi/'rage'	Noodle, noon, noose, noonday, noobie, snooby	杏/ɕɪŋ/仁/zən/露/lu/'almond milk', 马/ma/路/lu/'road', 梅花鹿/lu/'sika deer', 录/lu/音/in/机/tɕi/'recorder', 八/pa/路/lu/军/tɕyn/'Eighth Route Army', 鲁/lu/班/pæ/'Lu Ban', 火/xuɔ/炉/lu/'stove'	Loon, loose, look, loop, Luke, lute
[uo]	诺/nuo/言/jɛn/'Promise', 许/ɕy/诺/nuo/'Promise', 挪/nuo/动/tɔŋ/'Move', 懦/nuo/弱/zuo/'Cowardly', 糯/nuo/米/mi/'Sticky Rice'	Nurofen,	萝/luo/卜/pu/'radish', 洛/luo/阳/jɔŋ/'Luoyang', 骆/luo/驼/tʰuo/'camel', 下/ɕja/落/luo/'whereabouts', 骡/luo/子/tɕi/'mule', 巡/ɕyn/逻/luo/'patrol'	Lure,
[uæ]	暖/nuæ/和/xə/'warm', 暖/nuæ/气/tʃʰi/'heating', 地/ti/暖/nuæ/'underfloor heating'	-	乱/luæ/七/tʃʰi/八/pa/糟/tsəʊ/'Mess', 卵/luæ/石/ʃi/'pebbles', 鸟/njɔ/卵/luæ/'eggs', 峰/fəŋ/峦/luæ/'mountains'	-

Table 3. Xi Yin Rhymes -- [i y] without nasal coda

	Chinese Characters with Onset /n/	English #n	Chinese Characters with Onset /l/	English #l
[i]	拖/t ^h uo/泥/ni/带/tai/水/ʃueɪ/'sloppy', 匿/ni/名/miŋ/'anonymous', 尼/ni/姑/ku/'nun', 倪/ni/萍/p ^h iŋ/'Ni Ping', 油/jou/腻/ni/'greasy', 有/jou/你/ni/有/jou/我/uo/'with you and me'	need, needle, neap, neat, knee	居/tcy/里/li/夫/fu/人/zən/'Mrs. Curie', 努/nu/力/li/'effort', 奴/nu/隶/li/'slave', 有/jou/道/to/理/li/'justified', 理/li/由/jou/'reason', 利/li/益/i/'benefit', 礼/li/貌/mo/'politeness'	Leader, leak, lease, leek
[iu]	牛/niu/奶/nai/'milk', 纽/niu/扣/k ^h oo/'button', 别/pje/扭/niu/'awkward', 泡/p ^h o/妞/niu/'chasing girl', 纽/niu/带/tai/'bond', 枢/ʃu/纽/niu/'hub'	New, renew, nuclear, New York	柳/liu/树/ʃu/'willow', 六/liu/十/ʃi/'sixty', 流/liu/失/ʃi/'lost', 留/liu/学/cyæ/'study abroad', 河/xə/流/liu/'river', 溜/liu/达 ta/'stroll'	Lieutenant, Leo, portfolio, folio
[iə]	聂/niə/耳/aɪ/'Nie Er', 罪/tsueɪ/孽/niə/'Sins', 捏/niə/泥/ni/巴/pa/'Kneading Mud', 镍/niə/铬/kə/电/tiə/池/tci/'Nickel-Chrome Battery', 聂/niə/荣/zun/臻/tʃən/'NieRongzhen', 孽/niə/障/tʃən/'poor'	Near, veneer, souvenir, engineer, engineering	列/liə/宁/niŋ/'Lenin', 烈/liə/士/ʃi/'martyr', 猎/liə/人/zən/'hunter', 分/fən/裂/liə/'split'	Liaison, chandelier, clear, sillier,
[iæ]	过/kuo/年/niə/'Chinese New Year', 念/niə/书/ʃu/'study', 撵/niə/走/tsoo/'drive away', 碾/niə/压/ja/'crush'	Onion, Union, opinion, canyon, companion	洗/ci/脸/liæ/'face wash', 练/liæ/习/ci/'exercise', 联/liæ/合/xə/'unite', 莲/liæ/花/xwa/'lotus', 炼/liæ/油/jou/厂/tʃ ^h ən/'refinery'	million, billion, trillion, Italian, Sicilian
[y]	女/ny/娃/wa/子/ts/'girls', 妇/fu/女/ny/'women', 女/ny/朋/p ^h ən/友/jou/'girlfriends'	-	铝/ly/合/xə/金/tcin/'aluminum alloy', 毛/mo/驴/ly/'donkey', 绿/ly/色/sə/'green', 旅/ly/游/jou/'travel', 纪/tci/律/ly/'discipline'	-

Table 4. Hon Yang Rhymes -- [a o e u] with nasal coda

	Chinese Characters with Onset /n/	English #n	Chinese Characters with Onset /l/	English #l
[aŋ]	胶/tcjao/囊/naŋ/'Capsules', 囊/naŋ/肿/tʃoŋ/'cysts', 新/cin/疆/tcjaŋ/馕/naŋ/'Xinjiang cake'	-	野/jε/狼/laŋ/'Wolves', 狼/laŋ/狈/pei/'wolves', 浪/laŋ/花/xua/'waves',	Language, language, Lancaster, blank,
[oŋ]	农/nonŋ/贸/mo/市/ʃi/场/tʃ ^h ən/'farmers market, 脓/nonŋ/包/po/'pustule', 浓/nonŋ/雾/u/'fog',	Noon, noonday, afternoon	龙/lonŋ/舟/tʃoʊ/'Dragon Boat', 兴/ciŋ 隆/lonŋ/山/ʃæ/'Xinglong Mountain', 陇/lonŋ/西/ci/'Longxi', 鸟/nio/笼/lonŋ/'Bird Cage',	Loon, saloon, balloon, volunteer,

	作/tsuɔ/弄/nɔŋ/'trick'		九/tɕjɔʊ/龙/lɔŋ/'Kowloon', 小/xiɔ/笼/lɔŋ/包/pɔ/'steamed dumpling'	
[eŋ]	能/nɛŋ/干/kæ/'able', 能/nɛŋ/力/li/'competence', 能/nɛŋ/够/kou/'can', 太/tʰaɪ/阳/yaŋ/能/nɛŋ/'solar energy'	-	冷/lɛŋ/空/kʰɔŋ/气/tɕʰi/'cold air', 愣/lɛŋ/头/tʰɔʊ/愣/lɛŋ/脑/nɔ/'stupid'	Length,

Table 5. Xi Yang Rhymes -- [i y] with nasal coda

	Chinese Characters with Onset /n/	English #n	Chinese Characters with Onset /l/	English #l
[in]	您/nin/好/xɔ/'hello'	Ninja, ninny, Nintendo, Nina,	树/ʂu/林/lin/'woods', 临/lin/兆/tʰɔ/'Lintao', 磷/lin/肥/fei/'phosphate fertilizer', 邻/lin/居/tɕy/'neighbors', 鱼/y/鳞/lin/'fish scales'	Linda, Angelina, Jolin, Violin,
[iŋ]	会/xueɪ/宁/nin/'Huining', 拧/nin/紧/tɕin/'Tighten', 凝/nin/聚/tɕy/'Condensed', 柠/nin/檬/məŋ/'Lemon', 狰/tɕəŋ/狞/nin/'Grim', 安/æ/宁/nin/区/tɕʰy/'Anning region'	Cleaning, cunning, burning, turning, spinning,	零/lin/下/cja/'subzero', 铃/lin/铛/taŋ/'bell', 另/lin/外/uai/'plus', 灵/lin/活/xuɔ/'flexible', 领/lin/导/tɔʊ/'lead'	Linguistics, link, feeling. Stealing, peeling, sting, stink, darling
[ian]	酿/nian/酒/tɕjɔʊ/'brew', 姑/ku/娘/nian/'girl', 娘/nian/娘/nian/'mother'	-	两/lian/个/kə/'Two', 梁/lian/山/ɕæ/'Liang Mountain', 凉/lian/面/miæ/'cold noodles', 漂/pʰjɔ/亮/lian/'beautiful', 粮/lian/食/ʂi/'food'	-

5.4 Acoustic Analysis – Nasality

5.4.1 Annotation of WAV files

The audio files were manually annotated in Praat (Boersma & Weenink, 2019), as shown in the Figure 6. There were two tiers in the annotation, the vowel tier and the word tier. Both the vowel and the consonant were segmented in the vowel tier.

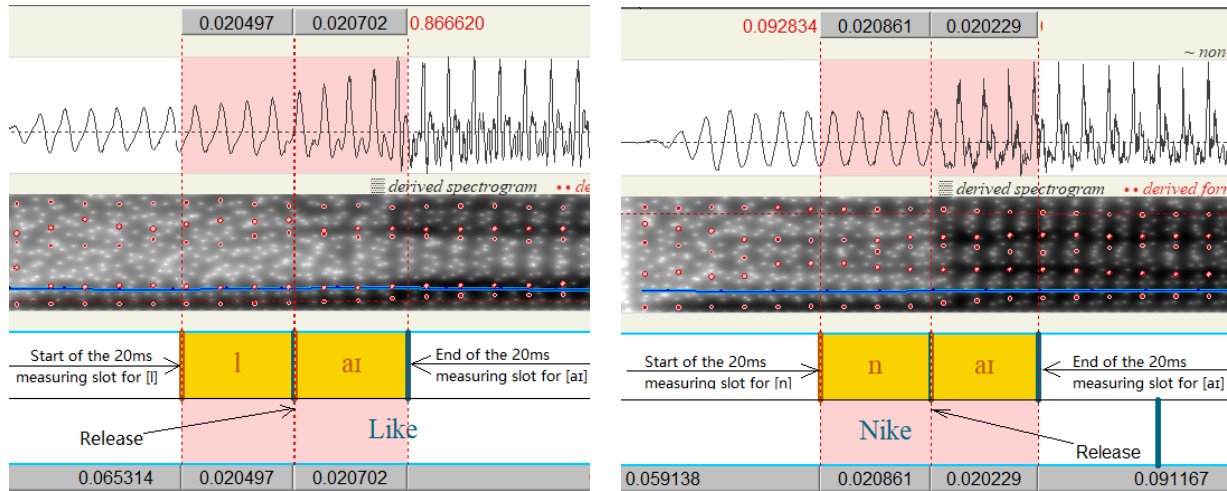


Figure 6. Annotation of WAV files. 20ms after the release point for the vowel and before for the nasal/lateral consonant. Both the left (*like*) and right (*Nike*) pictures are articulations of the native speaker ENF1.

The release of the lateral/nasal consonant was determined first from visual inspection, for pattern shifting in both the waveform and the spectrogram at the point of change in amplitude at the zero crossing. Then 20 milliseconds after the release point was marked for the vowel measuring slot and 20 milliseconds before the release for the consonant.

5.4.2 Nasality Automeasure Script for Praat

The Nasality Automeasure Script Package (Styler & Scarborough, 2018) was used to measure the nasality cues (F2-F1, A1P0, F3, BW1, DeltaA1, and Relative RMS). The script takes 33 measurements in a run, which includes frequencies, amplitudes, and bandwidths of formants (F1, F2, F3), harmonics (H1, H2, H3), and poles (P0, P1), A1P0, A1P1, A3P0, vowel amplitude RMS, and vowel duration. While A1P0, F3, and BW1 are provided by the script directly, F2-F1, DeltaA1, and Relative RMS need to be calculated based on the results of the script. The standard configuration, 5 measure points per vowel interval, was used in the script to

get the raw data, then the target nasality cues (F2F1, A1P0, F3, BW1, DeltaA1, and Relative RMS) were calculated at each measure point in Microsoft Excel. The furthest measure point, 20ms away from the release point, is the measure point C1/V1, while the nearest one is the measure point C5/V5, as shown in the example in Table 7.

Participant	Word	Vowel	Measure Point	freq_f1	amp_f1	width_f1	freq_f2
DXM1	Like	l	C1	305	33.4	37	2281
DXM1	Like	l	C2	305	34.54	60	2313
DXM1	Like	l	C3	305	34.37	192	2089
DXM1	Like	l	C4	281	34.76	157	2055
DXM1	Like	l	C5	281	34.76	157	2055
DXM1	Like	aɪ	V5	281	35.3	213	1742
DXM1	Like	aɪ	V4	281	34.49	160	1560
DXM1	Like	aɪ	V3	398	36.28	123	1542
DXM1	Like	aɪ	V2	398	36.06	96	1485
DXM1	Like	aɪ	V1	398	36.06	96	1485

Table 7. Five measure points in the 20ms intervals of the consonant /l/ and vowel /aɪ/ around the release point. The furthest one is the measure point C1/V1 while the nearest one is the measure point C5/V5.

5.4.3 Calculation of F2-F1, DeltaA, and Relative RMS

- $F2F1_1 = \text{freq_f2@C1} - \text{freq_f1@C1}, \dots, F2F1_5 = \text{freq_f2@C5} - \text{freq_f1@C5}$
- $A1P0_1 = \text{a1p0@V1}, A1P0_2 = \text{a1p0@V2}, \dots, A1P0_5 = \text{a1p0@V5}$
- $\text{DeltaA1_1} = \text{amp_f1@V1} - \text{amp_f1@C1}, \dots, \text{DeltaA1_5} = \text{amp_f1@V5} - \text{amp_f1@C5}$
- $\text{Relative RMS_1} = \text{vwl_amp_rms@V1} - \text{vwl_amp_rms@C1}, \dots, \text{Relative RMS_5} = \text{vwl_amp_rms@V5} - \text{vwl_amp_rms@C5}$

Styler argues in the README of the Nasality Automeasure Script that A1P0 is so far a robust, well studied and well correlated nasality measurement. Styler also suggests that A1P0 is not meaningful at a token-by-token level and cannot be compared cross speakers.

Because this study is about the Dingxi Mandarin n-l merger transferring to L2 English and there is no such n-l merger phenomenon in English, the two native English speakers' recordings were analyzed at first to find the right acoustic cues to distinguish nasal from lateral. The following tests show that F2-F1 is the best acoustic cue among the six candidates (F2-F1, A1P0, F3, BW1, DeltaA1, and Relative RMS) regarding nasality measurement. A1P0 also provides clear discrimination between [n] and [l], although with the limitation to non-high vowels only. All the other measurements, F3, BW1, DeltaA1, and Relative RMS, do not show meaningful difference between the two target consonants in either English or Mandarin.

5.4.4 F2-F1

F2-F1 is the frequency difference between formant 2 and formant 1 of the target [n/l] consonant. The Nasality Automeasure Script takes five measures per the manually annotated 20ms vowel/consonant interval. One measure at the middle point, two at the start and the end of the 20ms measuring slot, the other two in between the middle point and the start/end point. F2-F1 is not directly produced by the Nasality Automeasure Script but calculated based on formants' frequencies. Figure 8 is the contrast of F2-F1 between [n] and [l] with native English speakers ENF1 and ENM1 at various measuring points, which shows that A.F2-F1@C1, taken at the measure point C1, is the best option. The boxplots in A.F2-F1@C1 show less variability and more separation between /n/ and /l/ than the others.

A. F2-F1@C1

B. F2-F1@C3

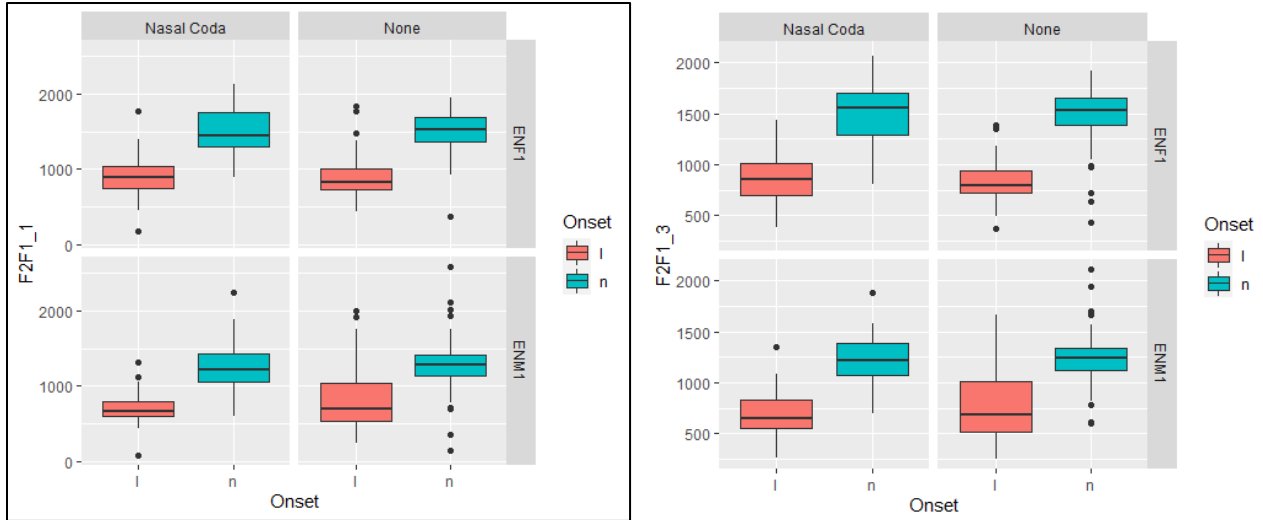


Figure 8. F2-F1 boxplot calculated at point C1 (A) (20 ms before the consonant release point), and at point C3 (B) (10 ms before the consonant release point, the middle of the annotated consonant interval) for the two native English-speaking controls. “None” for rhymes without nasal coda while “Nasal Coda” for rhymes with nasal coda.

5.4.5 A1-P0

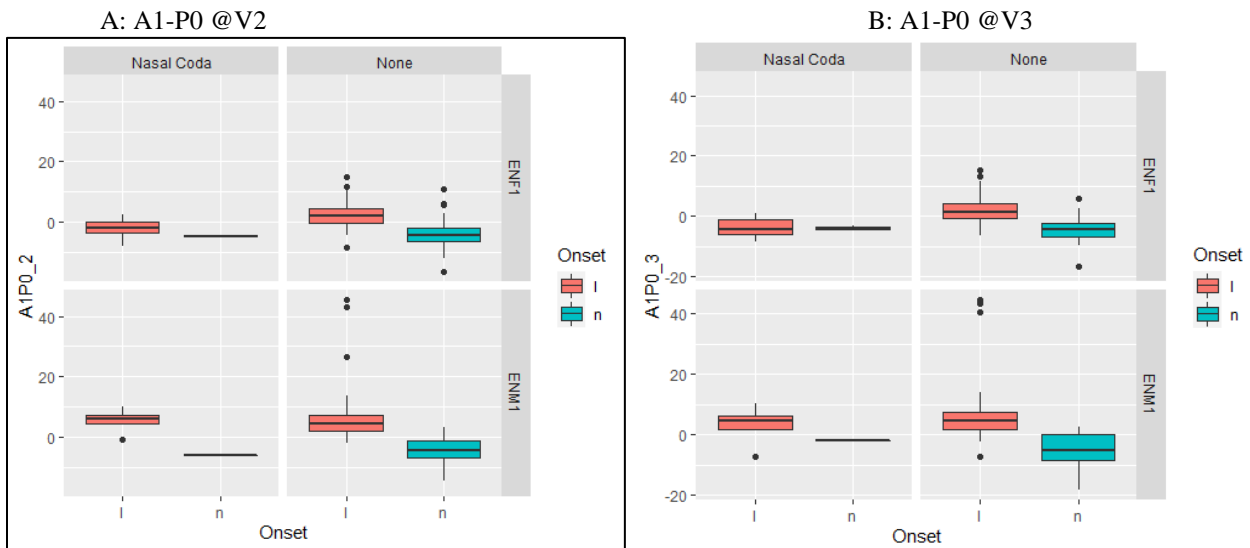


Figure 9. A1-P0 boxplot calculated at the measuring point V2 (15 ms after the consonant release point) (A) and (B) calculated at the measuring point V3 (10 ms after the consonant

release point, the middle of the annotated vowel interval) for the two native English-speaking controls.

A1-P0 is the difference between the amplitude of the first harmonic and the amplitude of the strongest harmonic below F1. A1-P0 is provided by the script directly at each measure point. The boxplots in Figure 9 show that A1-P0@V2 is the best choice to distinguish [n] and [l] among all five A1-P0 measurements.

Although Styler (2017) claims that A1-P0 is the best nasality measurement available, Figure 8 and Figure 9 show that F2-F1 is better than A1-P0 regarding discriminating /n/ and /l/.

5.4.6 F3

F3 is the frequency of the formant 3 of the target consonant. The F3 measurement is extracted directly from the script. Figure 10 shows that F3 represents no meaningful difference between /n/ and /l/ for both native English speakers.

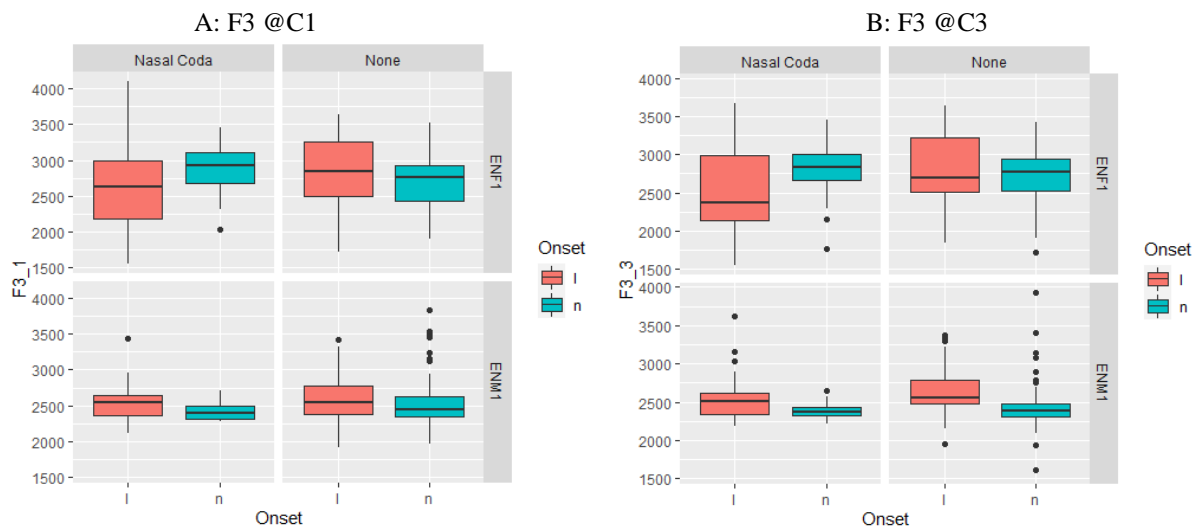


Figure 10. F3 boxplot at the measuring point C1 (20 ms before the consonant release point)(A), and (B) calculated at the measuring point C3 (10 ms before the consonant release point, the

middle of the annotated interval). “None” for rhymes without nasal coda while “Nasal Coda” for rhymes with nasal coda.

5.4.7 BW1

BW1 is the bandwidth of F1 of the vowel following the [n/l] consonant. House and Stevens (1956) argue that nasal tract coupling increases BW1. However, measurements shown in Figure 11 show no difference for both native English speakers.

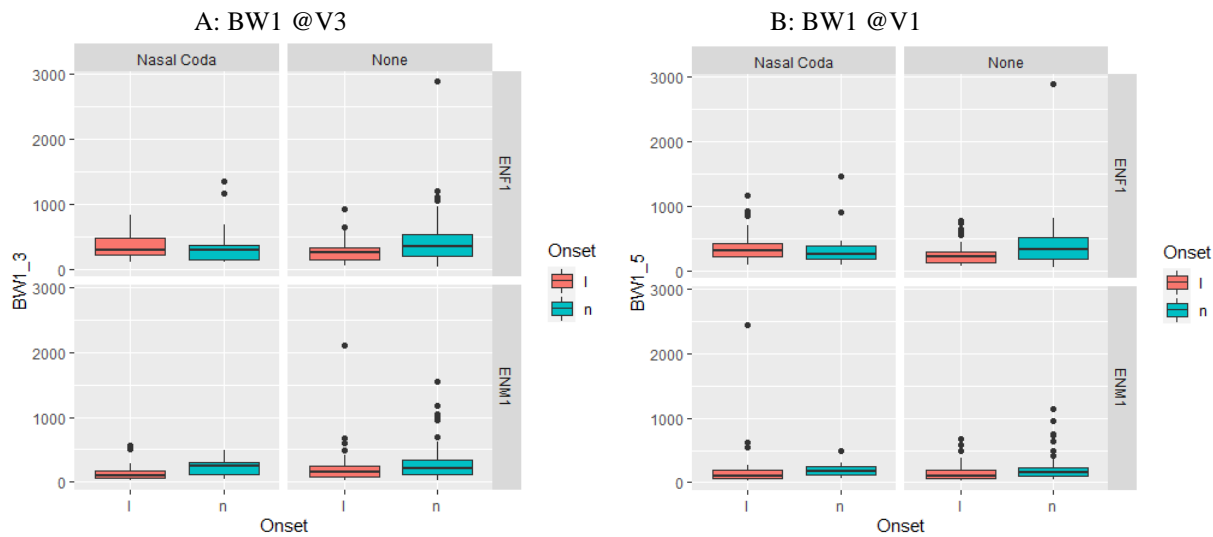


Figure 11. BW1 boxplot calculated at V3 (10 ms after the consonant release, the middle of the annotated vowel interval)(A), and (B) at the measuring point V3 (20 ms after the consonant release). “None” for rhymes without nasal coda while “Nasal Coda” for rhymes with nasal coda.

5.4.8 DeltaA1

DeltaA1 is defined as the difference between the F1 amplitude of the vowel and the F1 amplitude of the preceding consonant. DeltaA1 is not produced by the script directly but calculated based on the F1 amplitudes. Figure 12 illustrates that DeltaA1 does not work for distinguishing /n/ and /l/.

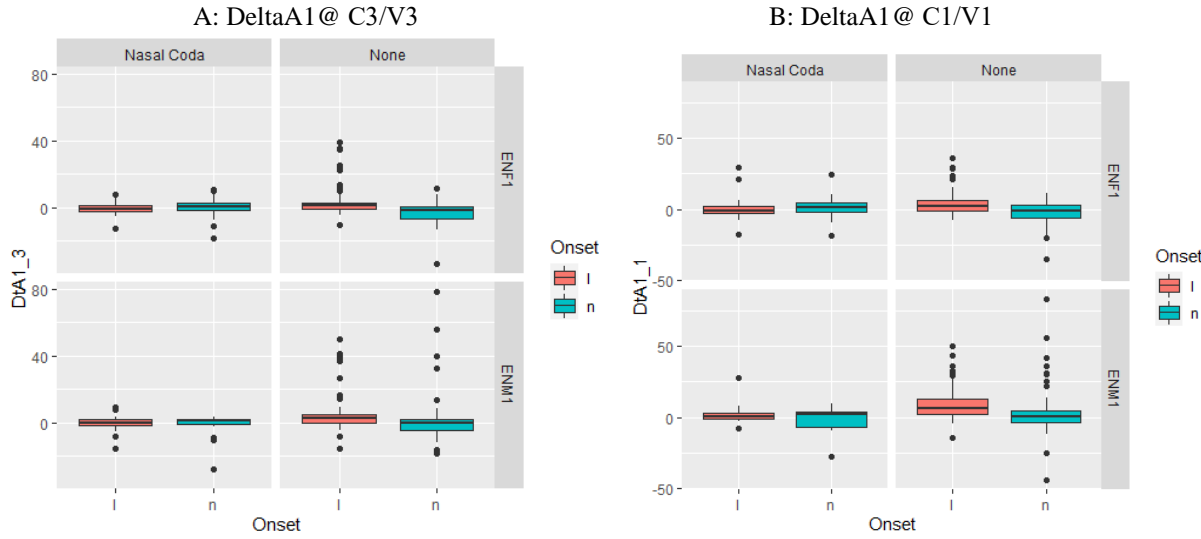


Figure 12. DeltaA1 boxplot calculated at points C3 and V3 (10 ms before/after the consonant release point, the middle of the annotated consonant/vowel interval) (A), and (B) at C1 and V1 (20 ms before/after the consonant release point). “None” for rhymes without nasal coda while “Nasal Coda” for rhymes with nasal coda.

5.4.9 Relative RMS

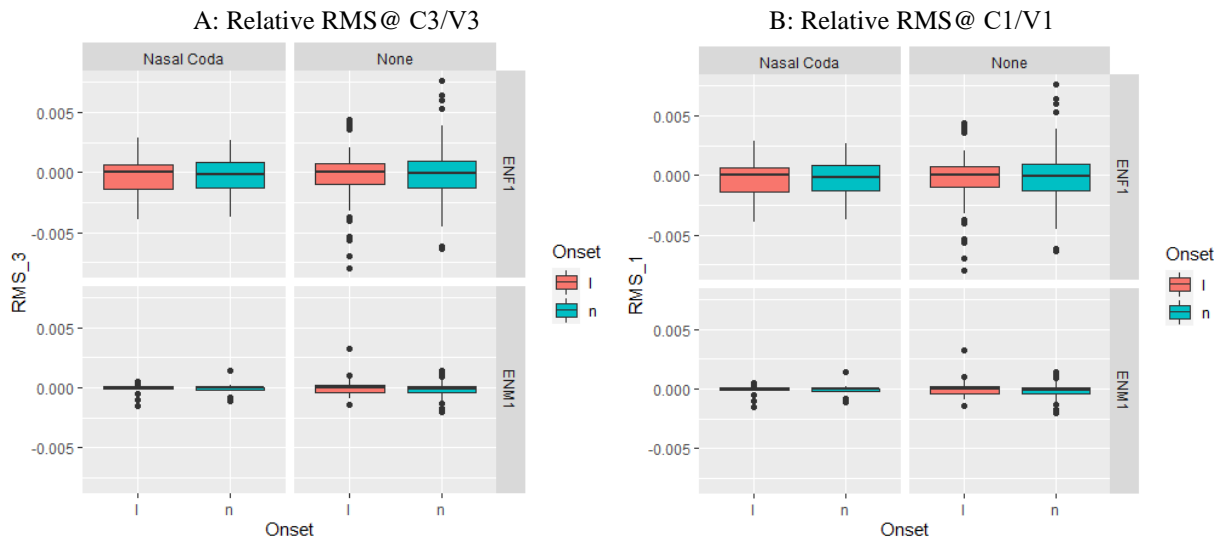


Figure 13. Relative RMS boxplot calculated at C3 and V3 (10 ms before/after the consonant release, the middle of the annotated consonant/vowel interval)(A), and (B) at C1 and V1 (20 ms

before/after the consonant release). “None” for rhymes without nasal coda while “Nasal Coda” for rhymes with nasal coda.

Relative RMS is the difference between the RMS amplitude of the vowel and the RMS amplitude of the preceding [n/l] consonant. Relative RMS is also not produced by the script directly and is calculated based on the RMS amplitudes. Figure 13 shows that Relative RMS does not clearly differentiate /n/ and /l/.

5.5 Phonological Analysis – [n/l] Assessment

The two native English speakers’ production of [n] and [l] are used as the reference of the [n/l] assessment. For each token (an onset [n/l]), a perception of [n], [l], or [ĩ] is assessed by the author (Appendix C). A strong nasal sound is assessed as [n], a zero nasal sound is assessed as [l], and a slight nasal sound is assessed as [ĩ]. The number of participants in the target Dingxi Group, Beijing Group, and English Group are 13, 2, and 2, respectively, which equals the maximum [l / n / ĩ] count per token for each group. Results are shown in boxplots and bar charts. Comparison between Mandarin and English in various phonological environments shows the pattern of the /n/-/l/ merger in L1 Mandarin and L2 English.

6 Results

6.1 Acoustic Analysis– Nasality Measuring

Styler (2017) argues that due to speaker variability, it is meaningless to directly compare acoustic nasality features cross speakers. The acoustic result of the present research confirms Styler’s argument. To show a clear pattern of the /n/-/l/ merger in Dingxi Mandarin and its

transfer to L2 English, the results of acoustic measurements are presented individually at first. Cross-speaker comparisons are focused on overall patterns rather than comparisons of specific acoustic values.

6.1.1 Individual Nasality -- DXM1

6.1.1.1 F2-F1: DXM1 compared to Native English Speakers

The left picture in Figure 14 (A) compares the F2-F1 value of the DXM1 participant in three dimensions, /n/ vs /l/, Hon vs Xi, and Dingxi Mandarin vs L2 English. The right one, Figure 14 (B), compares the F2-F1 value of native speakers instead of participant DXM1.

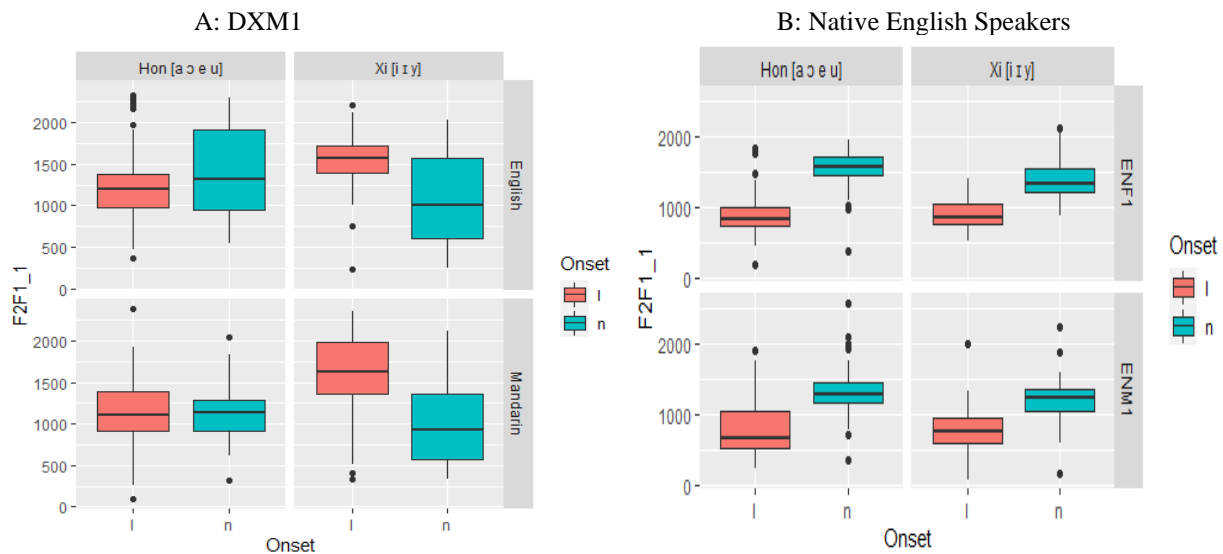


Figure 14. F2-F1 – Participant DXM1 vs Native English Speakers.

Native speakers (B) show a clear contrast between /n/ and /l/ regardless of Hon or Xi rhymes or individual speaker. DXM1's productions (A), on the other hand, show that in Hon rhymes of Dingxi Mandarin the two consonants merge into a place between /n/ and /l/ and become nearly identical. In Xi rhymes /n/ and /l/ are contrastive in both Dingxi Mandarin and L2

English, while in Hon rhymes of L2 English, the two consonants are overlapped to each other, with /n/ extending to higher F2-F1 values. This shows that the /n/-l/ merger patterns are similar in L1 Mandarin and L2 English, i.e., a transfer from L1 to L2.

However, it is puzzling that the native speakers' F2-F1 values of /n/ are higher than /l/ while DXM1's F2-F1 values of /n/ are lower than /l/, at least in Xi rhymes. Cheng (2022) argues on the basis of the perturbation theory that the complete anterior construction of alveolar nasal [n] causes F1 to slightly decrease and F2 to increase, i.e., a greater F2-F1 value for [n]. This prediction explains the pattern of native speakers while fails to do so for the one of Dingxi Mandarin speaker DXM1.

Cheng (2022) finds that there is no significant difference between /n/ and /l/ regarding the F2-F1 value in Standard Mandarin and Fuzhou Min. Cheng explains that because English lateral has coronal and velarized allophones while Mandarin lateral has only the coronal realization, velarized lateral has smaller F2-F1 spacing and leads to more contrastive lateral and nasal in English than in Mandarin. However, it cannot explain why DXM1's F2-F1 values of /n/ are lower than /l/ in Xi rhymes, the reversed pattern comparing to native speakers.

6.1.1.2 *Velum Coarticulation Hypothesis*

Based on the author's personal observation on Dingxi Mandarin, a velum coarticulation hypothesis is introduced here. For alveolar nasal [n] following Xi rhymes in Dingxi Mandarin, the velum coarticulates with the tongue tip, which causes a resonance between the oral and nasal cavities. The velum raises and limits the connection to the nasal cavity in the same way as the tongue tip reducing the openness of oral cavity by pushing close to the alveolar. The coarticulation of velum and the resonance of nasal and oral cavities reduces the nasality of

alveolar nasal in Dingxi Mandarin, and possibly results in the reversed pattern of a lower F2-F1 value for /n/ than /l/, compared to the two native English speakers. In Hon rhymes the velum coarticulates with the tongue for both /n/ and /l/ consonants, which leads to the /n-/l/ merge. There is no resonance between nasal and oral cavities with Hon rhymes because of the wider opening of both cavities.

6.1.1.3 F2-F1 -- Nasalized Lateral [l̃]

For the participant DXM1, onset lateral [l] is slightly nasalized as [l̃] by the nasal coda following Hon rhymes in Mandarin, while not Xi rhymes or any rhymes in L2 English.

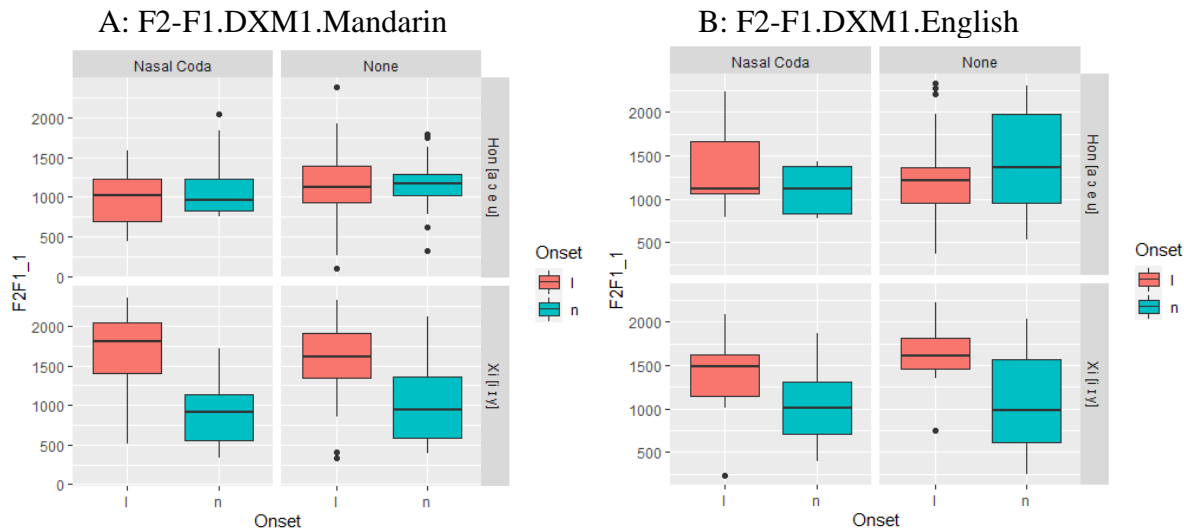


Figure 15. Nasalized lateral [l̃]. Mandarin Hon rhymes with nasal coda have lower F2-F1 value (A) than their counterparts in the next column of ‘None’. There are no nasalized [l̃] attested in L2 English or Xi rhymes of Mandarin. “None” for rhymes without nasal coda while “Nasal Coda” for rhymes with nasal coda.

Figure 15 (A) shows that the nasal coda following Hon rhymes can slightly lower the onset [n/l]’s F2-F1 value from positions in the neighboring ‘None’ (nasal coda) column. While in Fig. 15 (B) for L2 English and the lower part of Fig. 15 (A) for Mandarin Xi rhymes, there is no

meaningful difference of the F2-F1 value between the ‘Nasal Coda’ and the ‘None’ columns.

The [n/l] assessment test in the phonological analysis part also shows that the slightly nasalized [ĩ] is only perceived with the onset [l] preceding a Hon rhyme plus a nasal coda in Dingxi Mandarin.

6.1.1.4 A1-P0 -- DXM1 vs English Native Speakers

Figure 16 (A) shows that DXM1’s A1-P0 for /n/ and /l/ in the ‘None’ nasal coda column are nearly identical for both L1 Mandarin and L2 English, while those with nasal codas are completely overlapped with the lateral /l/ stretching wider than /n/. The pattern in L2 English is similar to L1 Mandarin. The native speakers, on the other hand, have clearly separated A1-P0 distributions regardless of nasal coda and individual speaker. This is clear evidence for the /n-/l/ merger in Hon rhymes of Dingxi Mandarin and its transfer to L2 English for DXM1.

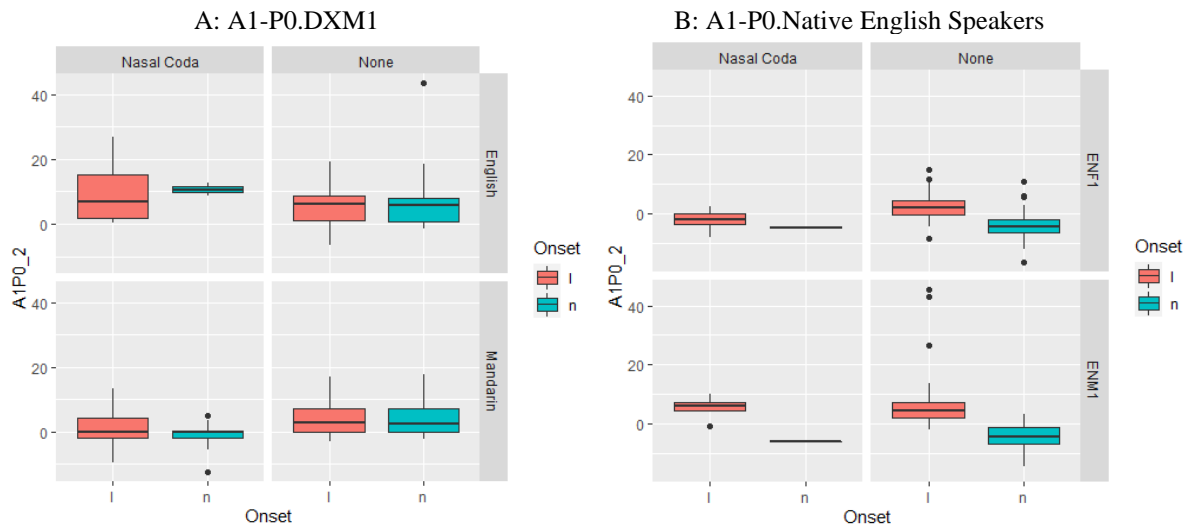


Figure 16. The pattern of the A1P0 of DXM1 is consistent with the F2-F1 of DXM1 for Hon rhymes, i.e., the /n-/l/ merger. Native speakers’ A1P0 (B) shows the similar pattern as their F2-F1, although with narrower spacing between /n/ and /l/. “None” for rhymes without nasal coda while “Nasal Coda” for rhymes with nasal coda.

Meanwhile, the figure shows a slight nasalization by the nasal coda in Mandarin, not L2 English. This is consistent with the pattern of F2-F1 of DXM1 for Hon rhymes.

6.1.1.5 F2-F1 vs A1-P0

Figure 17 shows a comparison of F2-F1 and A1-P0 between the two native English speakers. It shows that F2-F1 is the better one distinguishing onset /n/ and /l/. First, F2-F1 works for any vowels (Hon and Xi rhymes) while A1-P0 only works for non-high vowels, which excludes [u] from Hon rhymes. The plot on the right (B) shows that the A1-P0 values of /n/ and /l/ for Xi rhymes are overlapped and not clearly separated from each other, which partially confirms the argument about A1P0's limitation on non-high vowels in Styler (2017).

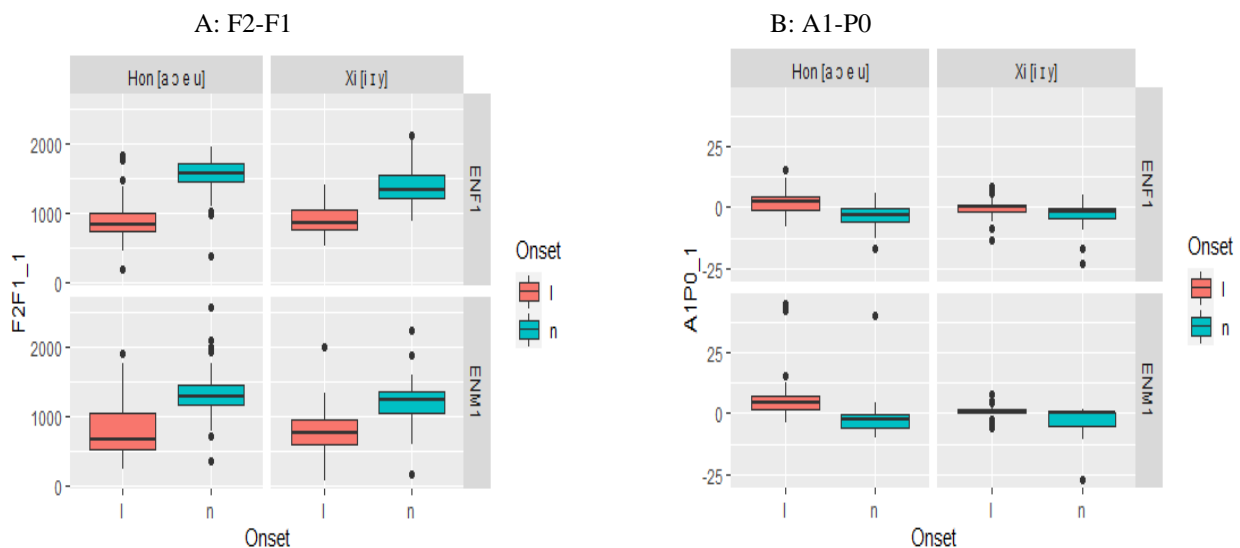


Figure 17. A comparison of F2-F1 vs A1-P0 between native English speakers.

Second, the difference of F2-F1 between /n/ and /l/ is greater than the one of A1P0. Therefore, F2-F1 provides clearer indications of nasality of onset consonant than A1P0.

F2-F1 is measured during the onset consonant interval while A1P0 is sampled in the following vowel interval. This explains why the former is better than the later regarding discriminating the two target consonants. Styler (2017) argues that A1P0 is the best single

number measure of vowel nasality available. Since this research is about the difference of the onset nasal and lateral consonants rather than the nasality of vowels, F2-F1 is chosen as the only acoustic cue for the other analysis.

6.1.2 Cross-Speaker Comparison

Cross-speaker comparison of vowel formants without normalization is meaningless due to individual variability, it is the same case for F2-F1 since F2-F1 is calculated from formants' frequencies. Therefore, cross-speaker F2-F1 comparison in this paper only focuses on overall patterns rather than specific value of acoustic cues.

Figure 18 shows the overall F2-F1 pattern of the /n/-/l/ merger in the target Dingxi group. Four participants, DXF1, DXF3, DXM1, and DXM4 are analyzed and compared with two native English speakers. The other participants in the target Dingxi group were not analyzed for nasality due to compromised recording quality (background noise, speaking too fast, or/and talking of other people by side in the college dormitory room).

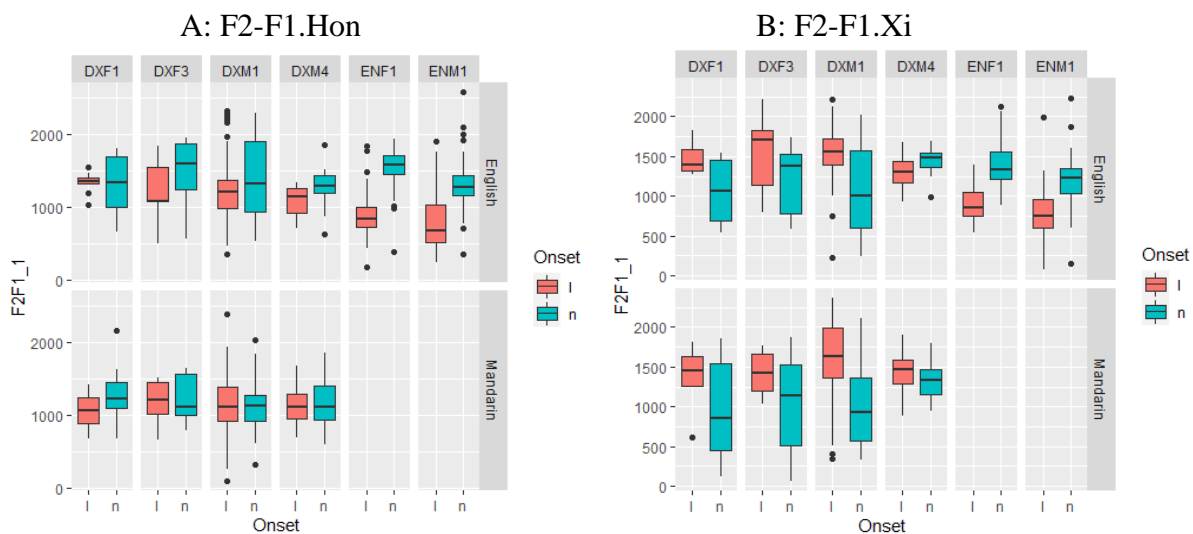


Figure 18. A comparison of Hon vs Xi regarding the overall F2-F1 pattern among Dingxi Mandarin speakers.

The boxplots in Figure 18 (A) shows participants' F2-F1 spacing between /n/ and /l/ for Hon rhymes of both English and Mandarin. Four Dingxi participants show a consistent pattern of /n/-/l/ merger in Mandarin, their boxplots of /n/ and /l/ are overlapped and the medians of /n/ and /l/ are close to each other. In the L2 English part, while the medians of /n/ and /l/ for the Dingxi group fall apart the boxplots of /n/ and /l/ are largely overlapped with the exception of DXM4(only some overlap).

In Figure 18 (B) for Xi rhymes, Dingxi participants have more separated F2-F1 value for both L2 English and Mandarin than for Hon rhymes. Participants DXF1, DXF3, and DXM1 have greater F2-F1 spacing than DXM4. Native English speakers' F2-F1 spacing between /n/ and /l/ are clearly separated regardless of Hon or Xi rhymes.

However, the same puzzling reversed /n/-/l/ pattern in Xi rhymes for the Dingxi group comparing to native speakers, attest in both L2 English and Mandarin for DXF1, DXF3, and DXM1, except DXM4 in L2 English. DXM4 has slightly higher F2-F1 value for /n/ than /l/, more like English native speakers, although overlapped and not clearly separated as them. Participants DXF1, DXF3, DXM1, and DXM4 were interviewed for their sensations of the velum position during the articulation of /n/ and /l/. They all gave positive feedback for Xi rhymes about the coarticulation of velum and tongue tip and the resonance between nasal and oral cavities. However, they were not sure about the velum position in Hon rhymes because they could not feel the resonance between nasal and oral cavities. The velum coarticulation theory explains the overall pattern of the F2-F1 pattern among Dingxi Mandarin speakers, at least for Xi rhymes. For Hon rhymes, medical instruments such as MRI or ultra-sound are needed to examine the velum movement of participants.

6.2 Phonological Analysis – [n/l] Assessment

Below Table 19 shows a brief summary of [n/l] assessment for the target Dingxi group (all 13 members).

Language	Onset	Hon/ Xi	Yin/ Yang	[n] Mean	[n] SD	[l] Mean	[l] SD	[ŋ] Mean	[ŋ] SD
Mandarin	l	Hon	Yin	0%	0%	100%	0%	0%	0%
Mandarin	l	Xi	Yin	5%	7%	95%	7%	0%	0%
Mandarin	n	Hon	Yin	12%	8%	88%	8%	0%	0%
Mandarin	n	Xi	Yin	98%	2%	2%	2%	0%	0%
L2 English	l	Hon	Yin	0%	0%	100%	0%	0%	0%
L2 English	l	Xi	Yin	0%	0%	100%	0%	0%	0%
L2 English	n	Hon	Yin	26%	13%	74%	13%	0%	0%
L2 English	n	Xi	Yin	97%	4%	3%	4%	0%	0%
Mandarin	l	Hon	Yang	0%	0%	27%	39%	73%	39%
Mandarin	l	Xi	Yang	0%	0%	97%	1%	3%	1%
Mandarin	n	Hon	Yang	74%	4%	17%	9%	9%	13%
Mandarin	n	Xi	Yang	100%	1%	0%	1%	0%	0%
L2 English	l	Hon	Yang	0%	0%	95%	6%	4%	6%
L2 English	l	Xi	Yang	0%	0%	100%	0%	0%	0%
L2 English	n	Hon	Yang	35%	44%	63%	43%	2%	3%
L2 English	n	Xi	Yang	97%	3%	3%	3%	0%	0%

Table 19. Summary of [n/l] assessment for target Dingxi participants.

There are high rates of n→l before Hon Yin rhymes in both Mandarin (88%) and L2 English (74%), which indicates the n-l merger in Dingxi Mandarin and its transferred to L2 English. Nasal codas significantly reverse the n-l merger before Hon Yang rhymes in Dingxi Mandarin (n→l = 17%), although only reduce the n→l rate in L2 English from 74% to 63%. Meanwhile, nasal codas nasalized onset [l] before Hon Yang rhymes by 73% in Dingxi Mandarin while 4% in L2 English.

6.2.1 Onset [n]

Figure 20 shows a cross-vowel comparison regarding the perception of onset [n] without nasal coda in Dingxi Mandarin.

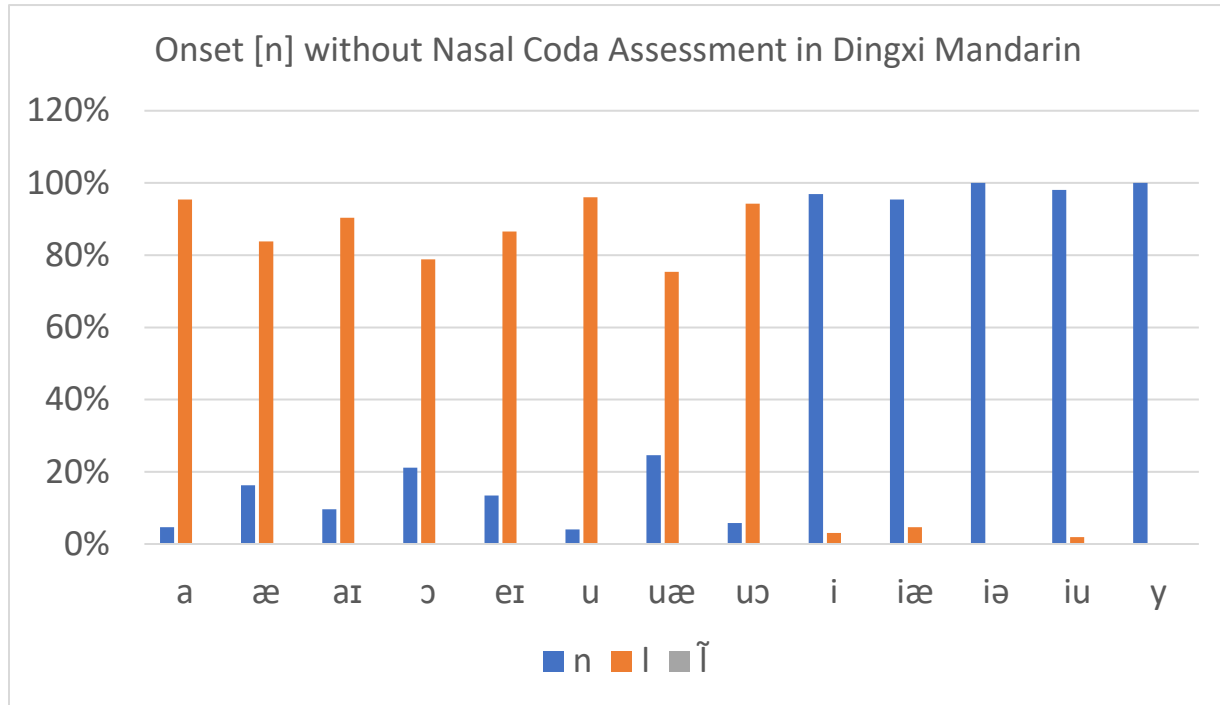


Figure 20. A cross-vowel comparison regarding the perception of onset [n] without nasal coda in Dingxi Mandarin.

In Dingxi Mandarin, onset [n] is highly perceived as [l] before Hon Yin rhymes [a, æ, ai, ɔ, ei, u, uæ, uɔ] while as [n] before Xi Yin rhymes [i, iæ, iə, iu, y]. This confirms Tian (2009) categorisation of Dingxi Mandarin as Hon-Xi-Rhyme Conditional.

Figure 21 shows a cross-vowel comparison regarding the perception of onset [n] without nasal coda in Dingxi L2 English.

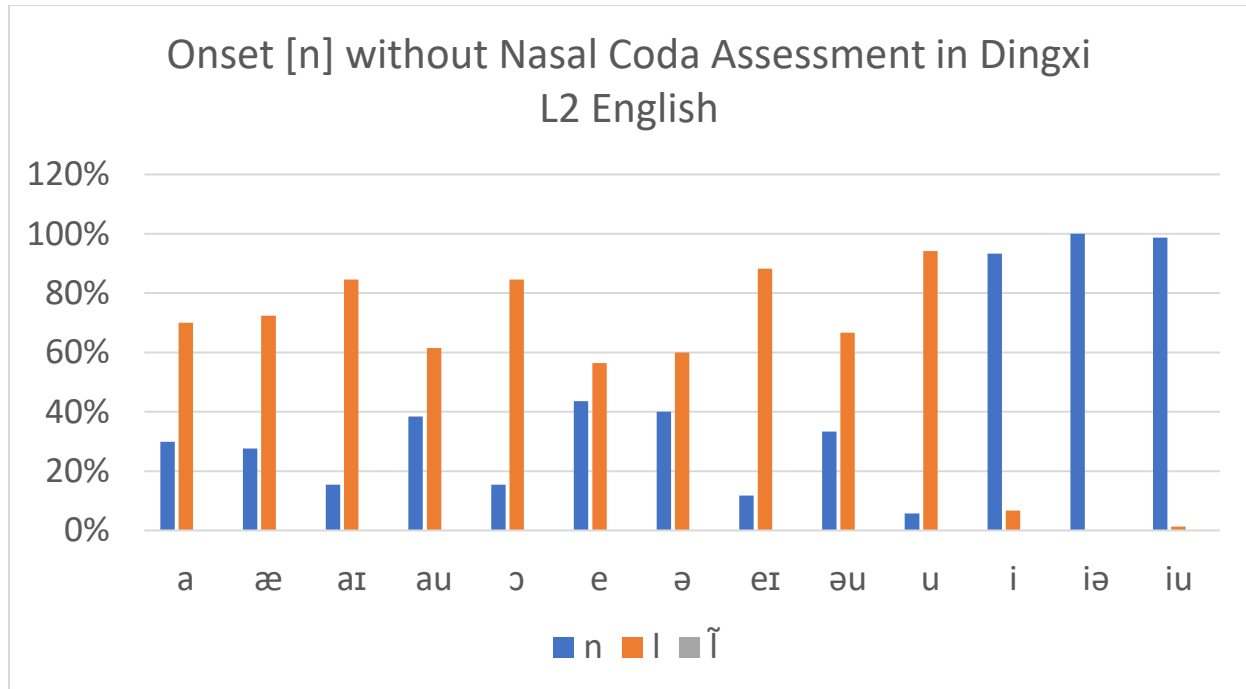


Figure 21. A cross-vowel comparison regarding the perception of onset [n] without nasal coda in Dingxi L2 English.

In Dingxi L2 English, onset [n] is highly perceived as [l] before Hon Yin rhymes [a, æ, ai, au, ɔ, e, ə, eɪ, əu, u] while as [n] before Xi Yin rhymes [i, iə, iu]. A consistent pattern comparing with Dingxi Mandarin which suggests a transfer from L1 to L2 English.

A cross-speaker comparison (Figure 22) shows the percentage of onset [n]s becoming onset [l]s before Hon rhymes in Mandarin and English in the target Dingxi and control groups.

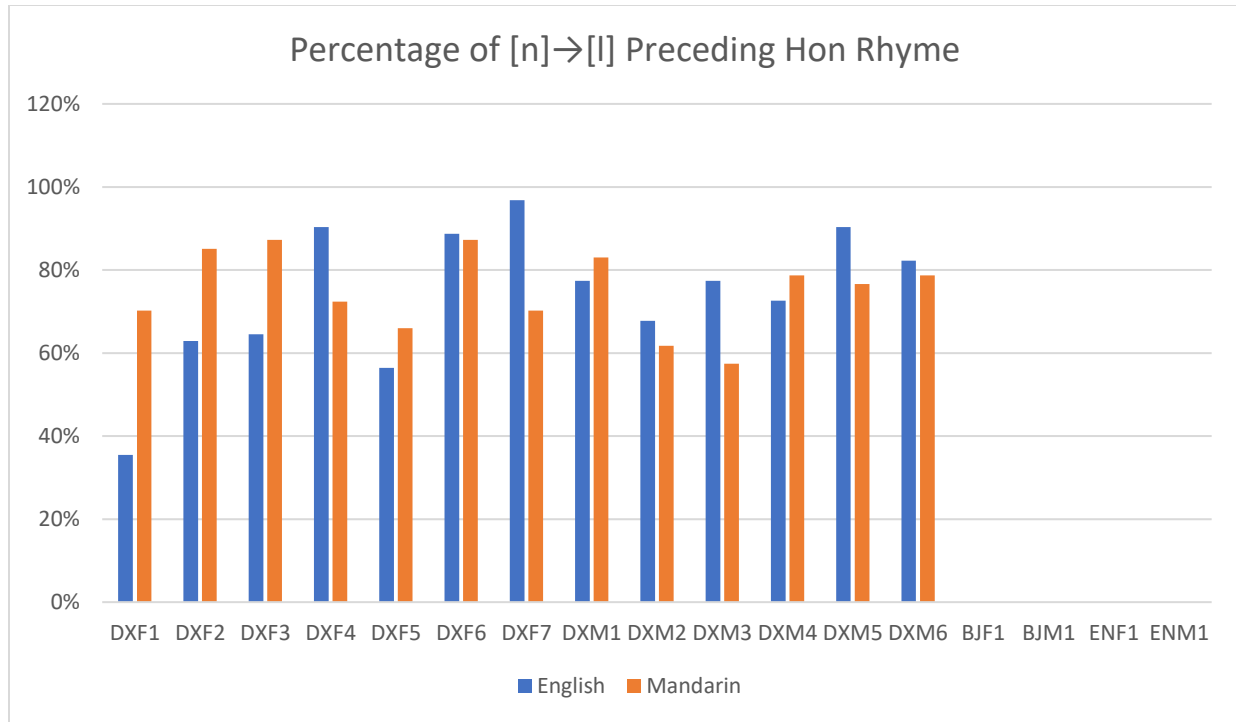


Figure 22. Percentage of [n]→[l] before Hon rhymes, a cross-speaker comparison.

Speakers in both Beijing and native English control groups attest 0% of [n]→[l] preceding Hon rhymes in both languages. While speakers in the target Dingxi group attest 74% in English and 75% in Mandarin on average. It shows that the /n-/l/ merger in Dingxi Mandarin transfers into L2 English and leads to a weak alveolar nasal [n] in speakers' L2 English productions.

6.2.2 Onset [l]

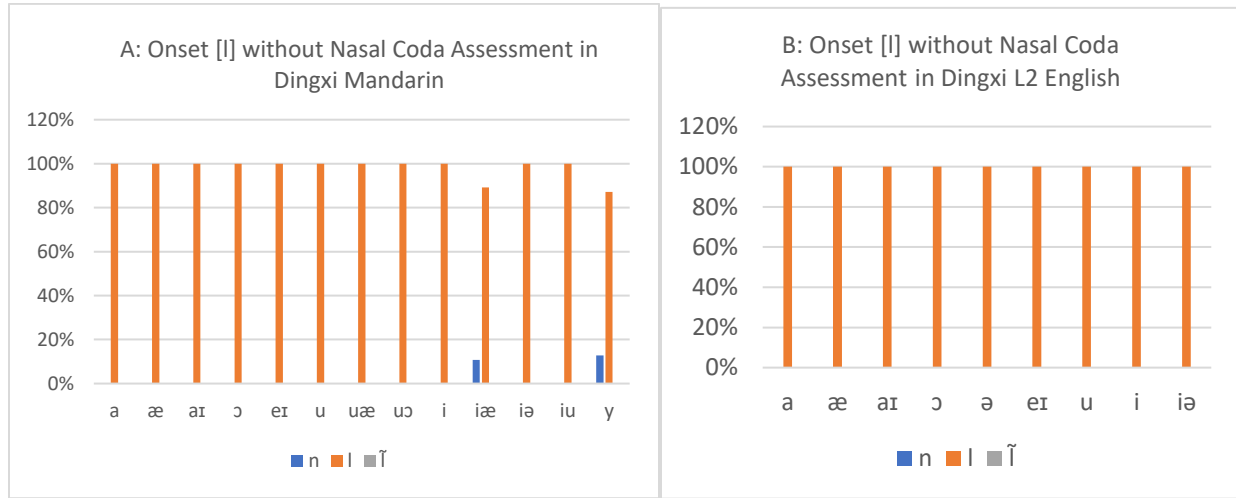


Figure 23. A comparison between L1 Mandarin and L2 English regarding the perception of onset [l].

The lateral [l] does not become alveolar nasal [n] in both L1 Mandarin and L2 English, with the exception of two characters in Dingxi Mandarin, 脸[liæ] ‘face’ and 铝[ly] ‘aluminum’, being articulated with onset alveolar nasal [n] rather than the lateral [l] (Figure 23-A).

脸[liæ] ‘face’ is always replaced by 眼[niæ] ‘eye’ in Dingxi Mandarin, while other homophones of [liæ], including 练 ‘practice’, 连 ‘connection’, 联 ‘unite’ etc., are never pronounced as [niæ]. Therefore, it is rather a morphological process of substituting 脸[liæ] ‘face’ with 眼[niæ] ‘eye’ than a phonological process of replacing the onset [l] with [n].

铝[ly] ‘aluminum’, on the other hand, is a different story. There's a legend shared in the Dingxi community that when some aluminum pots were introduced to the region in the 1930s they were mistakenly called 女[ny] ‘female’ pots. It is also true that other homophones of [ly],

驴 ‘donkey’, 绿 ‘green’, and 律 ‘rules’, are never articulated as [ny]. This is also a morphological process rather than a phonological one.

Ruling out these two exceptional characters, there is no other evidence of lateral [l] becoming alveolar nasal [n] in Dingxi Mandarin.

6.2.3 Nasal Coda and the n-l merger

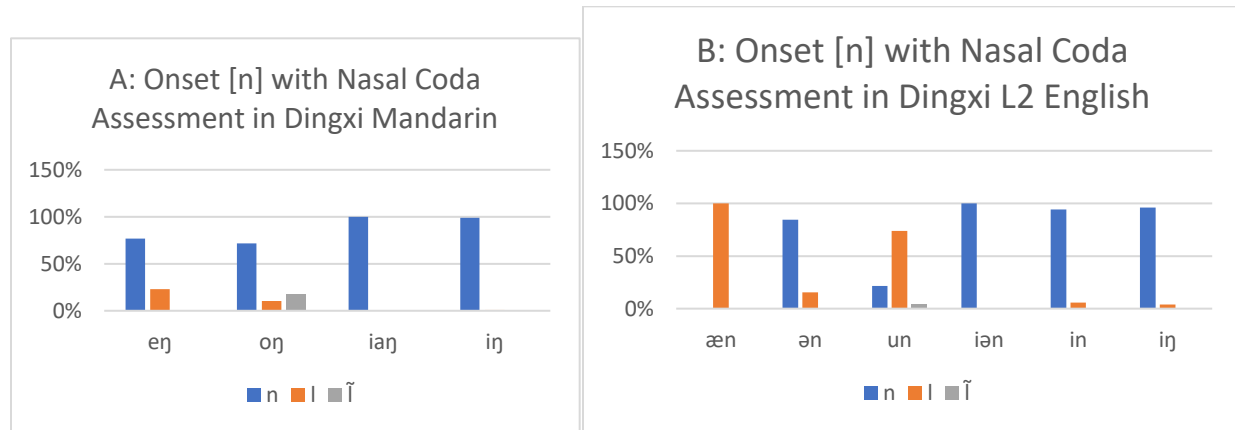


Figure 24. A comparison between Dingxi Mandarin and L2 English regarding the influence of nasal coda on the perception of onset [n].

Figure 24-A shows that nasal codas significantly reverse the n-l merger before Hon Yang rhymes in Dingxi Mandarin, the n→l rate drops from 88% before Hon Yin rhymes to 17% preceding Hon Yang rhymes. However, in Figure 24-B of L2 English the n-l merger pattern remains for [æ̃n, un] but not for the shwa [ə̃n]. Considering Mandarin is a mono syllabic language, most tokens for L2 English are word-initially positioned or stressed, except the shwa [ə̃n]. Unstressed tokens for the shwa plus a nasal coda, e.g., *Lieutenant*, are included in the tests. The possible reasons for difference between [ə̃n] and [æ̃n, un] are, word-initial position, stress,

and smaller openness of mouth for shwa (which makes it more like a Xi rhyme for Dingxi Mandarin-speaking English learners). Further study needs to be done to address this issue.

6.2.4 Nasalized [ĩ]

A comparison between Dingxi and Beijing Mandarin speakers regarding the nasalization of [l] by a nasal coda in both L1 Mandarin and L2 English is shown in Figure 25 and 26.

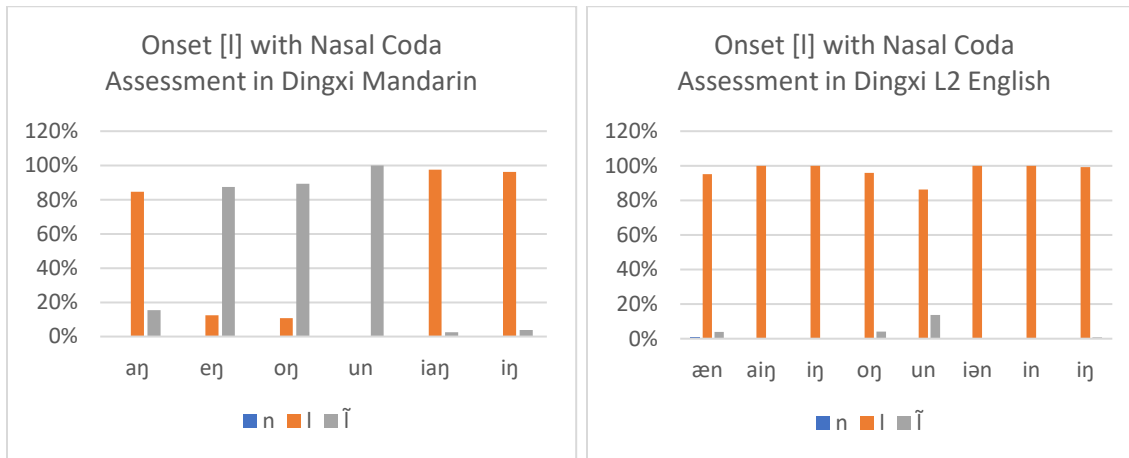


Figure 25. Comparison between Dingxi Mandarin and L2 English regarding nasalized [ĩ]

In Dingxi Mandarin, nasalized [ĩ] is frequently produced before Hon Yang rhymes [eŋ], [oŋ], and [un] but not [aŋ] ([æŋ] and [aiŋ] do not exist in Dingxi and Beijing Mandarin), while rarely before Xi Yang rhymes [iaŋ], [in], and [iŋ].

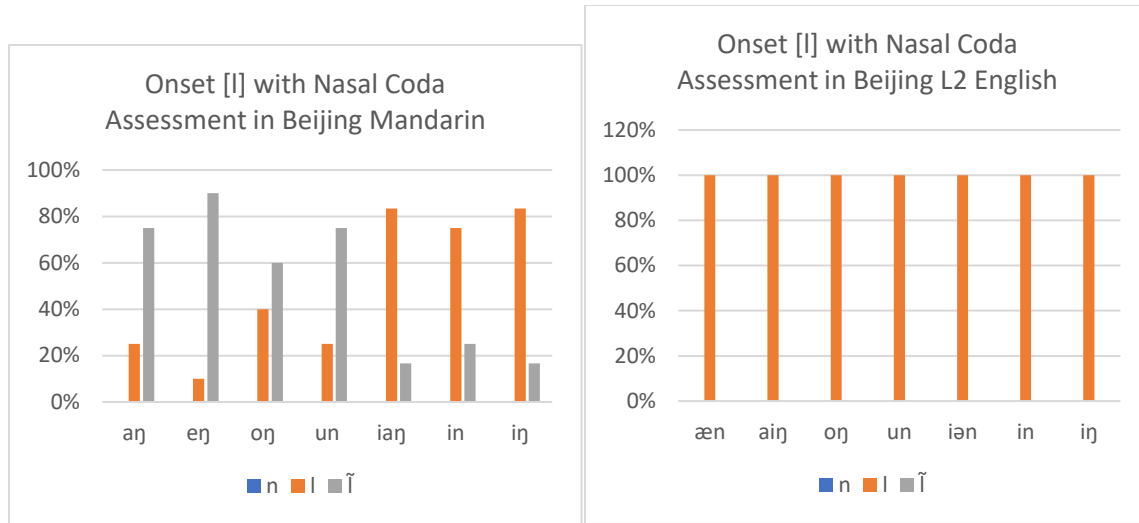


Figure 26. Comparison between Beijing Mandarin and L2 English regarding nasalized [l̃]

In Beijing Mandarin, the onset [l] nasalization pattern is similar with Dingxi Mandarin before Hon Yang rhymes [eŋ, oŋ, un], however different when preceding [aŋ], [iaŋ], and [in]. There is no transfer of the onset [l] nasalization to L2 English in the Beijing group while only a slight transfer in Dingxi group. This onset [l] nasalization is not consistent with the pattern of /n-/ /l/ merger before Hon rhymes and shows great individual variability. Both native English speakers demonstrate no onset [l] nasalization.

The above evidence shows that Mandarin onset [l] is more susceptible to the influence of a nasal coda than English, which can be explained with the Chinese syllable isochrony feature. Kao (1971) argues that Cantonese syllables have a duration of approximate 300ms regardless of how many segments in a syllable/character. Mandarin syllables are not as strictly isochronous as Cantonese, although also maintain a roughly equal duration for each character. Duanmu (2000) gives a Standard Chinese syllable structure (C)(G)V(N), and argues that Chinese syllables are more temporally compressed than other languages. This isochronous compression on syllable duration pushes the nasal coda closer to the onset [l] and leads to more of anticipatory nasalization.

7 Discussion

The results of nasality measurement and [n/l] assessment answer all the five research questions. First, F2-F1 is the best acoustic cue regarding distinguishing the alveolar nasal and lateral. Second, the /n/-/l/ merger happens before Hon rhymes in Dingxi Mandarin. Third, both the acoustic and the subjective phonological analysis suggest the transfer of the /n/-/l/ merger from L1 Mandarin to L2 English. Fourth, the /n/-/l/ merger is rather a convergence of the two consonants than a substitution of one with the other. Finally, the coarticulation of velum and tongue tip is the proposed articulatory mechanism that can explain the /n/-/l/ merger.

7.1 F2-F1 is the Best Acoustic Cue

Both F2-F1 and A1-P0 clearly distinguish /n/ and /l/ in the two native English speakers in the study, while the other acoustic cues (F3, BW1, DeltaA1, and Relative RMS) do not. F2-F1 is better than A1-P0 because the former provides further nasality distance between /n/ and /l/ than the later, besides A1-P0 has a limitation of non-high vowels while F2-F1 has not. Meanwhile, F2-F1 is a direct measurement on the target consonant while A1-P0 is an indirect test of the vowel nasality following the target consonant. Therefore, F2-F1 is the best acoustic cue to distinguish /n/ and /l/ in onset position.

7.2 The /n/-/l/ Merger and Its Transfer to L2 English

The individual F2-F1 acoustic analysis of participant DXM1 shows that /n/ and /l/ merge before Hon rhymes whilst stay contrastive proceeding Xi rhymes in Dingxi Mandarin. A similar F2-F1 pattern shows up in DXM1's English, indicating a transfer from L1 Mandarin to L2

English. The overall F2-F1 pattern cross four Dingxi participants and two native English controls demonstrates a consistent /n/-l/ merger in Hon rhymes of the Dingxi group members, as well as a transfer of this phenomenon from L1 Mandarin to L2 English.

In the [n/l] assessment, the target Dingxi group show a high percentage of [n]→[l] before Hon rhymes and low percentage preceding Xi rhymes in both Mandarin and English, while the Beijing and English control groups attest zero percent of [n]→[l] in both types of rhymes regardless of Mandarin or English.

7.3 A Convergence of /n/ and /l/ Instead of One Becomes the Other.

The individual F2-F1 boxplots of DXM1 shows that /n/ and /l/ converge to a place between the two consonants and become nearly identical before Hon rhymes in Dingxi Mandarin. This is clear evidence against previous literatures' claim of one becomes the other in the /n/-l/ merger.

7.4 The /n/-l/ Merger Relates to Velum and Tongue Tip Coarticulation

The author, born and raised in Dingxi, hypothesizes that there is a coarticulation of the velum and the tongue tip for the alveolar nasal /n/ in Dingxi Mandarin. The velum limits the connection to the nasal cavity in the same way as the tongue tip reducing the openness of the oral cavity by pushing close to the alveolar, which leads to a limited opening of the nasal cavity and consequently reduce the nasality of the alveolar nasal.

7.5 Isochrony of Chinese Syllable and the Anticipatory Nasalization

The anticipatory nasalization of onset /l/ by a nasal coda is not the case of /n/-l/ merger for Dingxi Mandarin. First, it is not associated with Hon/Xi rhymes. Second, the $l \rightarrow \tilde{l}$ count is much lower than the $n \rightarrow l$ count. Third, there is great individual variability among Dingxi and Beijing participants. Lastly, it is exhibited in neither L1 nor L2 English.

However, the Chinese syllable isochrony feature can explain such difference between Mandarin and English. Chinese languages maintain a roughly equal duration for each syllable /character (Kao, 1971). A syllable with multiple segments, e.g., nasal coda, is temporally compressed to fit all segments in a fixed duration (Duanmu, 2000). This isochronous compression on syllable pushes the nasal coda closer to the onset [l] and leads to higher chance of anticipatory nasalization.

7.6 Limitations

This study has certain limitations on the audio recording quality, stimuli sentence, age of target participants, cross-speaker F2-F1 comparison, and lack of evidence on velum coarticulation theory.

Some of the audio files of the Dingxi participants have compromised recording quality. Because the recordings are remotely collected through the Chinese social media platform Wechat, the author has no control over the recording environment. Nine out of sixteen recordings received have background noises, low volume, talking of other people by side, and other issues that led to reduced number of participants in the acoustic analysis.

Natural sentences are challenging for acoustic analysis. Segments are mixed and make it difficult for the annotation job in the Praat software. Although the Nasality Automeasure Script

works like a charm, the annotation scripts (Label from Text File, Montreal Forced Aligner, etc.) do not. Eventually the entire annotation task was done manually. Carrier sentences may be better for onset /n/ and /l/ acoustic analysis.

The age of target Dingxi participants might also be an issue. Participants were college students born and raised in Dingxi, age from 18 to 19. Many of them speak authentic Standard Mandarin in the oral consent, which shows that the government's Standard Mandarin policy has put great influence on local dialects. The older generation may have been a better participant pool. However, it is difficult to find older people with good English proficiency.

The cross-speaker F2-F1 comparison is only focused on the overall pattern not specific acoustic cues. F2-F1 normalization could have been done to overcome the individual variability with the formant frequencies. Finally, the velum coarticulation hypothesis is based on the author's intuition. Velum position measurement, MRI, ultra-sound imaging etc., could provide evidence for it.

7.7 Further Study

7.7.1 Other Mandarin Dialects & Chinese Languages with /n/-/l/ Merger

The same research should be extended to other Mandarin dialects and Chinese languages. The alveolar nasal has great individual and dialectal variability in Chinese languages. Cross-dialect study could possibly verify the velum coarticulation theory.

7.7.2 F2-F1 Normalization

Since the F2-F1 value is calculated from the frequency difference between F2 and F1 and frequencies of vowel formants need to be normalized for cross-speaker comparison, the F2-F1

value also needs to be normalized for cross-speaker comparison. Flynn (2011) argues that the Bigham normalisation procedure (Bigham, 2008) performs the best regarding the results of equalising and aligning the vowel space areas of different speakers.

The F2-F1 normalization is not done in this research due to the compromised recording quality of sound files collected through the Chinese social media Wechat. The 13 participants in the target Dingxi group recorded their voice in the dormitories of universities, nine recordings have strong background noises and other people talking by side. There is little research on nasal/lateral formants normalization despite well studied vowel formants normalization.

7.7.3 Velum position measuring

Velum position measuring can provide direct evidence for the velum coarticulation hypothesis. The present available medical machines, MRI, ultra-sound imaging, etc., could be helpful for understanding the velum movement during the articulation of alveolar nasal.



Figure 27. Laryngograph Device, http://www.laryngograph.com/pr_studio.htm

The Laryngograph device shown in Figure 27 could be modified for velum position measuring. One of the two electrodes could be modified with dental materials and be attached next to the velum, while the other electrode goes to the back of neck to let the electric current flow through the velum and the entry of the nasal cavity. The Laryngograph should be able to show the openness of nasal cavity just like it does with vocal folds.

8 Conclusion

Both acoustic and phonological analyses confirm the Tian (2009) argument about the /n/-/l/ merger before Hon rhymes in Dingxi Mandarin. The nasality measurement and [n/l] assessment suggests the transfer of the merger from L1 Mandarin to L2 English.

Either F2-F1 or A1P0 clearly distinguishes /n/ and /l/ in native English, F2-F1 is the better choice than A1P0 because it provides further distance between /n/ and /l/ without any limitations on the phonological environment. F2-F1 directly measures the target consonants while A1P0 measures the nasality of the vowel following the target consonant.

The /n/-/l/ merger in Dingxi Mandarin is rather a convergence of the two consonants than a substitution of one with the other. The individual acoustic analysis shows that the F2-F1 spacing of /n/ and /l/ converge to a place in between of the two rather than /n/ moves to the position of /l/. This is a new contribution as all previous literatures claims the /n/-/l/ merger in Dingxi Mandarin as a case of substitution.

The velum coarticulation hypothesis explains everything. It provides an explanation for the reduced nasality of alveolar nasal before Dingxi Mandarin. It explains why the F2-F1 value of /n/ and /l/ converge to a place in between in Hon rhymes. It explains the reversed F2-F1 pattern in Dingxi Mandarin Xi rhymes comparing to native English speakers. However, it needs experimental articulatory evidence to prove it.

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Appendix A – Chinese Sentences

	Chinese Sentences	Nbr of Tokens
1	吾个女[ny]娃娃孽[niə]障地很, 没饭吃。	2
2	兴隆[loŋ]山和梁[lian]山不是一个山, 临[lin]洮和陇[loŋ]西不是一搭的。	4
3	我咯着兰[læ]州拉[la]面没浆水面好吃, 我不放辣[la]椒吃不着下起。	3
4	吾个老[lo]奶[nai]奶[nai]到纽[niu]约旅[ly]游起了。	5
5	听说李[li]娜[na]会打网球, 爱吃腊[la]肉。	3
6	中央电视台的倪[ni]萍没有来[lai]过会宁[niŋ], 但是去过平凉[lian]。	4
7	吾个无赖[lai]乱[luæ]扔垃圾, 把地上弄[noŋ]地乱[luæ]七八糟。	4
8	我听说南[næ]瓜越老[lo]越香, 莲[liæ]藕越嫩[nen]越脆。	4
9	地暖[nuæ]比暖[nuæ]气暖[nuæ]和, 屋里[li]过年[niæ]一点都不冷[len]。	6
10	隔壁的刘[liu]罗[luə]锅上西岩山打猎[lia], 打住了一只野狼[lan]。	4
11	居里[li]夫人工作很努[nu]力[li], 你[ni]们要向她好好学习。	4
12	会宁[niŋ]人讲礼[li]貌, 兰[læ]州人叫师傅。	3
13	吾个农[noŋ]贸市场里[li]面有鸟笼[loŋ]子、磷[liŋ]肥、粮[lian]食、和毛驴[ly]。	6
14	牛[niu]旺的女[ny]朋友很漂亮[lian]。	3
15	下雨打雷[lei]不要在外面捏[niə]泥[ni]巴玩,	3
16	电动汽车用地是锂[li]电池不是镍[niə]铬电池。	2
17	秋天的粮[lian]食收割了要放着马路[lu]上, 让路[lu]过的汽车碾[niæ]压。	4
18	列[lia]宁[niŋ]会写字, 鲁[lu]班会木工, 哪[na]吒会闹[nə]海。	5
19	会宁[niŋ]的南[næ]山寺里[li]面有两个尼[ni]姑, 一个弥勒[lo]佛。	5
20	可乐[lo]比杏仁露[lu]甜, 骡[luə]子比毛驴[ly]大。	4
21	河南[næ]洛[luə]阳是一个交通枢纽[niu],	3
22	师大有些黎[li]巴嫩[nen]来[lai]的留[liu]学生, 他们爱打篮[læ]球。	5
23	去年[niæ]特别冷[len], 西伯利[li]亚的冷[len]空气经常来[lai]。	5
24	电脑[nə]不是脑[nə]袋, 纳[na]米不是糯[nuə]米, 莫言不是诺[nuə]言。	5
25	倒下, 为国捐躯的烈[lia]士; 起来, 不愿做奴[nu]隶[li]的人们。	3
26	大脓[noŋ]包爱吃小笼[loŋ]包, 癞[lai]蛤蟆爱吃天鹅肉。	3
27	吾个刘[liu]姥[lo]姥[lo]穿上耐[nai]克鞋浪[lan]展览[læ]馆起了。	6
28	冻梨[li]要放到零[liŋ]下才能冻住。	2
29	植树造林[lin]可以把荒山变成绿[ly]色的。	2
30	三八妇女[ny]节, 领[liŋ]导给女[ny]职工发了太阳能[nen]炉[lu]子和铝[ly]合金锅。	6
31	坐牢[lo]可耻, 劳[lo]动光荣。	2
32	在海底捞[lo]不能捞[lo]鱼, 可以吃火锅。	2
33	电壶内[nei]胆是保暖[nuæ]的, 但是得把盖子拧[niŋ]紧。	3
34	干活要干净利[li]落[luə], 不要拖泥[ni]带水。	3
35	鲁[lu]迅写地呐[na]喊, 聂[niə]耳写地国歌。	3
36	去年[niæ]的龙[loŋ]舟比赛说不让女[ny]娃子参加, 吾个小姑娘[niag]不服气, 还请了律[ly]师打官司。	5

37	吾个愣[leŋ]头愣[leŋ]脑[nɔ]的男[næ]人其实很能[neŋ]干，是色都会做。	5
38	昆仑[lun]山上有骆[luɔ]驼，没有梅花鹿[lu]。	3
39	唱皮影子戏要点蜡[la]烛，吹唢呐[na]。	2
40	张三总是耍赖[lai]皮，大家对他很无奈[nai]。	2
41	黄河流[liu]域普遍都有水土流[liu]失，但兰[læ]州安宁[niŋ]区比较严重。	4
42	碎旺早起刷牙洗脸[liæ]，然后在柳[liu]树底下念[niæ]了一阵子书。	3
43	国营炼[liæ]油厂为了利[li]益污染空气，但是老[lo]百姓敢怒[nu]不敢言。	4
44	看到娃娃们穿得很破烂[læ]，老[lo]师心里很难[næ]过。	3
45	牙疼吃莲[liæ]花清瘟胶囊[naŋ]不见起。	2
46	不怕男[næ]人是笨蛋，就怕男[næ]人太懒[læ]惰。	3
47	翻过栏[læ]杆，就到吾个蓝[læ]色帐篷的难[næ]民营了。	3
48	会宁[niŋ]没有柠[niŋ]檬，但是有萝[luɔ]卜。	3
49	我的邻[liŋ]居酿[nian]下的甜醅子甜地很，做下的凉[lian]皮也香地很。	3
50	我认为你的理[li]论[lun]虽然有道理[li]，但感觉很别扭[niu]。	4
51	孵化蚕卵[nuæ]需要付出很多努[nu]力[li]，不能气馁[nei]要坚持。	4
52	国内[nei]上大学太难[næ]，很多人选择留[liu]学。	3
53	对霸权不能懦[nuɔ]弱，对别人的承诺[nuɔ]也不能太当真。	2
54	新练[liæ]习册内[nei]容丰富、灵[liŋ]活多变，另[liŋ]外还有很多彩页，没有理[li]由不买一个。	5
55	风大了就容易流[liu]眼泪[lei]，天热了就爱打雷[lei]。	3

tokens per sentences

3.6

total number of tokens

197

Appendix B – English Sentences

(Some Chinese definitions provided to help participants)

	English Sentences	Nbr of Tokens
1	He likes basketball and Nike shoes.	2
2	Don't be such a ninny(笨蛋), you can't feed Alina peanuts, you know she is allergic.	3
3	Coke Cola is popular in Nepal(尼泊尔).	2
4	The naïve(无知的) girl believes all of Luke's lies. Luke is as cunning(狡猾)as a fox.	5
5	Yesterday Nathan said to Norman, "Have a nice afternoon".	4
6	Donald Trump is a narcissist(自恋狂). Lieutenant (上尉) Lance is a native American.	5
7	Vaping(电子烟) is as narcotic(有毒害的) as smoking. Namibia(纳米比亚) is larger than Netherland(荷兰).	5
8	Everyone knows that Natasha likes noodles but hates needles(打针).	3
9	Yesterday at noon Nate lured(引诱) Leo to the lake.	5
10	Kamala received a scholar for being a cheerleader and playing good lute(乐器) melody.	6
11	It is normal to think a cat is sillier(更愚蠢) than a dog, but it lacks clear evidence.	3
12	The national language of Canada is English.	3
13	The mother changed her baby's nappy(尿不湿) on her lap.	1
14	The news reports that some radioactive(辐射) material leaked from the nuclear power station(核电站).	4
15	Having bad luck, I step on a banana peel and landed on my knees.	5
16	In Milan you need a license(执照) to be a nurse.	4
17	Linda wants to take a nap(打盹) at noon.	3
18	A knife is larger and longer than a needle.	4
19	My neighbor built a nice and neat doghouse in the saloon for Snoopy(史努比).	5
20	You know, New Jersey is near North Atlantic Ocean.	5
21	The Ninja(忍者) is wearing a white-collar T-shirt, a souvenir(纪念品) from his Japan trip.	3
22	The riots(暴动) of slaves escalated(升级) to a civil war(内战).	2
23	The lock is broken, and we lost everything.	2
24	The landlord renewed the lease(租约) with him and fixed the spinning(旋转) blade(喷嘴) in the dish washer.	6
25	The cleaning machine is very useful and reliable.	3
26	The disease leads to a painful and lingering(慢慢的) death to the animal.	2
27	The link between the president's brother and the state company violates the law.	3
28	The loon, a large bird, is flying over Nordic(北欧) nations with its companion(伙伴).	6
29	The internship(实习) program ensures liaison(联系) between schools and employers.	2
30	Being multi-lingual(多语言的) is the norm(正常状态) in Canada.	3
31	The naughty boy chose the snake over a Nintendo(任天堂).	3
32	By eating neep and leek(两种蔬菜), Nina lost some weight, her clothes are loose for her now.	8
33	The walnut(核桃) veneer(木皮)of the furniture has burning marks.	3
34	In Mexicans' opinion, nachos(玉米卷) should be always served with onion.	3
35	A noobie's(新手的) luck doesn't last long in a casino(赌场), he/she could end up with nothing.	6

36	He was nabbed(逮捕) by the police for stealing, but his lawyer got him released the next day.	5
37	Those debts were a noose around his neck.	2
38	The balloon festival is on a loop(水岸) of the Yellow River, 30km south to the nuclear power station(核电站).	5
39	Having feelings for each other, they laid down together to look at the moon with their naked eyes.	4
40	The Union is calling for a lawful noontime(中午的) strike(罢工).	4
41	There is a laptop computer in the lab. The latitude(纬度) of the equator(赤道) is zero.	3
42	Last summer, Nancy was a volunteer in the Grand Canyon.	4
43	The Sicilian company provides a larger portfolio(系列) of wine than the Italian one.	4
44	Jolin gave her darlin(亲爱的) some chocolate at noon.	4
45	Diana uses Snapchat to share photos with her international friends.	2
46	The landslide(山崩) in Argentina is related to the flood.	4
47	One trillion(万亿/兆) equals one thousand billion(十亿), one billion equals one thousand million(百万).	4
48	The paint of the violin is peeling off, the chandelier(吊灯) above is crumbling(摇摇欲坠).	4
49	Canadian police arrested the suspect during a sting operation(钓鱼/卧底行动).	2
50	The astronaut(宇航员) and the engineer are turning the box to fix the engineering issue.	4
51	Tina is a linguist(语言学家), not a translator.	3
52	The tsunami(海啸) in New York is related to a lite earthquake.	4
53	That barrel(桶) of lard(猪油) is made from pig fat, it will be used to make body lotion(润肤露).	2
54	You need a ladder 梯子 to reach the latch(门闩) of the high window.	2

tokens per sentences

3.7

total number of tokens

198

Appendix C – Onset [n/l] assessment result for the Dingxi group

Dingxi Mandarin

Stc	W	IPA	Ryhme	NC	Onset	M1	M2	M3	M4	M5	M6	F1	F2	F3	F4	F5	F6	F7	n	l	ĩ
1	女	ny	y		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
1	孽	niə	iə		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
2	隆	loŋ	oŋ	NC	l	ĩ	ĩ	ĩ	ĩ	ĩ	ĩ	ĩ	ĩ	ĩ	ĩ	ĩ	ĩ	ĩ	0	0	13
2	梁	liɑŋ	iaŋ	NC	l	l	ĩ	l	l	l	l	l	l	ĩ	l	l	l	l	0	11	2
2	临	lin	in	NC	l	l	ĩ	l	l	l	l	l	l	ĩ	l	l	l	l	0	11	2
2	陇	loŋ	oŋ	NC	l	ĩ	ĩ	ĩ	ĩ	ĩ	ĩ	ĩ	ĩ	ĩ	ĩ	ĩ	ĩ	ĩ	0	0	13
3	兰	læ	æ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
3	拉	la	a		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
3	辣	la	a		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
4	老	lo	o		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
4	奶	naɪ	aɪ		n	l	n	l	l	l	l	l	l	l	l	l	l	l	1	12	0
4	奶	naɪ	aɪ		n	l	n	l	l	l	l	l	l	l	l	l	l	l	1	12	0
4	纽	niu	iu		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
4	旅	ly	y		l	l	l	l	n	l	l	l	l	l	l	l	l	l	1	12	0
5	李	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
5	娜	na	a		n	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
5	腊	la	a		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
6	倪	ni	i		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
6	来	laɪ	aɪ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
6	宁	niŋ	iŋ	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
6	凉	liɑŋ	iaŋ	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
7	赖	laɪ	aɪ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
7	乱	luæ	uæ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
7	弄	noŋ	oŋ	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
7	乱	luæ	uæ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
8	南	næ	æ		n	l	l	l	l	l	l	n	l	l	l	l	l	l	1	12	0
8	老	lo	o		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
8	莲	liæ	iæ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
8	嫩	nen	en	NC	n	n	n	l	l	l	n	l	n	n	n	n	l	n	8	5	0
9	暖	nuæ	uæ		n	l	n	l	l	n	l	l	l	l	n	n	l	n	5	8	0
9	暖	nuæ	uæ		n	l	n	l	l	n	l	l	l	l	n	n	l	n	5	8	0
9	暖	nuæ	uæ		n	l	n	l	l	n	l	l	l	l	n	n	l	n	5	8	0
9	里	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
9	年	niæ	iæ		n	n	n	l	n	n	n	n	l	l	n	n	n	n	10	3	0
9	冷	leŋ	eŋ	NC	l	ĩ	ĩ	l	-	l	l	ĩ	l	l	l	l	ĩ	l	0	8	4
10	刘	liu	iu		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0

10	罗	luo	uo		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
10	猎	lie	ie		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
10	狼	lan	an	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	10	3
11	里	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
11	努	nu	u		n	l	n	l	l	l	l	l	l	l	l	l	l	l	1	11	0
11	力	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	12	0
11	你	ni	i		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
12	宁	niŋ	iŋ	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
12	礼	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
12	兰	lan	an		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
13	农	noŋ	oŋ	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
13	里	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
13	笼	loŋ	oŋ	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	1	12
13	磷	liŋ	iŋ	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	11	2
13	粮	liang	iang	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
13	驴	ly	y		l	l	l	l	n	l	l	l	l	l	l	l	l	l	1	12	0
14	牛	niu	iu		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
14	女	ny	y		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
14	亮	liang	iang	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
15	雷	lei	ei		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
15	捏	nie	ie		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
15	泥	ni	i		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
16	锂	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
16	镍	nie	ie		n	n	n	-	n	-	n	n	n	n	n	n	n	n	11	0	0
17	粮	liang	iang	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
17	路	lu	u		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
17	路	lu	u		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
17	碾	nie	ie		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
18	列	lie	ie		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
18	宁	niŋ	iŋ	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
18	鲁	lu	u		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
18	哪	na/a	a/a		n	l	l	l	n	l	l	l	l	l	l	n	l	l	2	11	0
18	闹	no	o		n	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
19	宁	niŋ	iŋ	NC	n	n	n	n	l	n	n	n	n	n	n	n	n	n	12	1	0
19	南	nan	an		n	l	n	l	l	l	l	l	l	l	n	l	l	n	3	10	0
19	里	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
19	尼	ni	i		n	n	n	n	n	l	n	n	n	n	n	n	n	n	12	1	0
19	勒	le	e		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
20	乐	le	e		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
20	露	lu	u		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
20	骡	luo	uo		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0

20	驴	ly	y		l	l	l	l	n	l	l	l	l	l	n	l	l	l	2	11	0
21	南	næ	æ		n	l	l	n	l	l	l	l	l	l	l	l	l	n	2	11	0
21	洛	luɔ	uɔ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
21	纽	niu	iu		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
22	黎	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
22	嫩	nen	en	NC	n	n	l	l	l	l	l	l	n	l	l	l	l	n	3	10	0
22	来	lar	ar		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
22	留	liu	iu		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
22	篮	læ	æ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
23	年	niæ	iæ		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
23	冷	lenj	enj	NC	l	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	0	0	13
23	利	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
23	冷	lenj	enj	NC	l	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	0	0	13
23	来	lar	ar		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
24	脑	nɔ	ɔ		n	l	n	n	l	l	l	n	l	l	l	l	l	l	3	10	0
24	脑	nɔ	ɔ		n	l	n	n	l	n	n	l	l	l	l	l	l	n	5	8	0
24	纳	na	a		n	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
24	糯	nuɔ	uɔ		n	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
24	诺	nuɔ	uɔ		n	l	l	l	l	l	n	l	l	l	l	l	l	l	1	12	0
25	烈	liə	iə		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	12	0
25	奴	nu	u		n	l	l	l	l	l	l	l	l	l	l	l	l	l	0	12	0
25	隶	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	12	0
26	脓	noŋ	oŋ	NC	n	n	l	ǎ	ǎ	ǎ	ǎ	n	l	l	l	ǎ	ǎ	ǎ	2	4	7
26	笼	loŋ	oŋ	NC	l	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	0	6	7
26	癞	lar	ar		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
27	刘	liu	iu		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
27	姥	lɔ	ɔ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
27	姥	lɔ	ɔ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
27	耐	nar	ar		n	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
27	浪	lanj	anj	NC	l	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	ǎ	0	12	1
27	览	læ	æ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
28	梨	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
28	零	liŋ	iŋ	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
29	林	lin	in	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
29	绿	ly	y		l	l	l	l	l	l	l	l	l	l	n	n	l	l	2	11	0
30	女	ny	y		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
30	领	liŋ	iŋ	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
30	女	ny	y		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
30	能	nenj	enj	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
30	炉	lu	u		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
30	铝	ly	y		l	l	l	l	n	l	l	l	n	l	n	n	l	l	4	9	0

31	牢	lɑ	ɑ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
31	劳	lɑ	ɑ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
32	捞	lɑ	ɑ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
32	捞	lɑ	ɑ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
33	内	nei	ei		n	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
33	暖	nuæ	uæ		n	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
33	拧	niŋ	iŋ	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
34	利	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
34	落	luɑ	uɑ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
34	泥	ni	i		n	n	n	l	n	n	n	n	n	n	n	n	n	n	12	1	0
35	鲁	lu	u		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
35	呐	na	a		n	l	l	n	l	l	l	l	l	l	l	l	l	l	1	12	0
35	聂	niə	iə		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
36	年	niæ	iæ		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
36	龙	loŋ	oŋ	NC	l	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	0	0	13
36	女	ny	y		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
36	娘	niɑŋ	iɑŋ	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
36	律	ly	y		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
37	愣	leŋ	eŋ	NC	l	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	0	0	13
37	愣	leŋ	eŋ	NC	l	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	0	0	13
37	脑	nɑ	ɑ		n	l	l	n	n	n	l	l	l	l	l	l	l	l	3	10	0
37	男	næ	æ		n	l	l	l	l	l	l	l	l	l	l	n	l	l	1	12	0
37	能	neŋ	eŋ	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
38	仑	lun	un	NC	l	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	ŋ	0	0	13
38	骆	luɑ	uɑ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
38	鹿	lu	u		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
39	蜡	la	la		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
39	呐	na	a		n	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
40	赖	lai	ai		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
40	奈	nai	ai		n	l	l	n	l	l	l	n	l	l	l	n	l	l	3	10	0
41	流	liu	iu		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
41	流	liu	iu		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
41	兰	læ	æ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
41	宁	niŋ	iŋ	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
42	脸	liæ	iæ		l	n	l	l	n	n	n	n	l	l	n	l	l	n	7	6	0
42	柳	liu	iu		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
42	念	niæ	iæ		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
43	炼	liæ	iæ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
43	利	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
43	老	lɑ	ɑ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
43	怒	nu	u		n	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0

44	烂	læ	æ																	0	13	0	
44	老	lo	o																		0	13	0
44	难	næ	æ			n															2	11	0
45	莲	liæ	iæ																		0	13	0
45	囊	naŋ	aŋ	NC		n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
46	男	næ	æ			n															2	11	0
46	男	næ	æ			n															1	12	0
46	懒	læ	æ																		0	13	0
47	栏	læ	æ																		0	13	0
47	蓝	læ	æ																		0	13	0
47	难	næ	æ			n															1	12	0
48	宁	niŋ	iŋ	NC		n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
48	柠	niŋ	iŋ	NC		n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
48	萝	luo	uo																		0	13	0
49	邻	liŋ	iŋ	NC																	0	13	0
49	酿	niaŋ	iaŋ	NC		n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
49	凉	liɑŋ	iaŋ	NC																	0	13	0
50	理	li	i																		0	13	0
50	论	lun	un	NC		l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	0	13
50	理	li	i																		0	13	0
50	扭	niu	iu			n	n	n	n	l	n	n	n	n	n	n	n	n	n	n	12	1	0
51	卵	nuæ	uæ			n															1	12	0
51	努	nu	u			n															1	12	0
51	力	li	i																		0	13	0
51	馁	neɪ	eɪ			n															3	10	0
52	内	neɪ	eɪ			n															4	9	0
52	难	næ	æ			n															6	7	0
52	留	liu	iu																		0	13	0
53	懦	nuo	uo			n															1	12	0
53	诺	nuo	uo			n															1	12	0
54	练	liæ	iæ																		0	13	0
54	内	neɪ	eɪ			n															0	13	0
54	灵	liŋ	iŋ	NC																	0	13	0
54	另	liŋ	iŋ	NC																	0	13	0
54	理	li	i																		0	13	0
55	流	liu	iu																		0	13	0
55	泪	leɪ	eɪ																		0	13	0
55	雷	leɪ	eɪ																		0	13	0

Dingxi English

Stc	Word	IPA	Rm	NC	O	M1	M2	M3	M4	M5	M6	F1	F2	F3	F4	F5	F6	F7	n	l	l̥
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1	like	laɪ	aɪ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
1	nike	naɪ	aɪ		n	l	l	l	l	l	l	l	l	l	n	l	l	1	12	0	
2	ninny	nin	in	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0	
2	ninny	ni	i		n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0	
2	Alina	lin	in	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0	
2	Alina	na	a		n	l	n	n	n	n	n	n	n	l	n	-	n	10	2	0	
2	know	nəu	əu		n		n	l	l	l	l	n	n	n	l	n	n	l	6	6	0
3	Cola	lə	ə		l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0	
3	Nepal	nə	ə		n	l	-	l	n	n	n	-	n	-	n	n	l	l	6	4	0
4	naïve	naɪ	aɪ		n	l	l	l	l	l	l	n	n	n	l	n	l	l	4	9	0
4	Luke's	lu	u		l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0	
4	lies	laɪ	aɪ		l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0	
4	Luke	lu	u		l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0	
4	cunning	niŋ	iŋ	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0	
5	Nathan	neɪ	eɪ		n	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0	
5	Norman	nɔ	ɔ		n	l	l	l	l	l	l	n	l	l	l	l	l	1	12	0	
5	nice	naɪ	aɪ		n	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0	
5	afternoon	nun	un	NC	n	n	l	l	l	l	l	n	n	n	n	l	l	5	8	0	
6	narcissist	na	a		n	l	l	l	l	l	l	l	l	n	l	l	l	1	12	0	
6	Lieutenant	lu	u		l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0	
6	Lieutenant	nən	ən	NC	n	n	n	n	n	n	n	n	n	n	n	l	n	l	11	2	0
6	Lance	læn	æn	NC	l	n	l	l	l	l	l	l	l	l	l	l	l	1	12	0	
6	native	neɪ	eɪ		n	l	l	l	l	l	l	n	n	l	l	l	l	2	11	0	
7	narcotic	na	a		n	l	l	n	l	l	l	l	l	l	l	l	l	1	12	0	
7	Namibia	na	a		n	l	l	n	l	l	l	l	l	l	l	l	l	1	12	0	
7	larger	la	a		l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0	
7	Netherland	ne	e		n	l	l	n	l	n	n	l	l	l	l	l	l	3	10	0	
7	Netherland	læn	æn	NC	l	ŋ	l	l	l	l	l	l	l	l	l	l	l	0	12	1	
8	know	nəu	əu		n	-	l	l	l	l	l	n	l	n	l	l	l	2	10	0	
8	Natasha	na	a		n	l	l		l	l	l	n	l	l	l	l	l	1	11	0	
8	noodles	nu	u		n	l	l	l	l	l	l	n	l	l	l	l	l	1	12	0	
8	needles	ni	i		n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0	
9	noon	nun	un	NC	n	n	l	n	l	l	l	n	l	l	l	l	l	3	10	0	
9	Nate	neɪ	eɪ		n		l	l	l	l	l	l	l	n	l	l	l	1	11	0	
9	lured	lu	u		l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0	
9	Leo	liəu	iəu		l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0	
9	lake	leɪ	eɪ		l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0	
10	Kamala	la	a		l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0	
10	scholar	lə	ə		l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0	
10	leader	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0	
10	playing	leɪ	eɪ		l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0	

10	lute	lu	u		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
10	melody	lə	ə		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
11	normal	nɔ	ɔ		n	l	n	n	l	l	l	n	n	l	l	l	l	l	4	9	0
11	sillier	liə	iə		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
11	lack	læ	æ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
11	clear	liə	iə		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
12	national	næ	æ		n	l	n	n	n	l	l	n	n	l	l	n	l	l	6	7	0
12	language	læn	æn	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
12	Canada	nə	ə		n	l	l	l	n	l	l	n	n	l	l	n	l	l	4	9	0
13	nappy	næ	æ		n	l	l	l	l	l	l	n	l	n	l	l	l	l	2	11	0
14	news	niu	iu		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
14	leaked	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
14	nuclear	niu	iu		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
14	nuclear	liə	iə		l	l	l	l	l	l	l	-	l	l	l	l	l	l	0	12	0
15	luck	la	a		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
15	banana	na	a		n	l	n	n	l	l	l	n	n	n	l	n	l	l	6	7	0
15	banana	nə	ə		n	l	n	l	l	l	l	n	n	l	l	l	l	l	3	10	0
15	landed	læn	æn	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
15	knees	ni	i		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
16	Milan	læn	æn	NC	l		l	l	l	l	l	l	l	l	l	l	l	l	0	12	0
16	need	ni	i		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
16	license	laɪ	aɪ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
16	nurse	nə	ə		n	l	n	n	n	l	l	n	n	l	n	l	l	l	6	7	0
17	Linda	lin	in	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
17	nap	næ	æ		n	l	n	n	l	l	l	n	l	n	l	n	l	l	5	8	0
17	noon	nun	un	NC	n	n	l	l	l	l	l	n	l	l	l	l	l	l	2	11	0
18	knife	naɪ	aɪ		n	l	l	n	l	l	n	n	l	n	l	n	l	l	5	8	0
18	larger	la	a		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
18	longer	loŋ	oŋ	NC	l		l	l	l	l	l	l	l	l	l	l	l	l	0	12	0
18	needle	ni	i		n	n	n	n	n	n	n	n	n	n	l	n	n	l	11	2	0
19	neighbor	neɪ	eɪ		n	l	l	l	l	l	n	l	l	l	l	l	l	l	1	12	0
19	nice	naɪ	aɪ		n	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
19	neat	ni	i		n	n	n	n	n	n	n	n	n	n	l	l	n	l	10	3	0
19	saloon	lun	un	NC	l		l	l	l	l	l	l	l	l	l	l	l	l	0	12	0
19	Snoopy	nu	u		n	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
20	New	niu	iu		n	n	n	n	n	n	n	l	n	n	n	n	n	n	12	1	0
20	near	niə	iə		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
20	North	nɔ	ɔ		n	l	l	l	l	l	l	n	l	l	l	l	l	l	1	12	0
20	Atlantic	læn	æn	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
21	Ninja	nin	in		n	n	n	n	n	n	n	n	n	n	n	n	n	l	12	1	0
21	collar	lə	ə		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0

21	souvenir	niə	iə		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
22	slaves	leɪ	eɪ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
22	escalated	leɪ	eɪ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
23	lock	lɒ	ɔ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
23	lost	lɒ	ɔ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
24	landlord	lænd	æɪ	NC	l	l	ɿ	l	l	l	l	ɿ	ɿ	l	l	l	l	l	0	10	3
24	landlord	lɒ	ɔ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
24	renewed	niu	iu		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
24	lease	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
24	spinning	niŋ	iŋ	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
24	blade	leɪ	eɪ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
25	cleaning	niŋ	iŋ	NC	n	n	n	l	l	n	n	n	n	n	n	n	n	n	11	2	0
25	reliable	laɪ	aɪ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
26	leads	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
26	lingering	liŋ	iŋ	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
27	link	liŋ	iŋ	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
27	violates	leɪ	eɪ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
27	law	lɒ	ɔ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
28	loon	lun	un	NC	l	ɿ	ɿ	l	l	l	l	ɿ	ɿ	l	l	l	l	l	0	9	4
28	large	la	a		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
28	flying	laiŋ	aiŋ	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
28	Nordic	nɔ	ɔ		n	l	l	l	l	l	l	n	l	l	l	n	l	l	2	11	0
28	nations	neɪ	eɪ		n	l	l	l	l	l	l	l	l	l	l	n	n	l	2	11	0
28	companion	niən	iən	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
29	liaison	liə	iə		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
29	employers	lɔi	ɔi		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
30	lingual	liŋ	iŋ	NC	l	l	l	l	l	l	l	ɿ	l	l	l	l	l	l	0	12	1
30	norm	nɔ	ɔ		n	l	l	l	l	l	l	n	l	l	l	n	l	l	2	11	0
30	Canada	nə	ə		n	l	l	l	l	l	l	n	l	l	l	n	l	l	2	11	0
31	naughty	nɔ	ɔ		n	l	l	l	l	l	l	n	l	l	l	n	l	l	2	11	0
31	snake	neɪ	eɪ		n	l	l	l	l	l	l	n	l	n	l	n	l	l	3	10	0
31	Nintendo	nin	in	NC	n	n	-	n	n	n	n	n	l	n	n	n	n	l	10	2	0
32	neep	ni	i		n	n	n	n	n	n	n	n	n	n	l	n	n	n	12	1	0
32	leek	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
32	Nina	nin	in	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
32	Nina	na	a		n	l	n	n	n	n	n	l	n	n	l	l	l	l	7	6	0
32	lost	lɒ	ɔ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
32	loose	lu	u		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
32	now	nau	au		n	n	l	l	l	l	l	n	n	n	n	l	l	l	5	8	0
33	walnut	na	a		n	l	n	l	l	l	l	n	l	l	l	l	l	l	2	11	0
33	veneer	niə	iə		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0

33	furniture	ni	i		n	n	n	n	n	n	n	n	n	n	n	n	n	l	12	1	0
34	opinion	niən	iən	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
34	nachos	na	a		n	l	l	l	l	l	l	n	l	l	l	n	l	l	2	11	0
34	onion	niən	iən	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
35	noobie's	nu	u		n	l	l	l	l	l	l	n	l	l	l	l	l	l	1	12	0
35	luck	la	a		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
35	last	la	a		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
35	long	loŋ	oŋ	NC	l	ŋ	l	l	l	l	l	l	l	l	ll	l	l	l	0	11	1
35	nothing	na	a		n	l	l	l	n	l	l	l	l	l	l	n	l	l	2	11	0
36	nabbed	næ	æ		n	l	l	l	l	l	l	l	l	l	l	n	l	l	1	12	0
36	stealing	liŋ	iŋ	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
36	lawyer	lɔ	ɔ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
36	released	li	i		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
36	next	ne	e		n	l	n	n	n	l	l	l	n	l	l	n	l	n	6	7	0
37	noose	nu	u		n	l	l	l	l	l	l	l	l	l	l	n	l	l	1	12	0
37	neck	ne	e		n	l	n	l	n	l	n	l	n	n	n	n	n	l	8	5	0
38	balloon	lun	un	NC	l	ŋ	l	l	l	l	l	l	l	l	l	l	l	l	0	12	1
38	loop	lu	u		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
38	nuclear	niu	iu		n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
38	nuclear	liə	iə		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
39	feelings	liŋ	iŋ	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
39	laid	leɪ	eɪ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
39	look	lu	u		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
39	naked	neɪ	eɪ		n	l	l	l	l	l	l	l	l	l	l	n	l	l	1	12	0
40	Union	niən	iən	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
40	calling	liŋ	iŋ	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
40	lawful	lɔ	ɔ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
40	noonday	nun	un	NC	n	ŋ	n	l	l	l	l	n	n	l	l	l	l	l	3	9	1
41	laptop	læ	æ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	12	0
41	lab	læ	æ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	12	0
41	latitude	læ	æ		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	12	0
42	Last	la	a		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	12	0
42	Nancy	næn	æn	NC	n	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
42	volunteer	lun	un	NC	l	ŋ	l	l	l	l	l	ŋ	l	l	l	l	l	l	0	11	2
42	Canyon	niən	iən	NC	n	n	n	n	n	n	n	n	n	n	n	n	n	n	13	0	0
43	Sicilian	liən	iən	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
43	larger	la	a		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
43	portfolio	liu	iu		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
43	Italian	liən	iən	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
44	Jolin	lin	in	NC	l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0
44	darling	in	n		l	l	l	l	l	l	l	l	l	l	l	l	l	l	0	13	0

