

Research Article

Cross-Linguistic Influence on Nasalance in Vietnamese–English Bilingual Speakers: Why Is Nasalance Higher for the Vowel /a/ Than /i/?

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ABSTRACT

Purpose: Previous studies have reported higher nasalance values for the vowel /a/ compared to /i/ in Vietnamese-speaking children and adults. This study aims to determine whether the same pattern is present in Vietnamese–English bilingual speakers and whether their nasalance scores align more closely with those of monolingual Vietnamese or monolingual English speakers.

Method: Sixteen Vietnamese–English bilingual adults participated in the study. Nasalance data of 16 monolingual Vietnamese speakers and 16 monolingual English speakers were adopted from the author's previous studies. Nasalance scores were obtained for three prolonged vowels; syllables; and oral, oral–nasal, and nasal passages in both English and Vietnamese.

Results: Vietnamese–English bilingual speakers exhibited higher nasalance scores for the prolonged vowel /a/ compared to /i/. However, no significant differences were observed between the two vowels in the syllable context. For between-group comparisons, the bilingual speakers produced lower nasalance scores for prolonged vowels /a/ and /i/, syllables with /a/ vowel context, and all three Vietnamese passages, compared to Vietnamese monolinguals. However, the bilinguals' scores were similar to those of English monolinguals for all stimuli, except for /a/.

Conclusions: The nasalance scores of Vietnamese–English bilinguals more closely resembled those of monolingual English speakers, suggesting an influence of the second language on resonance domain. However, the higher nasalance score of /a/ compared to /i/ indicates that bilingual speakers retain native resonance characteristics when other linguistic factors are minimized. These findings contribute to our understanding of cross-linguistic influences on nasalance and provide important insight for clinical assessment in Vietnamese-speaking populations in the United States.

Resonance refers to the modification of sound produced by the vocal folds as it travels through the cavities of the vocal tract, including the pharynx, oral cavity, and nasal cavity. Structural or functional abnormalities in these cavities, or in the velopharyngeal valve, can result in resonance

disorders (Kummer, 2020). Although perceptual assessment is commonly used to evaluate resonance, its reliability varies across studies, highlighting the need for more objective assessment methods (Liu et al., 2022). Nasometry is a widely used instrumental approach that measures nasalance—the percentage of acoustic energy emitted through the nasal cavity relative to the total (nasal plus oral) acoustic energy. Studies involving English speakers have demonstrated good reliability and validity of the Nasometer in measuring nasalance and identifying resonance disorders (Brunnegard et al., 2012; Brunnegård & van Doorn, 2009; Dalston et al., 1991,

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1993; Hardin et al., 1992; Sweeney & Sell, 2008; Watterson et al., 1998).

Nasometry has been employed across a wide range of languages to establish normative nasalance data, including English (Luyten et al., 2012; Seaver et al., 1991; van Doorn & Purcell, 1998), French (Barbier et al., 2025), Spanish (Nicholas, 1999), Greek (Okalidou et al., 2011), Dutch (Van der Heijden et al., 2011), Flemish (D'haeseleer et al., 2015), Swedish (Brunnegård & van Doorn, 2009), Irish (Sweeney et al., 2004), Malay (Ibrahim et al., 2012), Korean (Park et al., 2014), Cantonese (Whitehill, 2001), and Vietnamese (D. M. Nguyen et al., 2021; V. T. Nguyen et al., 2019). The normative data have been used as a reference when evaluating resonance normalcy in both adults (D'haeseleer et al., 2015; D. M. Nguyen et al., 2021; Okalidou et al., 2011; Park et al., 2014; Seaver et al., 1991; Whitehill, 2001) and children (Barbier et al., 2025; Brunnegård & van Doorn, 2009; Ibrahim et al., 2012; Luyten et al., 2012; V. T. Nguyen et al., 2019; Sweeney et al., 2004; Van der Heijden et al., 2011; van Doorn & Purcell, 1998). Although cross-linguistic effects have been explored across various linguistic domains, most nasalance research has focused on monolingual speakers. Only a limited number of studies have examined nasalance for bilingual speakers or second-language (L2) learners. Investigating bilingual populations is especially important in countries like the United States, where over 20% of the population speaks a language other than English at home (Dietrich & Hernandez, 2019). Understanding how bilingualism affects resonance is essential for providing accurate clinical care, as speech-language pathologists need evidence-based guidance to distinguish typical bilingual speech patterns from disordered speech. Without such guidance, bilingual individuals may face increased risks of misdiagnosis or receiving inadequate care.

Cross-Linguistic Influence on Nasalance Values

Several studies have reported differences in nasalance between monolingual speakers and bilingual speakers or L2 learners, even when producing the same speech stimuli (Chatterjee et al., 2020; Kalyani et al., 2016; Liu & Lee, 2021; Pua et al., 2019). For instance, Pua et al. (2019) assessed Chinese–English bilinguals using both Mandarin and English passages and compared their Mandarin nasalance values with those of monolingual Mandarin speakers. The Mandarin speech samples of bilingual participants showed significantly lower nasalance scores on oral sentences but higher scores on oronasal and nasal sentences compared to the monolingual Mandarin data reported by Kim et al. (2016). The authors suggested that these differences might reflect an L2 influence on first-language (L1) nasalance, given that English typically yields lower nasalance scores

than Chinese (Kim et al., 2016). However, it remains unclear why bilinguals' Mandarin nasalance scores exceeded those of monolingual speakers on oronasal and nasal sentences. Since English productions were not directly compared between bilingual and monolingual English speakers, further research is warranted to explore whether L1 may also influence L2 nasalance values.

Liu and Lee (2021) addressed this gap by comparing nasalance scores in Chinese learners of English and native English speakers using English speech samples. They found that L2 learners consistently produced higher nasalance scores across prolonged vowels, syllables, sentences, and passages compared to native English speakers (Liu & Lee, 2021). The authors attributed this result to L1 influence, noting that Chinese is acoustically more nasal than English (Kim et al., 2016; Yuan & Liberman, 2011). Similar findings have been reported in other studies, although often based on indirect comparisons with existing normative data. For example, Chatterjee et al. (2020) found that Khasi-speaking women produced higher nasalance scores than native English speakers on the English Zoo Passage, Rainbow Passage, and Nasal Sentences. Similarly, Kalyani et al. (2016) reported elevated nasalance scores in Mizo speakers compared to English normative values reported by Awan et al. (2015). Consistent with Liu and Lee (2021), these studies suggest that L1 characteristics can influence nasalance patterns during L2 speech production.

While some studies have found an influence of L1 or L2, others have reported no significant differences in nasalance scores between bilingual and monolingual speakers. Doetzer (2008) examined 10 Spanish–English bilingual adults and 10 native English-speaking adults using standard English passages and found no significant differences. Similarly, Perry et al. (2019) studied 17 Spanish–English bilingual children and 17 monolingual English-speaking children and found comparable nasalance scores. Further research is needed to clarify the discrepancies among these studies. It remains unclear whether the inconsistent findings are due to the types of language (Chinese–English vs. Spanish–English) or the degree of L2 exposure (balanced bilinguals vs. L2-dominant bilinguals vs. L2 learners). Specifically, participants in both Spanish–English bilingual studies had extensive English exposure and high English proficiency, possibly mitigating the L1 effect (Doetzer, 2008; Perry et al., 2019). In contrast, the mean English language proficiency of Mandarin–English bilingual speakers in the study by Pua et al. (2019) was as low as 34%, with a range from 0% (no exposure) to 85% based on self-reported percentage points. However, it is important to note that the lack of significant differences in the Spanish–English studies may be due to the fact that nasalance scores of monolingual English and Spanish speakers were found to be similar, while those of monolingual Chinese and English speakers showed

substantial differences (Anderson, 1996; Yuan & Liberman, 2011). These findings highlight the need for further research examining nasalance in bilingual speakers of other language pairs and varying levels of language proficiency. Understanding nasalance in bilingual speakers provides valuable insights into how L2 exposure affects L1 nasalance production, and vice versa. Given the clinical importance of nasalance measurements in resonance assessment, this information is crucial for practitioners working with bilingual populations.

Vowel Effects on Nasalance Values

It is well known that high vowels have higher nasal and lower oral acoustic energy than low vowels (Hirano et al., 1966; Stevens & House, 1961). Numerous studies across languages consistently report higher nasalance scores for high vowels (e.g., /i/) than for low vowels (e.g., /a/; Alfwaress et al., 2022; Awan et al., 2011; Barbier et al., 2025; Blanton et al., 2015; Gildersleeve-Neumann & Dalston, 2001; Ha & Cho, 2015; Kim et al., 2016; Lewis et al., 2000; Sampaio-Teixeira et al., 2019; Sarac et al., 2011; Sudarshan Reddy et al., 2012; Thorp et al., 2013; Ünal-Logacev et al., 2020). For example, Gildersleeve-Neumann and Dalston (2001) reported higher nasalance scores for /i/ than for /a/ and /u/ in 60 English-speaking adults, attributing this to greater oral resistance to airflow and transpalatal sound transmission during high vowel production. Similarly, Alfwaress et al. (2022) observed nasalance ranges of 13%–21% for /i/ and 11%–16% for /a/ in 100 monolingual English speakers, with the higher nasalance of high vowels consistent across syllable and sentence contexts. This vowel-dependent nasalance pattern has also been reported in Chinese, Korean, Turkish, and Portuguese, although the absolute nasalance values differ across languages (Ha & Cho, 2015; Kim et al., 2016; Sampaio-Teixeira et al., 2019; Sarac et al., 2011; Ünal-Logacev et al., 2020). For example, Kim et al. (2016) reported nasalance values for the vowels /i/, /a/, and /u/ across four Chinese dialects, with all four dialects producing higher nasalance scores than English. The average nasalance values for /i/ and /a/ are 37% (ranging from 30% to 45%) and 31% (ranging from 25% to 37%), respectively.

An opposite pattern, however, has been observed in Vietnamese speakers, where low vowels yield higher nasalance scores (D. M. Nguyen et al., 2021; Shin et al., 2017). Shin et al. (2017) cross-linguistically compared nasalance values of five prolonged vowels (/a/, /e/, /i/, /o/, and /u/) produced by Vietnamese and Korean children without cleft palate. While Korean children produced /i/ with the highest nasalance scores, Vietnamese children showed the highest scores for /a/. This reversed pattern

between /a/ and /i/ in Vietnamese children without cleft palate may be partially attributed to the small number of Vietnamese children ($n = 3$) in that study. To verify this reversed pattern, D. M. Nguyen et al. (2021) investigated 75 Vietnamese adults and found the same pattern, with the higher nasalance for /a/ than for /i/ or /u/ across prolonged vowels. This reversed pattern was also observed in syllables containing plosive and fricative consonants, but not in nasal contexts. Specifically, no significant difference was found between /ma/ and /mi/ in participants (D. M. Nguyen et al., 2021).

The reason behind this reversed vowel effect in Vietnamese remains unclear and needs further verification. Understanding such language-specific differences is crucial for developing accurate nasalance norms and refining clinical assessment tools for Vietnamese and other understudied languages. Importantly, the findings of this study could have important clinical implications if the reversed pattern is still present in Vietnamese–English bilingual speakers. Specifically, nasality rating scales developed for English-speaking populations (e.g., Cleft Audit Protocol for Speech–Augmented [CAPS-A] Americleft Modification; CAPS-A) suggest that mild hypernasality occurs with closed vowels like /u/ and /i/, while moderate hypernasality is observed with both open vowels (e.g., /a/) and closed vowels (John et al., 2006). If the low vowel /a/ consistently shows higher nasalance scores than the high vowel /i/ in Vietnamese speakers, hypernasality ratings for this population may differ from those used for English speakers. Therefore, further research is needed to confirm this reversed vowel effect on nasalance scores in Vietnamese speakers.

Vietnamese Phonology

Vietnamese is an alphabetic tonal language with a consistent vowel inventory. However, the number of reported initial consonants varies between 21 and 24 (Đoàn, 2003; Hoàng, 2004; Lã et al., 2011; T. L. K. Nguyen, 2011). The language includes 11 Vietnamese monophthongs (/i, e, ɛ, u, ʊ, ɤ, ɤ a, ă, u, o, ɔ/) and three diphthongs (/ie, uɤ, uo/). All Vietnamese vowels are considered oral. While vowels may become nasalized in the context of adjacent nasal consonants, Vietnamese does not exhibit a phonemic contrast between nasal and oral vowels (Đoàn, 2003; T. C. Nguyen, 1997), a feature it shares with English. The language also features six tones: (a) level, (b) falling, (c) creaky, (d) dipping–rising, (e) rising, and (f) constricted.

The places and manners of articulation for initial consonants are shown in Appendix A. Some researchers (Hoàng, 2004; Lã et al., 2011; T. L. K. Nguyen, 2011) have proposed that the Vietnamese consonant inventory includes /p/. However, the consonant /p/ occurs only in a

limited number of foreign loanwords and is often realized as [b] in actual speech (Đoàn, 2003; Kirby, 2011). In addition, the glottal stop /ʔ/ typically appears before words that begin with a vowel or /w/ (Pham, 2009). Both /p/ and /ʔ/ are considered marginal phonemes, and their status is subject to dialectal variation and remains a subject of interpretive debate among linguists (Lee et al., 2024; Pham, 2009). When excluding /p, ʔ/, the Vietnamese consonant system comprises 16 high-pressure consonants and four nasal consonants, one more nasal and one fewer high-pressure consonant than English. Unlike English, which includes both voiced and voiceless cognates for all stop consonants, Vietnamese stops are either voiced or voiceless, with the alveolar series being an exception. Vietnamese alveolar stops are realized in three forms: /tʰ/ (aspirated voiceless), /t/ (unaspirated voiceless), and /d/ (voiced). The aspirated voiceless consonant /tʰ/ is produced with a long-lag voice onset time (VOT), similar to the English /t/ (Cho et al., 2019; Kirby, 2018; Nguyen-Phuoc & Lee, 2025). The unaspirated voiceless consonant /t/ is produced with a short-lag VOT, while the voiced consonant /d/ is produced with voicing lead (Nguyen-Phuoc & Lee, 2025). Given the similarity in VOT, comparisons of nasalance between Vietnamese and English should pair Vietnamese /tʰ/ with English /t/, rather than Vietnamese /t/ with English /t/ (Cho et al., 2019; Kirby, 2018).

Purposes of the Study

The proposed study aimed to investigate the nasalance scores of Vietnamese–English bilingual speakers. This study has two specific aims: (1) to examine whether the nasalance scores for the low vowel /a/ are higher than those for the high vowel /i/ in Vietnamese–English bilingual speakers and (2) to investigate whether the nasalance scores of Vietnamese–English bilingual speakers are more similar to those of monolingual Vietnamese or monolingual English speakers. For Aim 1, it is hypothesized that nasalance scores for the high vowel /i/ will be higher than those for the low vowel /a/, consistent with patterns observed in monolingual English speakers, because the bilingual participants had extensive experience with the English language. For Aim 2, it is hypothesized that the nasalance scores of bilingual speakers will be lower than those of monolingual Vietnamese speakers, reflecting the influence of extended exposure to English.

Investigating nasalance in Vietnamese is particularly valuable for understanding cross-linguistic influences on resonance, an area that remains underexplored. The findings have practical implications for the clinical assessment and diagnosis of resonance disorders in Vietnamese–English bilingual speakers—a growing population in the United States. Identifying nasalance characteristics in both

languages is essential for accurate evaluation and effective intervention in bilingual contexts.

Method

Nasalance was measured in Vietnamese–English bilingual adults using both Vietnamese and English speech stimuli. Comparative data from monolingual Vietnamese and monolingual English speakers were obtained from the authors' previous studies (Liu & Lee, 2021; D. M. Nguyen et al., 2021). A power analysis based on prior data indicated that a sample size of 16 participants per language group would yield 80% statistical power. From a pool of 75 monolingual Vietnamese participants in the previous study, a subset of 16 individuals (eight men, eight women) was randomly selected for inclusion in the current study. Simple random sampling, stratified by sex, was employed to reduce selection bias and enhance group comparability.

To validate this sampling approach, an additional analysis was conducted using the full Vietnamese data set from the original study. The results were consistent with those obtained from the randomly selected subsample, supporting the appropriateness of the sample size and selection approach. Accordingly, an equal number of participants were adopted for each language group in the current study. The bilingual and monolingual data sets were directly comparable, as they were collected using the same speech stimuli and measurement procedures in both Vietnamese and English.

Participants

Sixteen Vietnamese–English bilingual adults (eight men, eight women) were recruited from Vietnamese communities in Texas. The mean age of participants was 38.06 years ($SD = 8.78$). Inclusion criteria were: (a) Vietnamese as their L1, (b) residence in an English-speaking country for more than 10 years and self-reported proficiency in English, and (c) age between 18 and 65 years. Exclusion criteria were: (a) self-reported speech, resonance, or hearing disorders; (b) illnesses affecting resonance (e.g., cough, cold, rhinitis, craniofacial anomalies); or (c) birth and upbringing in the United States. All bilingual participants held professional positions (e.g., university professor or postdoctoral researcher) after completing terminal degrees in English-speaking countries. They had used English for an average of 13.15 years ($SD = 3.31$) in an English-speaking country and demonstrated oral reading proficiency, as confirmed by a native English-speaking research assistant. Most participants spoke the southern Vietnamese dialect, with three speaking the northern dialect and one speaking the central dialect.

Randomly selected data from 16 monolingual Vietnamese speakers (eight men, eight women) were obtained from the previous study (D. M. Nguyen et al., 2021). All monolingual Vietnamese participants were university students from a university in Mekong Delta, Vietnam ($M = 23.44$ years, $SD = 2.85$). They were born and raised in Vietnam and spoke Southern Vietnamese dialect. For the monolingual English group, nasalance data from 16 participants (eight men, eight women) were included from the previous study (Liu & Lee, 2021). All participants were university students who were enrolled in Allied Health Sciences programs ($M = 28$ years, $SD = 6.1$). They were born and raised in Texas and speak with a Southern dialect. None of the participants in any group reported a history of resonance, neurological, respiratory, laryngeal, or hearing disorders. Additionally, all participants reported no symptoms of cold or nasal congestion on the day of testing.

Data Collection

Speech samples for Vietnamese–English bilingual speakers were collected in a quiet university research laboratory. Each participant completed the assessment individually in a single session. The session began with a brief questionnaire to collect demographic information, which gathered information on their background and language experience. Nasalance was measured using a Nasometer (Model 6500, PENTAX Medical). The researcher positioned the handset on each participant's face, ensuring that the plate was perpendicular to the facial plane. Participants were instructed to maintain tight plate-to-philtrum contact while holding the handset.

Nasalance scores for both groups of monolingual speakers were obtained using the Kay PENTAX Nasometer II (Model 6450, PENTAX Medical). The version of the Nasometer used was the only difference in data collection produced between the bilingual and monolingual speaker groups. The Kay Pentax Nasometers have been widely used in clinical settings around the world (Mayo & Mayo, 2011). While nasalance values may vary across instruments from different manufacturers (i.e., Nasometer vs. NasalView), test–retest reliability within the same instrument has been reported to be high (Bressmann, 2005). To ensure consistency and accuracy, researchers followed the manufacturer's instructions for headset placement, ensuring the separation plate was positioned between the nose and upper lip, with firm contact against the philtrum and aligned perpendicularly to the frontal plane. The equipment was also carefully calibrated before each data collection session.

All participants were fully informed of the experimental procedure and were given a hard copy of the speech stimuli (see Appendix B), with instructions to review the pronunciation prior to testing. The Vietnamese–English

bilingual examiner first modeled each task (prolonged vowels, syllable repetitions, and syllables) at a regular pitch and loudness. Next, the participant read the stimuli at a regular pitch and loudness. If errors occurred (e.g., coughing or misreading), the speech sample was re-administered. Nasalance scores were calculated using the Nasometer II software installed on a laptop.

Speech Stimuli

For the bilingual group, participants produced three prolonged vowels, /i/, /a/, and /u/, and 10 syllables formed by combining the vowels /a/ and /i/ with five Vietnamese consonants, /d, t, ʔ^h, s, m/. They were then asked to read three Vietnamese passages: an oral passage (0% nasal consonants), an oral–nasal passage (14.5% nasal consonants), and a nasal passage (46.3% nasal consonants), all adopted from D. M. Nguyen et al. (2021). Instructions were given in Vietnamese during the Vietnamese data collection. In addition, the bilingual participants read three English passages: the Zoo Passage (0% nasal consonants), the Rainbow Passage (11% nasal consonants), and Nasal Sentences (35% nasal consonants; Kummer, 2020). Instructions were given in English during the English data collection. These speech stimuli are shown in Appendix B.

For the monolingual Vietnamese speakers, the speech stimuli included three prolonged vowels and six syllables formed by combining the vowels /a/ and /i/ with three Vietnamese consonants, /ʔ^h, s, m/. Participants also read the same Vietnamese oral passage (0% nasal consonants), oral–nasal passage (14.5%), and nasal passage (46.3%; D. M. Nguyen et al., 2021). For the monolingual English speakers, the speech stimuli included three prolonged vowels and six syllables combining the vowels /a/ and /i/ with three English consonants, /t, s, m/. They also read the Zoo Passage (0% nasals), Rainbow Passage (11%), and Nasal Sentences (35%; Liu & Lee, 2021).

Statistical Analysis

SPSS (Version 29.0; IBM, 2022) was used to conduct the statistical analyses. Means and standard deviations of nasalance scores were calculated for all participants across each type of speech stimulus (prolonged vowels, consonant–vowel syllables, three Vietnamese passages, and three English passages) within each language group (Vietnamese–English bilinguals, Vietnamese monolinguals, and English monolinguals). Two-way mixed analyses of variance (ANOVAs) were performed to examine the effects of speech stimulus type and language group on the nasalance scores of three groups. Additionally, a two-way repeated-measures ANOVA was performed to examine the effects of vowel and consonant on nasalance scores for syllables containing /d/, /t/, and /ʔ^h/ in the Vietnamese–English bilingual group. When significant main

effects or interaction effects were found, pairwise post hoc comparisons with Bonferroni correction were conducted to identify specific group differences.

Results

Nasalance Scores of Prolonged Vowels

Figure 1 presents the means and standard deviations for the three prolonged vowels across three groups of speakers (see also Appendix C). Both monolingual Vietnamese speakers and bilingual speakers produced the highest nasalance scores for the vowel /a/, followed by /i/, with /u/ showing the lowest values. In contrast, monolingual English speakers produced the highest values for the vowel /i/, slightly higher than /a/, while /u/ remained the lowest across all groups.

The two-way mixed ANOVA revealed a significant interaction effect between vowel type and language group, $F(3.58, 80.47) = 15.53$, $p < .001$, partial $\eta^2 = .408$. Significant main effects were also observed for vowel type, $F(1.79, 80.47) = 98.78$, $p < .001$, partial $\eta^2 = .687$, and language group, $F(2, 45) = 9.57$, $p < .001$, partial $\eta^2 = .298$. The partial eta squared (η^2) is a measure of effect size in ANOVA that indicates the proportion of variance in the dependent variable explained by an independent variable (Cohen, 2013). The partial η^2 values of .01, .06, and .14 represent small, medium, and large effects, respectively. Based on these criteria, both vowel type and language group, as well as interaction, exhibited large effect sizes, indicating a substantial influence on nasalance variation.

Post hoc comparisons showed that, in both Vietnamese–English bilinguals and monolingual Vietnamese speakers, nasalance scores for the vowel /a/ were significantly higher than those for vowels /i/ and /u/ ($p < .001$), and scores for /i/ were significantly higher than for /u/ ($p = .003$ for Vietnamese–English bilinguals; $p < .001$ for Vietnamese monolinguals). In

contrast, monolingual English speakers showed significantly higher nasalance scores for both /a/ and /i/ compared to /u/ ($p = .027$ for the /a/–/u/ comparison; $p < .001$ for the /i/–/u/ comparison), but there was no significant difference between /a/ and /i/ in this group ($p = .737$).

Between-group comparisons revealed that Vietnamese–English bilinguals produced significantly lower nasalance scores than Vietnamese monolinguals for the vowels /a/ ($p = .036$) and /i/ ($p = .044$), with no significant difference observed for /u/ ($p > .05$). Both bilinguals and Vietnamese monolinguals showed significantly higher nasalance scores for the vowel /a/ compared to English monolinguals ($p < .001$). No other pairwise comparisons reached statistical significance ($p > .05$).

Nasalance Scores of Vietnamese Syllable Repetitions of /t^ha/ and /t^hi/ and English Syllable Repetitions of /ta/ and /ti/

Figure 2 shows the means and standard deviations of nasalance scores for syllable repetitions: /t^ha/ and /t^hi/ in Vietnamese–English bilinguals and Vietnamese monolinguals and /ta/ and /ti/ in English monolinguals (see also Appendix C). Vietnamese monolinguals produced higher nasalance scores for /t^ha/ than for /t^hi/, whereas English monolinguals showed the opposite pattern, with higher scores for /ti/ than for /ta/. In contrast, Vietnamese–English bilinguals exhibited similar nasalance values between /t^ha/ and /t^hi/.

A two-way mixed ANOVA revealed a significant interaction between speech stimulus and language group, $F(2, 45) = 11.81$, $p < .001$, partial $\eta^2 = .344$, and a significant main effect of language group, $F(2, 45) = 9.51$, $p < .001$, partial $\eta^2 = .297$. However, the main effect of speech stimulus was not significant, $F(1, 45) = 1.77$, $p = .190$, partial $\eta^2 = .038$. The effect size ranged from moderate to large.

Post hoc comparisons indicated that monolingual Vietnamese speakers produced significantly higher nasalance

Figure 1. The nasalance scores of prolonged vowels in three language groups.

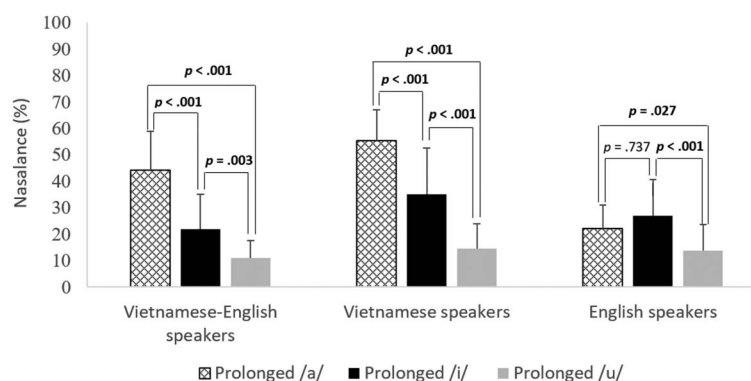
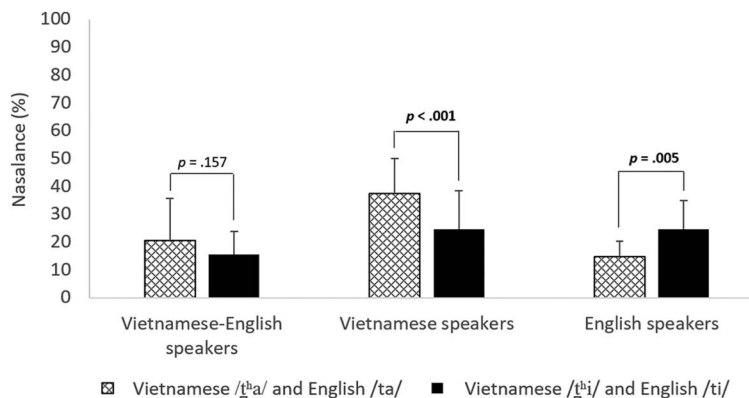


Figure 2. The nasalance scores of syllable repetitions of /t^ha/ and /t^hi/ in Vietnamese–English speakers and Vietnamese speakers and /ta/ and /ti/ in English speakers.



score for /t^ha/ than that for /t^hi/ ($p < .001$), while monolingual English speakers produced higher scores for /ti/ than for /ta/ ($p = .005$). No significant difference between /t^ha/ and /t^hi/ was observed for bilingual speakers ($p = .157$). Across language groups, monolingual Vietnamese speakers produced significantly higher nasalance scores for /t^ha/ compared to that of Vietnamese–English bilinguals and the scores for /ta/ of English speakers ($p < .001$). Other pairwise comparisons were not significant ($p > .05$).

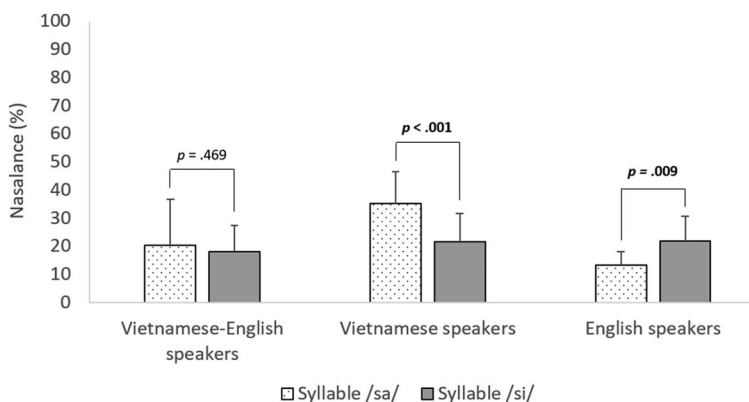
Nasalance Scores of Syllable Repetitions of /sa/ and /si/

Figure 3 displays the means and standard deviations of nasalance scores for the syllable repetitions /sa/ and /si/ across the three groups of speakers (see also Appendix C). Vietnamese monolinguals produced higher nasalance scores for /sa/ than for /si/, whereas English monolinguals showed the opposite trend, with higher scores for /si/ than for /sa/. In contrast, bilingual speakers exhibited similar nasalance values for both syllables.

A two-way mixed ANOVA showed a significant interaction between speech stimulus and language group, $F(2, 45) = 12.63$, $p < .001$, partial $\eta^2 = .360$, and a significant main effect of language group, $F(2, 45) = 7.06$, $p = .002$, partial $\eta^2 = .239$. However, the main effect of speech stimulus was not significant, $F(1, 45) = 1.85$, $p = .181$, partial $\eta^2 = .039$. The group and speech stimulus factors as well as interaction were found to have moderate-to-large effect sizes.

Post hoc comparisons indicated that monolingual Vietnamese speakers produced a significantly higher nasalance score for /sa/ compared to /si/ ($p < .001$), whereas monolingual English speakers exhibited a significantly higher nasalance score for /si/ than for /sa/ ($p = .009$). No significant difference was found between /sa/ and /si/ for bilingual speakers ($p = .469$). Additionally, monolingual Vietnamese speakers produced significantly higher nasalance scores for /sa/ than both bilingual ($p = .003$) and monolingual ($p < .001$) English speakers. Other between-group comparisons were not significant ($p > .05$).

Figure 3. The nasalance scores of syllable repetitions of /sa/ and /si/ in three language groups.



Nasalance Scores of Syllable Repetitions of /ma/ and /mi/

Figure 4 shows the means and standard deviations of nasalance scores for syllable repetitions /ma/ and /mi/ across the three groups of speakers (see also Appendix C). Both bilingual and monolingual English speakers produced higher nasalance scores for /mi/ than for /ma/. In contrast, monolingual Vietnamese speakers produced similar nasalance values for both syllables.

A two-way mixed ANOVA revealed a significant interaction between speech stimulus and language group, $F(2, 45) = 19.15$, $p < .001$, partial $\eta^2 = .460$, and a significant main effect of speech stimulus, $F(1, 45) = 77.75$, $p < .001$, partial $\eta^2 = .633$. However, the main effect of the language group was not significant, $F(2, 45) = 2.59$, $p = .086$, partial $\eta^2 = .103$. The group and speech stimulus factors as well as interaction were found to have moderate-to-large effect sizes.

Post hoc comparisons indicated that both bilingual and monolingual English speakers produced significantly higher nasalance score for /ma/ than that for /mi/ ($p < .001$), while monolingual Vietnamese speakers showed no significant difference between the two syllables ($p = .731$). When comparing across language groups, both bilingual ($p = .019$) and monolingual ($p < .001$) English speakers had higher nasalance scores for /mi/ than monolingual Vietnamese speakers. No other pairwise comparisons were significant ($p > .05$).

Nasalance Scores of Vietnamese Passages

Figure 5 shows the means and standard deviations of nasalance scores for three Vietnamese passages produced by Vietnamese–English bilingual speakers and monolingual Vietnamese speakers (see also Appendix C).

Across all three passages, bilingual speakers produced lower nasalance values than monolingual Vietnamese speakers.

A two-way mixed ANOVA revealed no significant interaction between speech stimulus and language group, $F(1.88, 56.31) = 3.11$, $p = .055$, partial $\eta^2 = .094$. However, significant main effects were found for speech stimulus, $F(1.88, 56.31) = 1552.69$, $p < .001$, partial $\eta^2 = .981$, and language group, $F(1, 30) = 7.41$, $p = .011$, partial $\eta^2 = .198$. The group and speech stimulus factors were found to have large effect sizes.

Post hoc comparisons indicated that for both groups, nasalance score increased progressively across the three passages: The oral passage had significantly lower nasalance scores than the oral–nasal passage, which in turn had lower nasalance than the nasal passage ($p < .001$). Additionally, for all three passages, Vietnamese–English bilingual speakers produced significantly lower nasalance scores compared to monolingual Vietnamese speakers ($p = .011$).

Nasalance Scores of English Passages

Figure 6 presents the means and standard deviations of nasalance scores for three English passages produced by Vietnamese–English bilingual speakers and monolingual English speakers (see also Appendix C). The nasalance scores for the Zoo Passage, Rainbow Passage, and Nasal Sentences were similar across the two groups.

A two-way mixed ANOVA showed no significant interaction between speech stimulus and language group, $F(1.68, 50.24) = 2.24$, $p = .125$, partial $\eta^2 = .069$, and no significant main effect of language group, $F(1, 30) = 2.21$, $p = .147$, partial $\eta^2 = .069$. However, the main effect of speech stimulus was significant, $F(1.68, 50.24) = 1418.25$, $p < .001$, partial $\eta^2 = .979$. The group and speech stimulus factors were found to have moderate-to-large effect sizes.

Figure 4. The nasalance scores of syllable repetitions of /ma/ and /mi/ in three language groups.

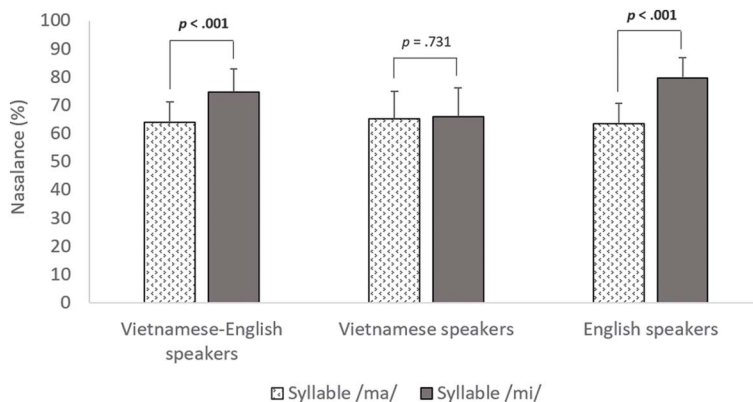
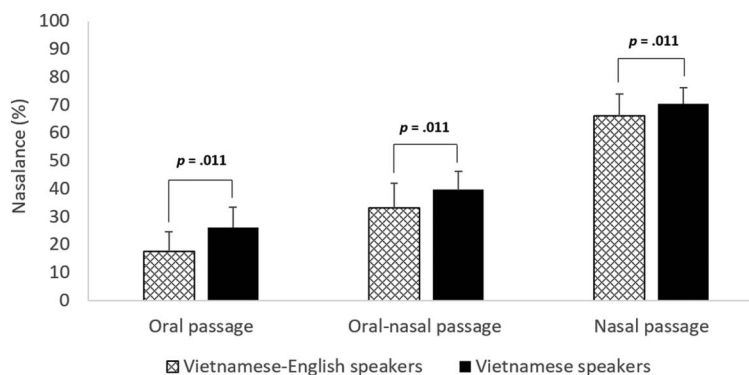


Figure 5. The nasalance scores of Vietnamese passages in Vietnamese–English speakers and Vietnamese speakers.



Post hoc comparisons revealed a consistent pattern across both groups: the Zoo Passage had the lowest nasalance scores, followed by the Rainbow Passage, and the highest scores observed for the Nasal Sentences ($p < .001$). No significant differences in nasalance scores were found between bilingual and monolingual English speakers across any of the three passages ($p = .147$).

Nasalance Scores of Syllable Repetitions With Vietnamese Stop Consonants /d, t, tʰ/

In addition to comparing the three groups, nasalance values of the three Vietnamese stop consonants were further examined. Figure 7 shows the means and standard deviations of nasalance scores for the syllable repetitions containing the three Vietnamese stop consonants /d, t, tʰ/ produced by Vietnamese–English bilingual speakers (also see Appendix C). Nasalance values were comparable across high and low vowel contexts across all three consonants.

A two-way repeated-measures ANOVA revealed no significant interaction between vowel type and speech stimulus, $F(1.32, 19.74) = 2.56$, $p = .118$, partial $\eta^2 = .146$. Neither the main effect of vowel type, $F(1, 19.74) =$

0.40, $p = .535$, partial $\eta^2 = .026$, nor the main effect of speech stimulus, $F(1.30, 19.74) = 1.39$, $p = .263$, partial $\eta^2 = .085$, reached significance. The group and speech stimulus factors were found to have moderate effect sizes.

Discussion

The current study tested two hypotheses corresponding to its primary aims. For Aim 1, it was hypothesized that nasalance scores for the high vowel /i/ would be higher than those for the low vowel /a/. For Aim 2, it was hypothesized that the nasalance scores of bilingual speakers would be lower than those of monolingual Vietnamese speakers. To evaluate these hypotheses, statistically significant effects were observed for both the stimulus and group factors, each associated with large effect sizes. Partial η^2 values range from .198 for the group factor to .687 for the stimulus factor, indicating that the independent variables in our study had a substantial and practically meaningful impact on nasalance variation. To our knowledge, this is the first study to examine nasalance in Vietnamese–English bilinguals residing in the United States, where more than 1.4 million people speak Vietnamese at home (Dietrich &

Figure 6. The nasalance scores of English passages in Vietnamese–English speakers and English speakers.

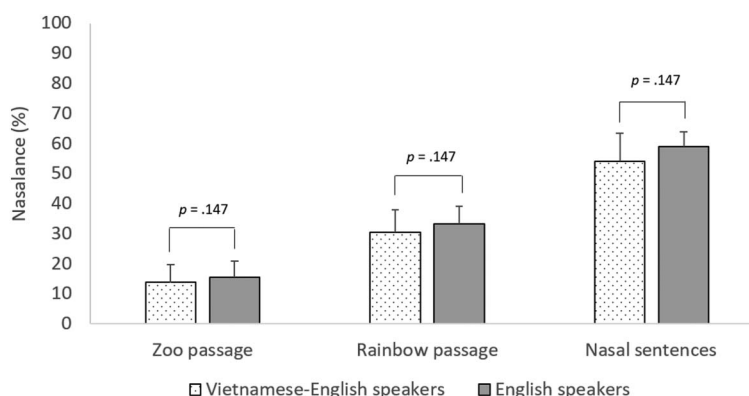
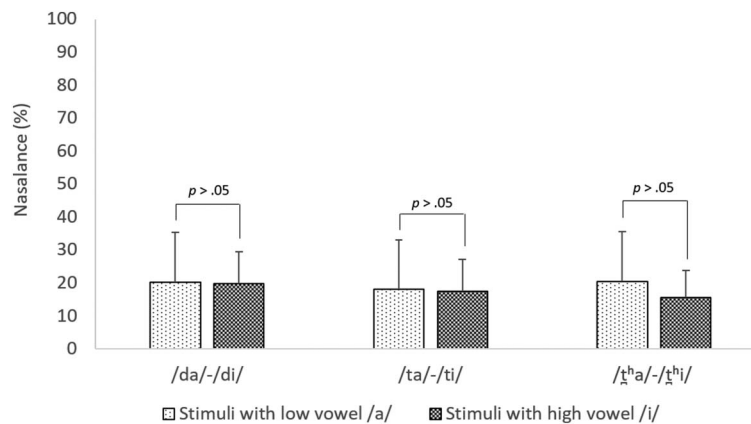


Figure 7. The nasalance scores of syllable repetitions, including three Vietnamese stop consonants /t^h, t, d/ in Vietnamese–English speakers.



Hernandez, 2019). These findings contribute to a better understanding of nasalance characteristics in speakers with Vietnamese language backgrounds.

Maintenance of L1 Nasalance Patterns in Bilingual Speakers

The current study hypothesized that Vietnamese–English bilingual speakers would produce higher nasalance scores for /i/ than /a/, mirroring the pattern observed in native English speakers, due to their extensive exposure to English. Contrary to this hypothesis, we found that Vietnamese–English bilingual speakers exhibited higher nasalance scores for /a/ compared to /i/ and /u/ for prolonged vowels. This pattern, previously reported in D. M. Nguyen et al. (2021), appears to be characteristic of Vietnamese. This finding contrasts with nasalance patterns observed not only in English but also in most other languages, where higher vowels such as /i/ typically yield higher nasalance scores (Alfwaress et al., 2022; Awan et al., 2011; Barbier et al., 2025; Blanton et al., 2015; Gildersleeve-Neumann & Dalston, 2001; Ha & Cho, 2015; Kim et al., 2016; Lewis et al., 2000; Sampaio-Teixeira et al., 2019; Sarac et al., 2011; Sudarshan Reddy et al., 2012; Thorp et al., 2013; Ünal-Logacev et al., 2020). Prior studies have attributed elevated nasalance scores in high vowels to increased oral resistance and greater transpalatal sound transmission during high vowel production (Gildersleeve-Neumann & Dalston, 2001; Kuehn & Moon, 1998).

The difference in nasalance value across dialects within a language has often been attributed to tongue position across vowels, suggesting that a smaller oral opening for the high vowel /i/ reduces oral energy and results in higher nasalance values (Awan et al., 2011). Similarly, Kummer (2008) noted that dialect-related nasalance variation is

primarily vowel-driven. These researchers highlight that tongue position plays a critical role in shaping nasalance patterns. Although tongue position for a given vowel may vary across languages, the formant values of shared vowels such as /i/ are generally comparable cross-linguistically. That is, the F1 value of Vietnamese /i/ is expected to resemble that of English /i/, rather than that of a lower vowel /a/. Consistent with English findings (Hillenbrand et al., 1995), Emerich (2012) reported that the F1 value for Vietnamese vowel /a/ is higher (600 Hz) than that for Vietnamese vowel /i/ (355 Hz). Yet, in Vietnamese, nasalance values were significantly higher for /a/ than for /i/. This reversed pattern suggests that nasalance differences may not be explained by tongue height alone. Instead, we propose that the higher nasalance observed for low vowels in Vietnamese may be associated with incomplete velopharyngeal closure. Earlier studies (Matsuya et al., 1974; Moll, 1962) have shown that Japanese and English speakers often produced low vowels, particularly /a/ or /a/, with incomplete velopharyngeal closure. Engwall et al. (2006) also documented individual differences in velopharyngeal closure among French speakers, with some lowering the velum even for oral vowels. Similarly, vowels and low-pressure phonemes such as /w/ and /j/ may be produced with velar lowering while still being perceived as oral (Hashemi Hosseninabad et al., 2019).

Liu and Lee (2021) argued that tongue height or oral opening may not be the primary contributing factor to nasalance differences between languages, especially between tone languages (e.g., Chinese) and nontone languages (e.g., English). They observed cross-linguistic differences in nasalance even though the front vowel /i/ was produced with comparable articulation. A similar explanation may also apply to Vietnamese.

Nonetheless, the role of tongue position warrants further investigation in Vietnamese. The current study did

not examine formant frequency values across the three groups, and prior work has shown discrepancies in Vietnamese data. For example, Emerich (2012) reported an average *F1* of 600 Hz for Vietnamese /a/, whereas Lee and Nguyen-Phuoc (2024) found substantially higher *F1* values: approximately 800 Hz for Vietnamese male speakers and 1020 Hz for female speakers. These values were similar to or even higher than those observed in English speakers (768 Hz for men; 936 Hz for women). In summary, we propose that the elevated nasalance values of Vietnamese prolonged vowels, especially /a/, may be associated with incomplete velopharyngeal closure. Because the Nasometer does not directly measure velopharyngeal function, future studies should integrate nasalance assessment with nasopharyngoscopy to evaluate velopharyngeal opening, as well as spectrographic analysis of vowel formants to examine tongue positioning. Such integration would provide a more comprehensive understanding of the interplay between velopharyngeal opening, tongue position, and nasalance.

Interestingly, this distinct vowel effect was observed only in the prolonged vowel context, but not in syllables produced by bilingual speakers. The presence of L1 effects exclusively in prolonged vowels may be due to the minimal articulatory complexity of these stimuli. Eshghi et al. (2017) noted that velopharyngeal closure is likely influenced by oral air pressure generated by adjacent oral stops in CV (C = consonant; V = vowel) or VCV syllables. These findings suggest that L1 phonetic patterns are maintained in isolated and simple speech tasks, whereas L2 influence may emerge more prominently in connected or consonant-rich speech. The bilingual speakers in the current study had lived in the United States for an extended period and were proficient in English. During syllable repetitions, their extensive exposure to English may have altered velopharyngeal closure dynamics and coarticulatory effects, leading to patterns that differ from those of Vietnamese monolinguals. These findings suggest that with extensive L2 exposure, velopharyngeal behavior may begin to reflect L2 speech patterns. The potential influence of L2 on L1 resonance patterns will be discussed further in the following section.

Influence of L2 on Nasalance in Vietnamese–English Bilingual Speakers

The current study hypothesized that the nasalance scores of bilingual speakers would produce lower nasalance values than those of monolingual Vietnamese speakers, due to extended exposure to English. Consistent with the hypothesis, we found that their nasalance values were significantly lower than those of Vietnamese for the prolonged vowels /a/ and /i/, syllables with /a/ vowel context, and all three Vietnamese passages. Their nasalance

patterns closely resembled those of English monolinguals across all speech stimuli, except for the vowel /a/, indicating a possible influence of L2 (English) on L1 (Vietnamese) resonance characteristics.

This observation aligns partially with the findings of Pua et al. (2019), who reported L2 influence on L1 nasalance in Mandarin–English bilinguals. However, while Pua et al. observed lower nasalance scores for the oral passage but higher nasalance scores for the oronasal and nasal passages in bilinguals compared to Mandarin monolinguals, the current study found consistently lower nasalance values across all three passages in Vietnamese–English bilinguals. This divergence may be due to differences in English proficiency and the longer exposure to English among the participants in the current study, whereas participants in Pua et al.'s study had a wider range of English proficiency (0%–85%).

These findings are consistent with research on Spanish–English bilinguals, which suggests that greater exposure to English and increased L2 dominance are associated with L2-to-L1 influence (Doetzer, 2008; Perry et al., 2019). Collectively, these findings support the notion that the extent of L2 exposure and language proficiency plays a critical role in shaping L1 resonance patterns in bilingual individuals. The bilingual speakers in this study may exhibit behavioral adaptations in speech motor control, potentially influenced by the dominant language used in their daily lives.

Although nasalance scores from syllable repetitions in bilingual speakers did not clearly reflect either L1 or L2 language patterns, these patterns may still be interpreted as evidence of L2 influence. When Vietnamese–English bilingual speakers produced syllable repetitions, their extensive exposure to English may alter the degree of velopharyngeal closure, resulting in patterns that differ from those of monolingual Vietnamese. However, because the syllable stimuli lacked English-specific linguistic features, their nasalance values did not closely resemble those of monolingual English speakers either. These nasalance patterns parallel findings in other domains of bilingual speech production. For example, a study on French–English bilinguals has shown that their VOT values fall between the values for French and English, rather than aligning fully with either language (Caramazza et al., 1973).

An additional cross-linguistic L2 effect was observed in nasal syllables: Bilinguals demonstrated higher nasalance values for /mi/, resembling the pattern of English monolinguals and diverging from the neutral pattern seen in Vietnamese monolinguals. These findings suggest that L2 influence may be pronounced and more readily observable in contexts where L1 effects are minimal. They also underscore the dynamic and context-dependent nature of

bilingual speech behavior, in which phonetic characteristics may shift based on linguistic input and task complexity.

Based on our findings, we propose that differences in velopharyngeal valve activity may vary across speakers of different language backgrounds. While phonemes are traditionally characterized as either [+nasal] or [–nasal], implying a binary operation of the velopharyngeal mechanism, this dichotomous framework may oversimplify the underlying physiology, and the function of the velopharyngeal mechanism may be more complex than this binary framework suggests (Kuehn & Moon, 1998). That is, although velopharyngeal function typically involves closure during the production of oral sounds and opening for nasal sounds, the degree of closure may be modulated by their linguistic experience. Bilingual speakers, in particular, may differ from monolinguals in the timing, tightness, or positioning of the velopharyngeal valve even when producing the same speech samples. For example, English and Vietnamese differ not only in their phoneme inventories but also in syllable structure and prosodic characteristics. Substantial exposure to English, the dominant ambient language for our bilingual participants, may influence their velopharyngeal coarticulatory patterns, thereby affecting nasalance values during passage reading. These physiological adaptations to ambient language experience may contribute to the cross-linguistic differences in nasalance observed in this and other studies. To further investigate these mechanisms, future studies employing nasopharyngoscopy and magnetic resonance imaging are warranted to examine how linguistic experience shapes velopharyngeal coarticulation patterns.

It should be noted that the cross-linguistic nasalance differences cannot be attributed solely to anatomical variation, as both bilingual and monolingual Vietnamese speakers share similar anatomical structures. If anatomy were the only factor accounting for cross-linguistic differences, Vietnamese–English bilinguals would be expected to exhibit nasalance profiles similar to those of Vietnamese monolinguals. However, we observed the opposite pattern: The nasalance profiles of Vietnamese–English bilinguals more closely resembled those of English monolinguals than those of Vietnamese monolinguals. Finally, one might speculate on the potential influence of the French language on Vietnamese nasalance values. Vietnam's historical connection to the French is well documented, as the country was under colonial rule for more than 6 decades (Taylor, 2013). French influence remains evident in various aspects of Vietnamese society, including the lexicon, writing system, education, and culture (Marr, 1981). While research on nasalance in the French language is limited, Rochet et al. (1996) examined nasalance values in adult speakers of Western Canadian English and French. Their findings, which did not include statistical analyses, showed mixed results: The nasalance score for the English

Zoo Passage was lower than its French counterpart, whereas the English Rainbow and Nasal passages were associated with higher nasalance scores than the corresponding French passages. Given the limited research, it remains unclear whether French has influenced Vietnamese resonance. Nevertheless, because French includes phonemic nasal vowels, the potential influence of French nasal vowels, especially /*ã*/, on Vietnamese vowel production warrants further empirical investigation.

Clinical Implications

Clinically, these results carry important implications. Nasality rating scales developed for English-speaking populations (e.g., CAPS-A Americleft Modification; CAPS-A) suggest that mild hypernasality occurs with closed vowels like /u/ and /i/, while moderate hypernasality is observed with both open vowels (e.g., /a/) and closed vowels (John et al., 2006). Vowel-based hypernasality rating scales developed for English speakers may not be directly applicable to Vietnamese or Vietnamese–English speakers due to language-specific vowel effects. Given the measurable influence of English exposure on nasalance, clinicians should carefully consider a client's language background when interpreting nasometry results. Additionally, normative data derived from monolingual speakers should not be rigidly applied to bilingual individuals. Instead, clinical decisions should be guided by a holistic approach—one that integrates the client's speech and language history, speech characteristics, and quantitative assessments.

Conclusions and Future Directions

In the bilingualism and L2 acquisition literature, the influence of L1 on L2—and vice versa—has been widely documented across multiple domains (Caramazza et al., 1973; Chang, 2012; Flege & Eefting, 1987a, 1987b; MacKay et al., 2001; Pallier et al., 2003; Sancier & Fowler, 1997). This study provides additional evidence of cross-linguistic influence on nasalance in Vietnamese–English bilingual speakers. The unique vowel effect observed in monolingual Vietnamese speakers was also present in bilinguals, though modulated by exposure to English (L2). These findings suggest that resonance, like segmental features, is susceptible to cross-linguistic interaction.

In addition to incorporating nasopharyngoscopy and spectrographic analysis and investigating potential French influence on Vietnamese nasalance, a couple of other important considerations should be addressed in future research on this topic. First, the current study did not include all possible syllable types in Vietnamese and

English. To more comprehensively examine the influence of English on Vietnamese, future studies may benefit from including additional syllable types, particularly those containing phonemes that are specific to English (e.g., aspirated bilabial plosive). Furthermore, while the Vietnamese language dominantly consists of open syllables, English is composed of frequent closed syllables. The effect of closed syllables on nasalance was not investigated in the current study. The inclusion of such stimuli might provide further insight into L2 effects on nasalance patterns.

Second, the present study compared the English nasalance values of Vietnamese–English bilingual speakers with those of monolingual English speakers who speak a Southern dialect. While Awan et al. (2011) reported that English speakers with Southern dialects tend to exhibit higher nasalance scores than those with Northern dialects, this finding contrasts with Seaver et al. (1991), who reported that Mid-Atlantic speakers had significantly higher nasalance scores than their Southern counterparts. These conflicting findings suggest that the nasalance values produced by Vietnamese–English bilinguals might yield different statistical outcomes if compared to monolingual English speakers of other regional dialects. Future studies should consider including multiple English dialect groups to better understand how dialectal variation may interact with bilingualism and cross-linguistic influence.

Ethics Statement

The current study was approved by the institutional review board of Texas Tech University Health Sciences Center (IRB# FY2024-221). Consents were obtained from participants before the study was conducted.

Data Availability Statement

The data sets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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Appendix A

Vietnamese Initial Consonants

Manner	Voicing feature	Bilabial	Labiodental	Alveolar	Retroflex	Palatal	Velar	Glottal	
Plosive	Aspirated voiceless	(p ^ʰ)		t ^h	ʈ	c	k	(ʔ ^ʰ)	
Nasal	Unaspirated voiceless			t					
Fricative	Voiced								d
Liquid	Voiced								n
	Voiceless			f		s	ɳ		ŋ
	Voiced				z	ʂ	x		
	Voiced		v	l	ʐ	ɣ			

Note. Information from Lee et al., 2024.
*These consonants /p, ʔ/ are controversial among authors.

Appendix B

Speech Stimuli for Nasalance Measurement in Vietnamese–English Speakers

1. Prolonged sounds:

Instruction: Prolong each vowel:

a (/a/)

i (/i/)

u (/u/)

2. Syllable repetitions:

Instruction: Repeat these syllables:

đa đa đa đa đa (/da da da da da/)

đi đi đi đi đi (/di di di di di/)

ta ta ta ta ta (/ta ta ta ta ta/)

ti ti ti ti ti (/ti ti ti ti ti/)

tha tha tha tha tha (/tʰa tʰa tʰa tʰa tʰa/)

thi thi thi thi thi (/tʰi tʰi tʰi tʰi tʰi/)

xa xa xa xa xa (/sa sa sa sa sa/)

xi xi xi xi xi (/si si si si si/)

ma ma ma ma ma (/ma ma ma ma ma/)

mi mi mi mi mi (/mi mi mi mi mi/)

3. Vietnamese passages*

Instruction: Read these three passages:

Oral passage:

Hè, Bé và Bi về quê, đi tàu hỏa, khỏi phì phò. Ở quê, có thỏa thê các loại hoa quả: dâu da, đu đủ, ổi. Buổi trưa, bờ hè có cây cối lòa xòa, gió thổi rì rào, lá kêu xào xạc. Chiều chiều, Bé hí hoáy tập tô và chơi với Bi, Bi bập bẹ “papa”. Trời khuya, gió khe khẽ, bà lặc lự đọc thơ, Bé say sưa, gật gù, Bi cười khúc khích.

Oral–Nasal passage:

Trầu ơi ta bảo trầu này: Trầu ra ngoài ruộng trầu cày với ta. Cấy cày vốn nghiệp nông gia. Ta đây trầu đấy ai mà quản công. Bao giờ cây lúa có bông. Thì còn ngọn cỏ ngoài đồng trầu ăn.

Nasal sentences:

Nu na nu nống

Trống nằm trong

Nong nằm ngoài

Nói chuyện lan man

Mẹ Minh mua một múi mít

Nhí nha nhí nhảnh

Ngày nghỉ nghĩ ngơi ngấm nghỉ

4. English passages:

Instruction: Read these three passages:

Zoo passage:

Look at this book with us. It's a story about a zoo. That is where bears go. Today it's very cold out of doors, but we see a cloud overhead that's a pretty white fluffy shape. We hear that straw covers the floor of cages to keep the chill away, yet a deer walks through the trees with her head high. They feed seeds to birds so they're able to fly.

Rainbow passage:

When the sunlight strikes raindrops in the air, they act as a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. When a man looks for something beyond his reach, his friends say he is looking for the pot of gold at the end of the rainbow.

Nasal sentences:

Mama made some lemon jam.

Ten men came in when Jane rang.

Dan's gang changed my mind.

Ben can't plan on a lengthy rain.

Amanda came from Bounding, Maine.

*Vietnamese passages were adopted from the authors' previous study (D. M. Nguyen et al., 2021).

Appendix C

Nasalance Scores of Vietnamese–English Speakers, Vietnamese Speakers, and English Speakers

Speech stimuli	Vietnamese–English speakers (<i>n</i> = 16) <i>M</i> (<i>SD</i>)	Vietnamese speakers (<i>n</i> = 16) <i>M</i> (<i>SD</i>)	English speakers ^a (<i>n</i> = 16) <i>M</i> (<i>SD</i>)
Prolonged /a/	44.19 (14.64)	55.25 (11.69)	22.25 (8.69)
Prolonged /i/	21.88 (13.23)	35.19 (17.28)	26.88 (13.72)
Prolonged /u/	10.94 (6.55)	14.50 (9.40)	13.81 (9.81)
Syllable repetition /da/	20.31 (15.15)		
Syllable repetition /di/	19.88 (9.53)		
Syllable repetition /ta/	18.13 (14.94)		14.63 (5.73)
Syllable repetition /ti/	17.56 (9.65)		24.63 (10.18)
Syllable repetition /t ^h a/	20.44 (15.23)	37.50 (12.59)	
Syllable repetition /t ^h i/	15.56 (8.17)	24.56 (13.81)	
Syllable repetition /sa/	20.44 (16.22)	35.13 (11.53)	13.38 (4.86)
Syllable repetition /si/	18.19 (9.35)	21.69 (10.06)	21.81 (8.84)
Syllable repetition /ma/	64.00 (7.38)	65.31 (9.74)	63.63 (7.23)
Syllable repetition /mi/	74.75 (8.32)	65.94 (10.37)	79.81 (7.03)
Vietnamese oral passage	17.63 (7.01)	26.25 (7.13)	
Vietnamese oral–nasal passage	33.31 (8.61)	39.63 (6.73)	
Vietnamese nasal passage	66.19 (7.92)	70.56 (5.73)	
Zoo passage	13.75 (5.91)		15.44 (5.37)
Rainbow passage	30.38 (7.51)		33.31 (5.72)
Nasal Sentences	54.00 (9.32)		59.00 (4.87)

^aMonolingual English speakers' data were adopted from the authors' previous study (Liu & Lee, 2021).