Effects of Accent and Vowel Context on Thai Learners' Perception of English Dental Fricatives

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Abstract

English dental fricatives /ð/ and /θ/ are known to pose persistent perceptual difficulties for Thai learners of English because these sounds do not exist in the Thai phonological system. In addition, variation in English accents and surrounding phonetic environments may further influence learners' ability to perceive and distinguish these consonants accurately. This study investigates how Thai learners perceive the English dental fricatives /ð/ and /θ/ across different English accents and vowel contexts. Thai participants listened to English words containing the sounds /f, θ, ð, t, d/ in word-initial position. After hearing each stimulus, they identified the sound they perceived and rated its similarity using a goodness rating scale. The results show that Thai learners identified some English accent varieties, particulary the American accent, more accurately than others. Accent significantly influenced the identification of /ð/ across all vowel contexts, while vowel context affected the perception of /θ/ only in the low and high vowel contexts. However, accent did not have a significant effect on the identification of /θ/ in the back vowel context. Additional analyses revealed that learners frequently assimilated /ð/ to the English categories /ð/ and /d/, whereas /θ/ was often perceived as /f/ or /t/. The goodness rating and identification results showed that learners could generally distinguish all target contrasts in the American and Philippine accents. However, difficulties were observed for the /d–ð/ contrast in the British, Indian, and Thai accents, particularly across high and back vowel contexts. Learners also had difficulty distinguishing the /t–θ/ contrast in the Indian and Thai accents in several vowel contexts. Overall, the findings highlight the influence of accent variation and phonetic context on Thai learners' perception of English dental fricatives. These findings suggest that exposure to diverse English accents and phonetic contexts may play an important role in improving Thai learners' perception of English dental fricatives.

Keywords: dental fricative, world Englishes, vowel context, accent, intelligibility

1. Introduction

The perception of non-native speech sounds has long been a central topic in second language (L2) phonetic and phonology research. A substantial body of literature has demonstrated that adult learners' perception of L2 sounds is strongly shaped by their first language (L1) phonological system, often resulting in persistent difficulties even after years of exposure to the target language (Kalaivanan et al., 2023; Schmidt et al., 2025). Among English consonants, dental fricatives /θ/ and /ð/ are well known to be particularly challenging for learners whose L1 lacks these sounds, including Thai learners of English (e.g., Naruemon et al., 2024; Pathanasin et al., 2026; Sridhanyarat, 2017). Despite their high functional load in English, these sounds are frequently misperceived, substituted, or assimilated to other familiar categories, such as /t/, /d/, or /f/.

The difficulty associated with English dental fricatives has been widely documented in both perception and production studies (Aminjonov et al., 2024; Nguyen & Hoang, 2025; Nogita, 2010; Reis, 2006). However, much of the existing research has focused on a limited range of speaker varieties, most often native speakers of American or British English. In contrast, learners in many English as Lingua Franca (ELF) contexts are routinely exposed to multiple English accents, including those spoken by non-native speakers. This mismatch between research focus and learners' actual input raises important questions about how accent variation affects L2 speech perception and how learners assimilate unfamiliar sounds across different English varieties.

From a theoretical perspective, dominant models of L2 speech perception emphasise the role of perceptual similarity between L1 and L2 sound categories, i.e. the Perceptual Assimilation Model-L2 (PAM-L2) (Best et al., 2007), the revised version of the Speech Learning Model (SLM-r) (Flege et al., 2021), and the revised Second Language Linguistic Perception (L2LP) (Van Leussen & Escudero, 2015). According to these models, when an L2 sound is perceived as sufficiently similar to an existing L1 category, learners tend to assimilate it to that category, which may impede accurate perception and category formation. While these frameworks have provided valuable insights into why certain sounds are difficult to perceive, they have primarily been tested using canonical native-speaker input. As a result, relatively little is known about how these theoretical predictions extend to situations in which learners are exposed to multiple accent varieties that differ systematically in their phonetic realisation of the same phonological categories.

English dental fricatives offer a particularly suitable testing ground for addressing this gap. Cross-linguistic research has shown that /θ/ and /ð/ exhibit substantial phonetic variation across English accents. For example, /ð/ may be realised with greater stop-like qualities in some varieties, such as a dental stop [d̪] in Liverpool (Watson, 2007) and [d] in Cajun English, a dialect of Southern American English (Dubois & Horvath, 1998), while /θ/ may be produced with increased labiodental characteristics in others, such as [f] in London (Labov, 1969). Such variation has the potential to alter learners' perceptual assimilation patterns, leading to accent-specific difficulties that cannot be fully explained by L1 influence alone.

Empirical studies on the perception of English dental fricatives by Thai learners have consistently reported low identification accuracy and frequent substitutions (Atthaphonphiphat, 2017; Kitikanan, 2017; Roengpitya, 2025). Thai lacks dental fricatives in its phonemic inventory, and previous research suggests that Thai learners often assimilate /θ/ and /ð/ to alveolar stops, such as /t/ and /d/ or fricatives, such as /f/ and /s/ that are more familiar in their L1. However, most prior studies have examined perception using a single speaker or a single accent, typically American or British English (e.g., Atthaphonphiphat, 2017; Kitikanan, 2017; Roengpitya, 2025).

Another limitation of previous work concerns the role of phonetic context. Although vowel context is known to influence the perception of consonants, especially fricatives (Kitikanan, 2017), it has not been systematically examined in relation to accent variation in the perception of English dental fricatives by Thai learners. Differences in vowel height and backness can affect coarticulatory cues and acoustic properties of adjacent consonants, potentially facilitating or hindering accurate identification (Hardison, 2003; Kitikanan, 2017; Schmidt, 1996). The study contributes to the literature by examining the combined effects of accent variation, vowel context, and perceptual assimilation on Thai learners' perception of English dental fricatives. The present study aims to address these theoretical and empirical gaps by examining how Thai learners perceive English dental fricatives across multiple English accents and vowel contexts. Specifically, the study investigates the identification accuracy and perceptual assimilation patterns of /θ/ and /ð/ produced by speakers of American, British, Indian, Philippine, and Thai English. The selected accents represent both widely encountered international English varieties and a familiar localised variety frequently heard by Thai learners in educational contexts. The inclusion of Thai English was intended to examine the potential influence of accent familiarity on speech perception. Furthermore, by systematically manipulating vowel height and backness, the study provides insight into how phonetic context interacts with accent variation in shaping perceptual outcomes.

2. Literature Review

This section reviews previous research relevant to the perception of English dental fricatives by L2 learners. It first outlines major theories of L2 speech perception, followed by studies on learners' perception of /θ/ and /ð/. The section then discusses the influence of accent variation and phonetic context on L2 speech perception.

2.1 L2 Speech Perception Theories

Research on L2 speech perception has proposed several theoretical frameworks to explain how learners perceive unfamiliar sounds in a new language. Among the most influential models are the SLM-r (Flege et al., 2021), the PAM-L2 (Best et al., 2007), and the L2LP (Van Leussen & Escudero, 2015). Although these models differ in their assumptions and focus, they all emphasise the important role of learners' existing linguistic knowledge in shaping the perception of L2 sounds.

The SLM-r model (Flege et al., 2021) proposes that L2 speech sounds are learned through their interaction with existing L1 phonetic categories. According to this model, learners compare incoming L2 sounds with the phonetic categories already established in their L1. When an L2 sound is perceived as sufficiently different from any L1 category, learners may create a new phonetic category for that sound. However, if the L2 sound is perceived as similar to an existing L1 sound, learners may assimilate it into that category, which can make it more difficult to perceive the contrast accurately. As a result, the degree of perceived similarity between L1 and L2 sounds plays an important role in determining the success of L2 speech perception.

The PAM-L2 (Best et al., 2007) focuses on how listeners map unfamiliar L2 sounds onto their native phonological categories. PAM-L2 proposes that listeners perceptually assimilate non-native sounds to the closest L1 categories, and the type of assimilation influences how well they can distinguish contrasts. For example, when two L2 sounds are both assimilated to the same L1 category, learners may have difficulty distinguishing between them. In contrast, when the sounds are mapped onto different L1 categories, discrimination is expected to be more accurate. PAM-L2 therefore highlights the importance of perceptual assimilation patterns in predicting learners' success in perceiving non-native phonological contrasts.

The L2LP (Van Leussen & Escudero, 2015), which emphasises the role of perceptual learning and the relationship between acoustic cues and phonological representations. According to L2LP, learners must adjust their perceptual mappings so that acoustic cues in the L2 are correctly associated with appropriate phonological categories. When learners rely on perceptual mappings that are appropriate for their L1 but not for the L2, misperception may occur. Successful L2 perception therefore requires learners to reorganise the relationship between acoustic input and phonological categories through experience and exposure to the target language.

Taken together, these theoretical models suggest that L2 speech perception is strongly influenced by learners' existing phonological system and their perceptual experience. In particular, they predict that learners may experience difficulty when unfamiliar L2 sounds are perceived as similar to existing categories in their native language. This prediction is especially relevant for the perception of English dental fricatives /θ/ and /ð/ by Thai learners, as these sounds are absent from the Thai phonological inventory and may therefore be

assimilated to more familiar consonant categories.

2.2 Perception of English Dental Fricatives by L2 Learners

The English dental fricatives /θ/ and /ð/ are widely recognised as among the most challenging consonants for L2 learners (e.g., Brannen, 2011; Hancin-Bhatt, 1994). These sounds are relatively uncommon across the world's languages, and many languages, such as Thai, do not have dental fricatives in their phonological inventories. L2 learners often experience difficulty perceiving and producing these sounds. Previous research has shown that learners frequently rely on more familiar consonant categories when encountering unfamiliar dental fricatives, leading to systematic patterns of substitution, such as substituting /θ/ and /ð/ with [s] and [z] in European French and Japanese speakers (Hancin-Bhatt, 1994).

A common observation in literature is that learners tend to replace /θ/ and /ð/ with consonants that share certain phonetic properties with the target sounds. For example, English /θ/ is often substituted with [t] (Burkardt, 2008; Kitikanan, 2016), [s], or [f] (Kitikanan, 2017), while /ð/ is commonly replaced with [d] (Burkardt, 2008; Kitikanan, 2016, 2017). These substitutions are typically explained in terms of perceptual similarity and the influence of the learners' L1 phonological system. The difficulty associated with English dental fricatives is particularly relevant for Thai learners. Thai phonology does not include dental fricatives, and therefore Thai speakers do not have established phonological categories corresponding to /θ/ or /ð/. Instead, Thai contains a set of stop and fricative consonants that may serve as perceptual substitutes for these unfamiliar sounds. As predicted by cross-linguistic speech perception theories, the absence of dental fricatives in Thai may lead learners to identify these sounds to more familiar categories, such as /t/, /d/, or /f/. Consequently, Thai learners may experience challenges in accurately identifying English dental fricatives, especially when these sounds occur in varying phonetic environments or across different English accents.

2.3 Accent Variation and Phonetic Context in L2 Perception

English is spoken in a wide range of accent varieties around the world. These varieties differ in their phonetic and phonological characteristics. As English increasingly functions as an international language, L2 learners are likely to encounter multiple accent varieties rather than a single standard form. Understanding how learners perceive speech across different accents has become an important issue in research on L2 speech perception.

Previous studies have shown that accent variation can influence intelligibility and speech perception (e.g., Jacewicz & Fox, 2013; Stringer & Iverson, 2019). Learners often find certain accents easier to understand than others, depending on factors, such as familiarity, exposure, and phonetic similarity to their own speech patterns. For example, participants rated the American and British speakers more positively in terms of intelligibility, perception, and attitudes compared with the other speakers (Jeong et al., 2021). Learners may demonstrate higher accuracy when listening to accents that are more frequently encountered in educational contexts or media. In contrast, unfamiliar accents may introduce additional phonetic variability that makes speech perception more challenging. This variation can affect how listeners identify and categorise specific speech sounds.

In addition to accent variation, the phonetic context in which a sound occurs can also influence speech perception. The phonetic environment, such as the vowel that follows a consonant, may affect the acoustic realisation of the consonant and the perceptual cues available to listeners. For instance, although modest in magnitude, vowel context significantly affects consonant recognition among average listeners, with better performance occurring in back vowel context compared to the front vowel (Donaldson & Kreft, 2006). This suggests that coarticulation between consonants and vowels can modify the acoustic properties of the consonant, potentially making it easier or more difficult for learners to identify the sound accurately. Consonant perception may vary depending on the vowel context in which the consonant appears.

Despite growing interest in these issues, many studies on L2 speech perception have focused primarily on native-speaker varieties of English, particularly American (e.g., Hisagi et al., 2022; Roberts 2023) or British accents (e.g., Doan & Oh, 2023; Kitikanan, 2022). While such studies have provided valuable insights into learners' perception of specific phonological contrasts, they may not fully reflect the diversity of accents encountered in real-world communication. Furthermore, relatively few studies have examined how accent variation interacts with phonetic context in shaping the perception of challenging consonants. This gap is particularly relevant for the perception of English dental fricatives by Thai learners. Given the absence of /θ/ and /ð/ in Thai and the potential influence of both accent variation and phonetic context, it is important to examine how these factors jointly affect learners' perception of these sounds. Therefore, the present study investigates Thai learners' perception of the English /θ/ and /ð/ across different English accents and vowel contexts. Therefore, the present study investigates Thai learners' perception of the English /θ/ and /ð/ across different English accents and vowel contexts by examining (1) how accent variation and vowel context affect identification accuracy and (2) how learners perceptually assimilate these consonants across different accent conditions.

3. Research Methodology

3.1 Stimuli

All stimuli consisted of 40 English words. The words were systematically selected to vary according to vowel height and vowel frontness. Specifically, the vowel contexts included high, low, and back vowels. Five target consonants were examined: /f, θ, ð, t, d/. Each target sound appeared in six words, with two words representing each vowel context. In total, 30 words contained the target sounds. The remaining 10 words served as distractors and did not begin with dental fricatives. The complete list of stimuli is presented in Table 1.

Table 1. Wordlist for stimuli used in this study

	High vowel context	Low vowel context	Back vowel context
/f/	"feel", "fit"	"fan", "fat"	"food", "foot"
/θ/	"thing", "thick"	"thank", thatch"	"thought", "Thorne"
/ð/	"these", "this"	"that", than"	"those", "though"
/t/	"tea", "tip"	"tap", "tag"	"two", "tool"
/d/	"deep", "dip"	"dad", "dash"	"do", "doom"

The stimuli were produced by five male speakers from different linguistic backgrounds: Thai, Philippine, Indian, British, and American. All speakers were affiliated with academic institutions. The stimuli were presented to the speakers using a PowerPoint presentation displayed on a computer. The recordings were conducted in a soundproof booth at Naresuan University. Speech was recorded using a Focusrite audio interface and a TASCAM TM-280 condenser microphone, with a sampling rate of 48 kHz and 24-bit resolution. Each speaker was recorded individually in the presence of the first researcher and produced the target words within the carrier phrase, "Say ____ again."

3.2 Participants

Thirty-eight participants took part in this task (six males). They were undergraduate students from majors other than English, such as science, tourism, mass communication, and accounting. Their ages ranged from 18 to 20 years. All participants were Thai and had not received any formal training in English phonetics. Although the participants had studied English in Thailand for approximately 15 years through formal schooling, their overall English proficiency was relatively low. General information about participants' English proficiency was obtained from institutional academic records, which indicated that many participants had previously received relatively low grades in English courses.

3.3 Data collection

The experiment was conducted using the ExperimentMFC interface in Praat (Boersma & Weenink, 2023) with a customised script. Before beginning the task, participants watched a three-minute instructional video in Thai that explained the procedure. The video included three-example stimuli to familiarise them with the task. During the experiment, participants were asked to identify the sound they heard by selecting the corresponding English letter(s). Seven response options were provided: "f", "th (as in 'thank')", "th (as in 'the')", "d", "t", "s", and "other sound". After making their selection, they rated how similar the sound they heard was to the sound they selected using a seven-point scale (1 = very different, 7 = very similar). Once the instruction phase was completed, the main experiment began. All stimuli consisted of English words containing the target consonant followed by the first 100 milliseconds of the subsequent vowel. The order of the stimuli was randomised using the <PermuteBalancedNoDoublets> command in Praat's ExperimentMFC to avoid repetition patterns. Each participant listened to 200 stimuli (40 words x 5 speakers). They spent approximately 30 to 50 minutes completing the task, and received 100 Baht as compensation. Ethical approval for the study was granted by the Survey and Behavioural Research Ethics Faculty Sub-Committee of the Chinese University of Hong Kong, Faculty of Education (EDU2026-027).

3.4 Data analysis

This study yielded a total of 5,700 responses, calculated from 150 trials (30 trials × 5 speakers) completed by 38 listeners. The data were transferred to *Microsoft Excel* for descriptive statistical analysis. To examine the relationships among dental fricatives, vowel context, and accent, generalised linear mixed-effects models (GLMMs) were conducted using *lme4* package (Bates et al., 2015) in *R* via *Rstudio* (RStudio Team, 2026). Of the total responses, 2,280 were included in the GLMM analyses. This reduced number resulted from selecting only responses that were correctly matched with the target English sounds. Response accuracy (correct vs. incorrect) was specified as the dependent variable. The independent variables included vowel context (low, high, back), dental fricative (/ð/, /θ/), and accent (American, British, Indian, Philippine, and Thai). Participants and stimuli were entered as random intercepts. Model fitting was performed using the bobyqa optimiser with an increased maximum number of iterations to ensure convergence. Model diagnostics indicated that the fitted model was not singular, suggesting that the random-effects structure was appropriate. The significance of fixed effects and their interactions was evaluated using likelihood ratio tests (LRTs) based on chi-square statistics. Post-hoc comparisons using estimated marginal means (EMMs) computed with the *emmeans* package (Lenth, 2024). Speaker contrasts were examined separately within each vowel context. Pairwise comparisons were adjusted for multiple testing using the Holm correction.

Goodness ratings for sounds with overlapped identification were analysed using linear mixed-effect model (LMM) implemented in *RStudio* (RStudio Team, 2026). The model was fitted using the *lme4* package (Bates et al., 2015). The dependent variable was goodness rating. Following the procedures proposed by Lengeris (2009, p.176), identification results and goodness-of-fit ratings were combined into a single measure, called "the fit index". For each English sound, the percentage of responses identifying a Thai consonant category (multiplied by 0.01) was multiplied by the corresponding goodness-of-fit score. The fit index represents the perceived similarity between an English sound and an L1 consonant category, with higher values indicating greater perceived similarity. The fixed effects included accent (American, British, Indian, Philippine, Thai), vowel context (low, high, back), target sound (/ð/, /θ/, /f/, /d/, /t/), and response (/θ/, /f/, /d/, /t/). These predictors were entered as categorical variables. Random intercepts were included for participant and item. Post-hoc analyses were carried out using the *emmeans* package (Lenth, 2024). Estimated marginal means were computed on the response scale (i.e., predicted probabilities of correct identification) for accent, conditional on vowel and sound. Pairwise comparisons between accents were then performed separately for each vowel context–sound combination. To control for multiple comparisons, p-values were adjusted using

the Holm correction method. Odds ratios are reported to indicate the direction and magnitude of significant contrasts, with values greater than 1 reflecting higher odds of correct identification for the first accent listed.

4. Results

The results are organised into three sections corresponding to the main aspects of the analysis: identification accuracy, perceptual assimilation patterns, and goodness ratings. Together, these findings provide insight into how Thai learners perceived English dental fricatives across different accent and phonetic conditions.

4.1 Identification Accuracy

The results of the GLMM analyses and subsequent post-hoc comparisons indicated that Thai learners were able to perceive some varieties of English /ð/ and /θ/ more accurately than others. The results also showed that vowel context influenced perception in most vowel environments, although no significant effect was observed for /θ/ in the back vowel context. The detailed results are presented below.

For the correct identification of /ð/, significant differences across accents were observed in all vowel contexts. In the low vowel context, Thai learners showed significantly lower identification accuracy for the British accent than for the Indian accent. In the high vowel context, identification accuracy was significantly higher for the American accent than for the Thai accent. In the back vowel context, substantial accent-related differences emerged. Identification accuracy for the American accent was significantly higher than for the British, Indian, Philippine, and Thai accents. In addition, the British accent yielded significantly higher accuracy than the Indian accent. The Indian accent showed significantly lower accuracy than the Philippine accent, while the Philippine accent showed significantly higher accuracy than the Thai accent.

For the correct identification of /θ/ in the low vowel context, Thai learners demonstrated significantly higher accuracy for the American accent than for the British and Philippine accents. In the same context, identification accuracy for the British, Indian, and Philippine accents was significantly lower than for the Thai accent. This finding may reflect the influence of accent familiarity, as Thai learners are likely to have greater exposure to Thai-accented English in educational and everyday communication contexts. In the high vowel context, identification accuracy for the American accent was significantly higher than for the Philippine accent. In addition, the British accent showed significantly lower accuracy than the Indian accent, while the Indian accent demonstrated significantly higher accuracy than the Philippine accent. Table 2 shows pairwise comparisons of correct sound identification accuracy across speakers and vowel contexts. Figure 1 shows predicted probability of correct identification of /ð/ and /θ/ across accents and vowel contexts.

Table 2. Pairwise accent contrasts in correct sound identification across vowel contexts (significant comparisons only)

Sound	Vowel	Accents	Odds ratio	SE	*z*	*p*
/ð/	Low	British-Indian	0.30	0.12	-2.90	0.04
	High	American-Thai	3.77	1.55	3.23	0.01
	Back	American-British	6.64	2.55	4.94	0.00
		American-Indian	30.23	16.20	6.37	0.00
		American-Philippine	3.21	1.15	3.26	0.01
		American-Thai	13.42	5.80	6.00	0.00
		British-Indian	4.55	2.51	2.75	0.02
		Indian-Philippine	0.11	0.06	-4.19	0.00
		Philippine-Thai	4.18	1.81	3.30	0.00
/θ/	Low	American-British	4.77	1.88	3.96	0.00
		American-Philippine	6.47	2.68	4.50	0.00
		British-Thai	0.14	0.05	-5.03	0.00
		Indian-Thai	0.28	0.10	-3.49	0.00
		Philippine-Thai	0.10	0.04	-5.50	0.00
	High	American-Philippine	8.20	4.82	3.58	0.00
		British-Indian	0.23	0.11	-3.22	0.01
		Indian-Philippine	10.92	6.38	4.10	0.00

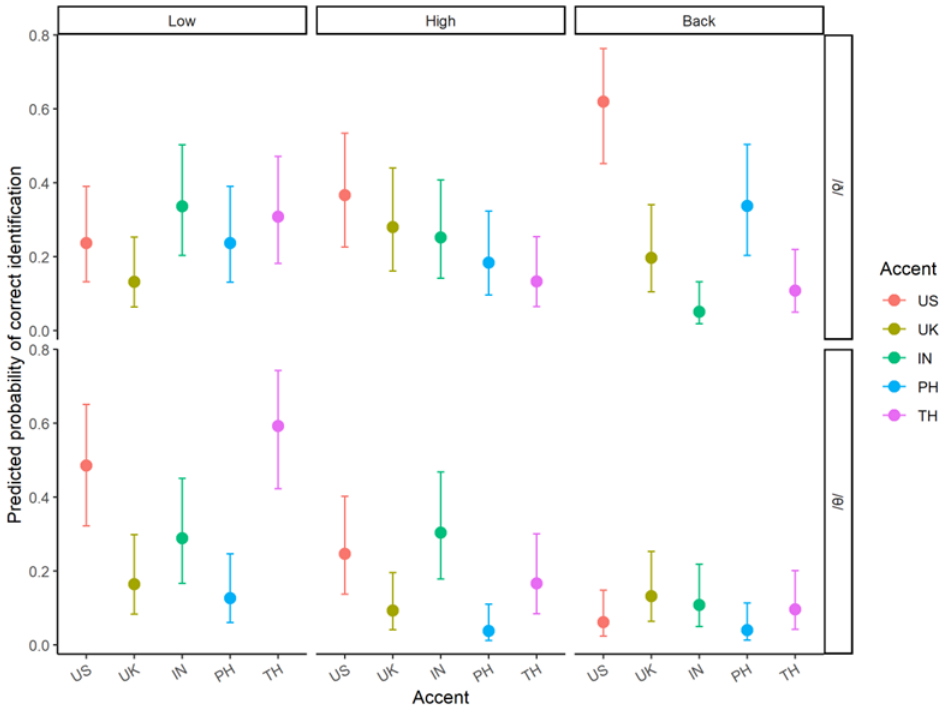

Figure 1. Predicted probability of correct identification of English dental fricatives across accents and vowel contexts

4.2 Perceptual Assimilation Patterns

With respect to the matching of English dental fricative variants, related sounds, and English phonemic representations, the English sounds /d/, /f/, and /t/ across all variants were predominantly matched with their corresponding English categories.

For the variants of English /ð/, assimilation patterns varied across vowel contexts and accents. The sound was most frequently assimilated to /ð/ itself in the high vowel context in the American accent, in the back vowel context in the American and Philippine accents, and in the low vowel context in the Indian accent. In contrast, it was most often assimilated to its voiceless counterpart /θ/ in the low vowel context in the American and Philippine accents. The /ð/ variants were most commonly matched with /d/ in the high vowel context in the British, Indian, and Thai accents; in the low vowel context in the Thai accent; and in the back vowel context in the Indian and Thai accents. Additionally, /ð/ was frequently matched with other sounds in the low and back vowel contexts in the British accent and in the high vowel context in the Philippine accent.

For the variants of English /θ/, the sound was most frequently assimilated to /θ/ itself in the low vowel context in the American and Thai accents, and in the high vowel context in the Indian accent. Although /θ/ was not predominantly assimilated to its voiced counterpart, it was most commonly matched with /f/ in the high and back vowel contexts in the American and Philippine accents, in the high vowel context in the British accent, and in the low vowel context in the British and Philippine accents. The /θ/ variants were also most often matched with /s/ in the back vowel context in the British accent. In addition, they were frequently matched with /t/ in the low and back vowel contexts in the Indian accent, as well as in the back and high vowel contexts in the Thai accent. Table 3 shows the percentages of perceptual assimilation of English sounds into English categories, with mean fit indices shown in parentheses.

Table 3. Percentage of the perceptual assimilation patterns of English sounds to English sounds and mean fit index in parenthesis. Bold percentage for the most-frequently-identified matching

			Perceived sound						
	Target sound	Vowel context	/d/	/ð/	/f/	other	/s/	/t/	/θ/
American	/d/	Low	38.16% (2.06)	30.26%	0.00%	1.32%	0.00%	11.84%	18.42%
		High	68.42% (3.50)	21.05%	0.00%	0.00%	0.00%	5.26%	5.26%
		Back	85.53% (4.87)	2.63%	0.00%	7.89%	0.00%	2.63%	1.32%

	Target sound	Vowel context	Perceived sound /d/	/ð/	/f/	other	/s/	/t/	/θ/
	/ð/	Low	9.21%	26.32%	7.89%	3.95%	0.00%	9.21%	43.42% (2.29)
		High	32.89%	38.16% (2.11)	1.32%	17.11%	1.32%	3.95%	5.26%
		Back	7.89%	60.53% (3.55)	0.00%	6.58%	9.21%	5.26%	10.53%
	/f/	Low	1.32%	2.63%	75.00% (4.36)	5.26%	2.63%	0.00%	13.16%
		High	2.63%	0.00%	90.79% (5.35)	3.95%	0.00%	0.00%	2.63%
		Back	1.32%	0.00%	90.79% (5.12)	6.58%	0.00%	1.32%	0.00%
	/t/	Low	2.63%	5.26%	0.00%	10.53%	1.32%	55.26% (2.92)	25.00%
		High	2.63%	2.63%	0.00%	11.84%	0.00%	75.00% (4.20)	7.89%
		Back	3.95%	6.58%	0.00%	2.63%	0.00%	84.21% (4.46)	2.63%
	/θ/	Low	2.63%	5.26%	32.89%	2.63%	6.58%	1.32%	48.68% (2.62)
		High	2.63%	2.63%	32.89% (1.87)	2.63%	27.63%	3.95%	27.63%
		Back	0.00%	5.26%	59.21% (3.08)	6.58%	18.42%	2.63%	7.89%
British	/d/	Low	47.37% (2.51)	25.00%	1.32%	5.26%	0.00%	6.58%	14.47%
		High	63.16% (3.50)	28.95%	0.00%	5.26%	0.00%	2.63%	0.00%
		Back	77.63% (4.01)	14.47%	0.00%	3.95%	1.32%	1.32%	1.32%
	/ð/	Low	5.26%	15.79%	17.11%	44.74% (1.68)	1.32%	3.95%	11.84%
		High	38.16% (2.28)	30.26%	1.32%	21.05%	0.00%	2.63%	6.58%
		Back	5.26%	22.37%	25.00%	28.95% (1.38)	2.63%	5.26%	10.53%
	/f/	Low	2.63%	0.00%	86.84% (4.77)	2.63%	0.00%	1.32%	6.58%
		High	1.32%	2.63%	89.47% (5.25)	2.63%	0.00%	1.32%	2.63%
		Back	2.63%	2.63%	90.79% (5.30)	0.00%	3.95%	0.00%	0.00%
	/t/	Low	0.00%	7.89%	1.32%	1.32%	1.32%	51.32% (2.77)	36.84%
		High	0.00%	2.63%	2.63%	0.00%	2.63%	76.32% (4.18)	15.79%
		Back	1.32%	7.89%	1.32%	2.63%	5.26%	75.00% (4.12)	6.58%
	/θ/	Low	0.00%	0.00%	68.42% (3.69)	3.95%	6.58%	1.32%	19.74%
		High	1.32%	6.58%	67.11% (3.72)	5.26%	6.58%	1.32%	11.84%
		Back	1.32%	0.00%	22.37%	14.47%	36.84% (1.94)	9.21%	15.79%
Indian	/d/	Low	38.16% (2.12)	28.95%	1.32%	5.26%	0.00%	5.26%	21.05%
		High	80.26% (4.38)	15.79%	0.00%	2.63%	1.32%	0.00%	0.00%
		Back	89.47% (5.01)	3.95%	1.32%	1.32%	0.00%	2.63%	1.32%
	/ð/	Low	23.68%	35.53% (1.85)	0.00%	2.63%	0.00%	6.58%	31.58%
		High	53.95%	27.63%	0.00%	11.84%	2.63%	3.95%	0.00%

	Target sound	Vowel context	Perceived sound /d/	/ð/	/f/	other	/s/	/t/	/θ/
		Back	(2.91) 76.32%						
	/f/	Low	(3.92)	6.58%	0.00%	2.63%	0.00%	6.58%	7.89%
		High	1.32%	3.95%	84.21% (4.52)	7.89%	1.32%	0.00%	1.32%
		Back	2.63%	0.00%	92.11% (5.24)	2.63%	0.00%	2.63%	0.00%
	/t/	Low	2.63%	1.32%	93.42% (5.48)	1.32%	0.00%	1.32%	0.00%
		High	19.74%	10.53%	2.63%	6.58%	0.00%	31.58% (1.64)	28.95%
		Back	36.84% (2.02)	14.47%	0.00%	3.95%	0.00%	36.84% (2.01)	7.89%
	/θ/	Low	31.58%	2.63%	0.00%	9.21%	0.00%	53.95% (2.98)	2.63%
		High	2.63%	7.89%	0.00%	6.58%	0.00%	51.32% (2.45)	31.58%
		Back	11.84%	10.53%	2.63%	17.11%	0.00%	25.00%	32.89% (1.90)
Philippine	/d/	Low	1.32%	7.89%	1.32%	5.26%	0.00%	71.05% (3.55)	13.16%
		High	56.58% (3.05)	26.32%	0.00%	2.63%	1.32%	3.95%	9.21%
		Back	65.79% (3.78)	28.95%	1.32%	1.32%	0.00%	1.32%	1.32%
	/ð/	Low	85.53% (4.74)	7.89%	0.00%	1.32%	0.00%	2.63%	2.63%
		High	9.21%	26.32%	11.84%	10.53%	3.95%	2.63%	35.53% (2.00)
		Back	19.74%	21.05%	9.21%	40.79% (1.85)	0.00%	2.63%	6.58%
	/f/	Low	11.84%	35.53% (2.03)	2.63%	22.37%	3.95%	9.21%	14.47%
		High	0.00%	1.32%	90.79% (5.20)	2.63%	3.95%	0.00%	1.32%
		Back	0.00%	2.63%	96.05% (5.44)	0.00%	0.00%	1.32%	0.00%
	/t/	Low	1.32%	1.32%	88.16% (5.24)	2.63%	3.95%	0.00%	2.63%
		High	0.00%	5.26%	1.32%	10.53%	0.00%	53.95% (2.94)	28.95%
		Back	0.00%	1.32%	1.32%	7.89%	0.00%	84.21% (4.97)	5.26%
	/θ/	Low	1.32%	5.26%	0.00%	5.26%	0.00%	84.21% (4.75)	3.95%
		High	1.32%	2.63%	72.37% (4.15)	3.95%	2.63%	1.32%	15.79%
		Back	0.00%	2.63%	75.00% (4.13)	1.32%	14.47%	1.32%	5.26%
Thai	/d/	Low	2.63%	0.00%	78.95% (4.24)	3.95%	9.21%	0.00%	5.26%
		High	35.53% (1.97)	27.63%	1.32%	2.63%	1.32%	10.53%	21.05%
		Back	73.68% (4.11)	18.42%	0.00%	3.95%	1.32%	1.32%	1.32%
	/ð/	Low	86.84% (4.82)	6.58%	0.00%	3.95%	1.32%	1.32%	0.00%
		High	40.79% (2.30)	32.89%	1.32%	2.63%	0.00%	3.95%	18.42%
		Back	81.58% (4.47)	15.79%	0.00%	2.63%	0.00%	0.00%	0.00%
			43.42% (2.25)	13.16%	1.32%	5.26%	0.00%	25.00%	11.84%

Target sound	Vowel context	Perceived sound /d/	/ð/	/f/	other	/s/	/t/	/θ/
/f/	Low	0.00%	3.95%	89.47% (5.20)	2.63%	0.00%	1.32%	2.63%
	High	1.32%	1.32%	93.42% (5.49)	2.63%	0.00%	0.00%	1.32%
	Back	1.32%	1.32%	94.74% (5.65)	1.32%	1.32%	0.00%	0.00%
/t/	Low	1.32%	5.26%	0.00%	1.32%	0.00%	60.53% (3.41)	31.58%
	High	0.00%	6.58%	1.32%	3.95%	0.00%	75.00% (4.07)	13.16%
	Back	2.63%	2.63%	0.00%	1.32%	0.00%	86.84% (4.88)	6.58%
/θ/	Low	1.32%	5.26%	2.63%	5.26%	0.00%	27.63%	57.89% (3.35)
	High	11.84%	15.79%	0.00%	9.21%	0.00%	43.42% (2.31)	19.74%
	Back	5.26%	13.16%	1.32%	11.84%	0.00%	56.58% (2.93)	11.84%

Note: Yellow highlight refers to highest percentage of assimilation, whereas red letters refer to the sound that has overlapped identification.

In addition to accent variation, the phonetic context in which a sound occurs can also influence speech perception. Overall, the results indicate that Thai learners exhibited overlapping assimilation patterns across all accent variants. Such overlap may reflect difficulty in distinguishing English sounds perceptually. The overlapping patterns can be summarised as follows. In the American accent, Thai learners most frequently matched both /ð/ and /θ/ to /θ/ in the low vowel context. In the high and back vowel contexts, they also tended to match both /f/ and /θ/ to /f/. In the British accent, Thai learners most often matched /d/ and /ð/ to /d/ in the high vowel context, and matched /f/ and /θ/ to /f/ in both the low and high vowel contexts. In the Indian accent, /d/ and /ð/ in the high and back vowel contexts, as well as /t/ in the high vowel context, were most commonly matched to /d/, whereas /t/ and /θ/ were most often matched to /t/ in the low and back vowel contexts. In the Philippine accent, Thai learners predominantly matched /f/ and /θ/ to /f/ across vowel contexts. Finally, in the Thai accent, /d/ and /ð/ were most frequently matched across vowel contexts, and in the high and back vowel contexts, /t/ and /θ/ were most commonly matched to /t/.

4.3 Goodness Ratings

To examine which sound contrasts that had overlapped matchings posed difficulties for the learners, goodness ratings were compared using t-tests based on the Kenward–Roger approximation. The results indicated that Thai learners may have difficulty distinguishing between /d/ and /ð/ in the high vowel context when listening to the British accent ($p > .05$). For the Indian accent, learners appeared to experience difficulty with the /d/–/ð/ contrast in both high and back vowel contexts, as well as with the /t/–/θ/ contrast in low and back vowel contexts (all p values > .05). In the Thai accent, learners showed potential difficulty distinguishing /d/ and /ð/ across vowel contexts, and /t/ and /θ/ in the high and back vowel contexts (all p values > .05).

Overall, learners showed little difficulty in distinguishing several sound contrasts across accents, as reflected by significant differences in goodness ratings. In the American accent, significant differences were observed across all vowel contexts. In the low vowel context, goodness ratings for /ð/ were significantly higher than for /θ/. In the high and back vowel contexts, /f/ received significantly higher goodness ratings than /θ/ (all $p < .01$). For the British accent, learners showed reliable distinctions between /f/ and /θ/ in both the low and high vowel contexts, with /f/ receiving significantly higher goodness ratings in each case ($p < .01$). In the Indian accent, significant differences emerged in the high vowel context: goodness ratings for /d/ were significantly higher than for /t/, and /ð/ was also rated significantly higher than /t/ ($p < .05$). For the Philippine accent, learners demonstrated clear distinctions between /f/ and /θ/ across all vowel contexts, with /f/ consistently receiving higher goodness ratings ($p < .01$). Table 4 shows pairwise analysis of goodness ratings across accents, vowel contexts, and sound contrasts with overlapping identification. Figure 2 shows estimated goodness ratings for English dental fricatives and competing categories across accent varieties and vowel contexts.

Table 4. Pairwise comparisons of goodness ratings across accents, vowel contexts, and sound contrasts with overlapping identification (signifcant comparisons only)

Accent	Vowel	Response	Contrast	E	SE	df	t.ratio	p.value
American	Low	/θ/	/ð/-/θ/	1.42	0.4	31.4	3.56	0.00
	High	/f/	/f/-/θ/	1.42	0.37	22	3.88	0.00
	Back			1.42	0.37	22	3.88	0.00
British	Low	/f/	/f/-/θ/	1.42	0.37	22	3.88	0.00
	High			1.42	0.37	22	3.88	0.00
Indian	High	/d/	/d/-/t/	1.82	0.41	34.1	4.44	0.00
	High		/ð/-/t/	1.06	0.40	31.7	2.63	0.05

Accent	Vowel	Response	Contrast	E	SE	df	t.ratio	p.value
Philippine	Low	/f/	/f/-/θ/	1.42	0.37	22	3.88	0.00
	High			1.42	0.37	22	3.88	0.00
	Back			1.42	0.37	22	3.88	0.00

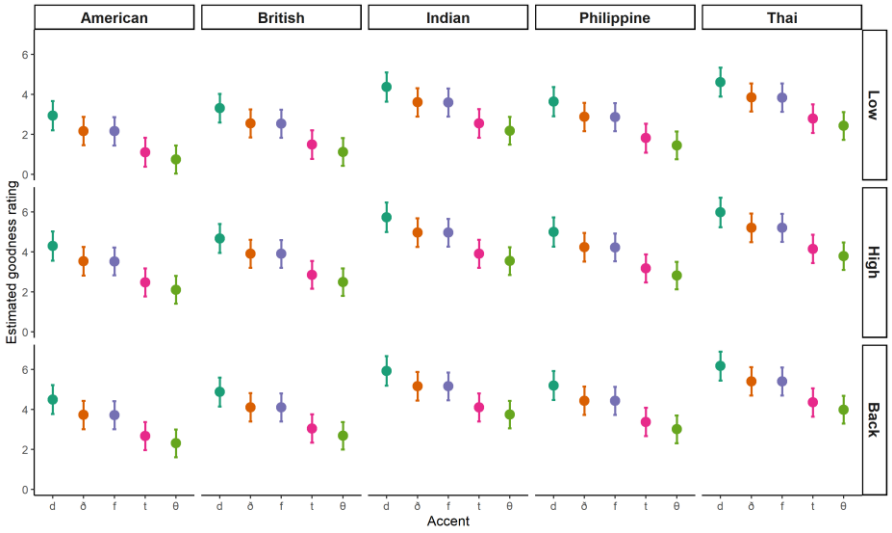

Figure 2. Estimated goodness ratings of consonant categories across accent varieties and vowel contexts

With respect to sound contrasts that showed overlapping identification, Thai learners did not appear to have difficulty distinguishing these contrasts in the Philippine and American accents, as the goodness ratings differed significantly. In contrast, the greatest difficulty was observed for the Thai accent, followed by the Indian and British accents, respectively, where overlapping identification was more evident.

5. Discussion

This study examined how Thai learners perceive the English dental fricatives /ð/ and /θ/ across different English accents and vowel contexts. The findings show that accent variation and phonetic context influence learners' perception of these sounds. Overall, Thai learners were able to identify some accent varieties more accurately than others, with the American accent being identified most accurately. This finding aligns with the interview results of Choomthong and Manowong (2020), in which many Thai learners reported that they understood American speech more easily than other accents due to their greater exposure to American popular culture, including television series, films, and music. This suggests that accent-related phonetic variation plays an important role in L2 speech perception (de Marneffe et al., 2011; Kriengwatana et al., 2016).

One key finding is that accent significantly affected the identification of /ð/ across all vowel contexts. In particular, the American accent consistently yielded higher identification accuracy than several other accents, especially in the back vowel context. This may reflect greater exposure to American English among Thai learners through media, education, and language learning materials. Previous studies have suggested that familiarity with a particular accent can facilitate L2 speech perception because learners develop stronger phonetic representations for frequently encountered variants (Alexander & Nygaard, 2019; Cox, 2005). In contrast, lower accuracy for certain accents, such as the Thai or Indian accents in the back vowel context, may indicate that phonetic realisations of /ð/ in these accents differ from the learners' expectations or from the input they are most familiar with.

The influence of vowel context further supports the idea that speech perception is sensitive to phonetic environment. Although vowel context significantly influenced perception in /ð/ across all vowel contexts, and in /θ/ in the low and high vowel contexts, no significant effect was found for /θ/ in the back vowel context. This may suggest that contextual cues in this environment were insufficient to facilitate more accurate identification, or that the acoustic cues distinguishing /θ/ from other sounds were less salient in that context. Similar context-dependent effects have been reported in L2 phonetic perception research, where surrounding vowels can influence the perceptual clarity of consonantal contrasts (Eger & Bohn, 2015; Hedrick & Thornton, 2024; Kitikanan, 2017). However, the present finding regarding difficulty in the back vowel context differs from that reported by Donaldson and Kreft (2006), who found that perception was more accurate in the back vowel context than in the front vowel context. This discrepancy may be attributed to differences in participant backgrounds, as the participants in their study were cochlear implant users, whereas the participants in the present study were Thai learners of English.

The perceptual assimilation patterns observed in this study provide further insight into the mechanisms underlying learners' perception. Thai learners frequently mapped English /ð/ onto /ð/ or /d/, while /θ/ was commonly assimilated to /f/ or /t/. These patterns likely reflect the influence of the Thai phonological system, which lacks dental fricatives. As a result, learners may rely on acoustically similar or

articulatorily related categories when interpreting unfamiliar sounds. For example, the assimilation of /ð/ to /d/ may occur because both sounds are voiced coronal consonants, and /d/ may be perceived as the closest familiar category for representing the target sound. Similarly, the mapping of /θ/ to /f/ or /t/ may reflect similarities in frication or the absence of voicing. Such assimilation patterns are consistent with predictions of cross-linguistic perception models, which suggest that unfamiliar L2 sounds are interpreted through the filter of existing L1 phonological categories (Best et al., 2007; Flege et al., 2021; Van Leussen & Escudero, 2015).

The presence of overlapping assimilation patterns across accents further suggests that the learners experienced difficulty distinguishing certain sound contrasts, such as /ð-d/, and /θ-t/. According to PAM-L2, when contrasting non-native sounds are assimilated to the same native phonological category, discrimination difficulty is likely to increase (Best & Tyler, 2007). In addition, the overlapping patterns in non-native contrasts observed in this study indicate that Thai learners sometimes perceived /ð/ and /θ/ as belonging to the same or closely related categories, particularly in the low vowel context for the American and Philippine accents.

In addition, the goodness rating results provide additional evidence regarding which contrasts were particularly challenging. Thai learners showed potential difficulty distinguishing the /d–ð/ contrast in the British accent and greater difficulty with both /d–ð/ and /t–θ/ contrasts in the Indian and Thai accents. These difficulties may arise when the acoustic realisation of these sounds closely resembles familiar categories in the learners' phonological system. By contrast, learners showed greater ability to distinguish the sounds in the American and Philippine accents. This may indicate that the realisation of these sounds in the American and Philippine accents provided perceptual cues that were more accessible to Thai learners.

Although overlapping identification patterns were observed, learners were still able to reliably distinguish several contrasts, as indicated by significant differences in goodness ratings. For example, learners distinguished the /f–θ/ contrast when listening to Philippine (in all vowel contexts), American (in the high and back vowel contexts), and British (in the low and high vowel contexts) accents, and the /ð–θ/ contrast when listening to the American accent in the low vowel context. These findings suggest that Thai learners were sensitive to certain phonetic differences despite inconsistent identification accuracy. In other words, even though correct identification performance was uneven, some perceptual sensitivity was still present. The significant differences in goodness ratings indicate that learners could perceive some distinctions between the target sounds, supporting the view that L2 phonological categories develop gradually (Flege et al., 2021).

Overall, the findings highlight the complex interaction between accent variation, phonetic context, and cross-linguistic influence in L2 speech perception. The results suggest that Thai learners' perception of English dental fricatives is shaped not only by the absence of these sounds in their native phonological system but also by their exposure to different English accents and the phonetic environments in which the sounds occur. These findings contribute to a better understanding of how learners process phonetic variability in multilingual listening contexts and emphasise the importance of considering accent diversity in research on L2 speech perception.

6. Conclusion

This study examined Thai learners' perception of the English dental fricatives /ð/ and /θ/ across different English accents and vowel contexts. The results showed that both accent variation and phonetic context influenced learners' perception of these sounds. Thai learners were able to identify some accent varieties more accurately than others, with the American accent generally yielding higher identification accuracy than several other accents. In addition, vowel context affected the perception of these sounds in most environments, indicating that surrounding phonetic conditions play an important role in the perception of L2 consonants. The perceptual assimilation results further revealed that Thai learners often mapped English /ð/ to /ð/ or /d/, and /θ/ to /f/ or /t/. These patterns suggest that learners primarily interpreted unfamiliar English sounds through the lens of their L1 Thai phonological categories. The goodness rating analyses also showed that learners experienced varying levels of difficulty distinguishing certain sound contrasts across accents, with greater difficulty observed in the Thai, British and Indian accents and clearer distinctions in the American and Philippine accents. Overall, the findings highlight the combined influence of accent variation, phonetic context, and cross-linguistic phonological differences on Thai learners' perception of English dental fricatives. The study contributes to a better understanding of how learners process phonetic variation across English accents in multilingual listening environments.

Regarding limitation of the study, there are three limitations. First, the study examined only a limited number of English accents. Although the selected accents represent different varieties of English, they cannot fully capture the wide range of phonetic variation found across global Englishes. Nevertheless, this experimental design allows a systematic comparison across varieties while maintaining experimental control. Future research could expand the range of accents examined, including additional regional or international varieties, to better understand how accent familiarity and phonetic variability influence L2 speech perception. Second, the stimuli in the present study were restricted to word-initial consonants in isolated words. This is to ensure that the perception of the target sounds was not influenced by other contextual factors. Future studies could therefore investigate how Thai learners perceive these sounds in connected speech, sentences, or conversational contexts to determine whether similar perceptual patterns emerge in more natural listening situations. Third, the study focused exclusively on perception rather than production. While examining perception provides important insight into how learners categorise unfamiliar sounds, perception and production are closely related aspects of L2 phonological development. However, focusing only on perception allows the study to isolate perceptual processes without the influence of articulatory constraints. Future research could adopt a combined perception–production approach to explore how perceptual assimilation patterns may influence learners' production of English dental fricatives across different accents.

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Author contributions

Associate Prof. Dr. Patchanok Kitikanan was primarily responsible for the study conception and design, data collection, data analysis, and drafting of the manuscript. Ho Ting Chak contributed to the revision and critical review of the manuscript. All authors read and approved the final version of the manuscript.

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No additional data are available.

References

Alexander, J. E., & Nygaard, L. C. (2019). Specificity and generalization in perceptual adaptation to accented speech. *The Journal of the Acoustical Society of America*, *145*(6), 3382-3398. https://doi.org/10.1121/1.5110302

Aminjonov, A., Tulanboev, M., & Isroilov, M. (2024). Production and perception of English interdental fricatives by native Uzbek speakers. *외국학연구, 68,* 35-64.

Atthaphonphiphat, S. C. (2017). The production and perception for English final consonant sounds of Thai students. *International Conference on Language, Innovation, Culture & Education*, *8*(1), 182-191.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of statistical software*, *67*, 1-48. https://doi.org/10.18637/jss.v067.i01

Best, C. T., Tyler, M., Bohn, O., & Munro, M. (2007). Nonnative and second-language speech perception. In M. J. Munro & O. S. Bohn (Eds.), *Language experience in second language speech learning* (Vol. 17, pp. 13-34). John Benjamins. https://doi.org/10.1075/lllt.17.07bes

Brannen, K. J. (2011). *The perception and production of interdental fricatives in second language acquisition*. McGill University (Canada).

Burkardt, B. A. (2008). *Acquisition sequence of the English interdental fricatives by Thai ESL learners*. Southern Illinois University at Carbondale.

Choomthong, D., & Manowong, S. (2020). Varieties of English accents: A study of the degree of preference and intelligibility among second-year English major students at Maejo University. *Manusya: Journal of Humanities*, *23*(2), 151-169. https://doi.org/10.1163/26659077-02302001

Cox, E. A. (2005). *Second language perception of accented speech*. The University of Arizona.

de Marneffe, M.-C., Tomlinson Jr, J., Tice, M., & Sumner, M. (2011). The interaction of lexical frequency and phonetic variation in the perception of accented speech. Paper presented at *Proceedings of the 33rd Annual Conference of the Cognitive Science Society*, Austin. Retrieved from https://web.stanford.edu/~sumner/Publications/2013_deMarneffe_CSS.pdf

Doan, T. L. A., & Oh, E. (2023). The role of L2 experience on the perceived similarity and identification of British English vowels by Vietnamese speakers. *Linguistic Research*, *40*, 127-149.

Donaldson, G. S., & Kreft, H. A. (2006). Effects of vowel context on the recognition of initial and medial consonants by cochlear implant users. *Ear and hearing*, *27*(6), 658-677. https://doi.org/10.1097/01.aud.0000240543.31567.54

Dubois, S., & Horvath, B. M. (1998). Let's tink about dat: Interdental fricatives in Cajun English. *Language Variation and Change*, *10*(3), 245-261. https://doi.org/10.1017/s0954394500001320

Eger, N. A., & Bohn, O. S. (2015). Picking up the cues to a new consonant contrast: Danish learners' production and perception of English word-final/s/-/z. Proceedings of the 18th International Congress of Phonetic Sciences, Glasgow.

Flege, J. E., Aoyama, K., & Bohn, O. S. (2021). The revised speech learning model (SLM-r) applied. *Second language speech learning: Theoretical and empirical progress*, 84-118. https://doi.org/10.1017/9781108886901.003

Hancin-Bhatt, B. (1994). Segment transfer: A consequence of a dynamic system. *Second Language Research*, *10*(3), 241-269. https://doi.org/10.1177/026765839401000304

Hardison, D. M. (2003). Acquisition of second-language speech: Effects of visual cues, context, and talker variability. *Applied Psycholinguistics*, *24*(4), 495-522. https://doi.org/10.1017/s0142716403000250

Hedrick, M., & Thornton, K. (2024). Reaction time for correct identification of vowels in consonant-vowel syllables and of vowel segments. *JASA Express Letters*, *4*(1). https://doi.org/10.1121/10.0024334

Hisagi, M., Baker, M., Alvarado, E., & Shafiro, V. (2022). Online assessment of speech perception and auditory spectrotemporal processing in Spanish–English bilinguals. *American Journal of Audiology*, *31*(3S), 936-949. https://doi.org/10.1044/2022_aja-21-00225

Jacewicz, E., & Fox, R. A. (2013). Regional accents affect speech intelligibility in a multitalker environment. Interspeech. 2081-2085. https://doi.org/10.21437/Interspeech.2013-494

Jeong, H., Elgemark, A., & Thorén, B. (2021). Swedish Youths as Listeners of Global Englishes Speakers With Diverse Accents: Listener Intelligibility, Listener Comprehensibility, Accentedness Perception, and Accentedness Acceptance. *Front. Educ.*, *6*, 651908. https://doi.org/10.3389/feduc.2021.651908

Kalaivanan, K., Wong, P. C., Wong, F. C., & Chan, A. H. (2023). Native language perceptual sensitivity predicts nonnative speech perception differently in younger and older Singaporean bilinguals. *Journal of Speech, Language, and Hearing Research*, *66*(3), 987-1017. https://doi.org/10.1044/2022_JSLHR-22-0019

Kitikanan, P. (2016). *L2 English fricative production by Thai learners* [Doctoral disseration. Newcastle University].

Kitikanan, P. (2017). The effects of L2 experience and vowel context on the perceptual assimilation of English fricatives by L2 Thai learners. *English Language Teaching*, *10*(12), 72-82. https://doi.org/10.5539/elt.v10n12p72

Kitikanan, P. (2022). The effect of L2 experience on the identification of British English monophthongs by L2 Thai learners. *Theory and Practice in Language Studies*, *12*(4), 676-683. https://doi.org/10.17507/tpls.1204.07

Kriengwatana, B., Terry, J., Chládková, K., & Escudero, P. (2016). Speaker and accent variation are handled differently: Evidence in native and non-native listeners. *Plos one*, *11*(6), e0156870. https://doi.org/10.1371/journal.pone.0156870

Labov, W. (1969). *A Study of Non-Standard English*. ERIC Clearinghouse for Linguistics.

Lengeris, A. (2009). Perceptual assimilation and L2 learning: Evidence from the perception of Southern British English vowels by native speakers of Greek and Japanese. *Phonetica*, *66*(3), 169-187. http://doi.org/10.1159/000235659

Lenth, R. (2024). emmeans: Estimated Marginal Means, aka Least-Squares Means. *R package version 1.10. 5*. Retrieved from https://CRAN.R-project.org/package=emmeans

Naruemon, D., Bhoomanee, C., & Pothisuwan, P. (2024). Challenges of Thai learners in pronouncing English consonant sounds. *The Golden Teak: Humanity and Social Science Journal*, *30*(3), 1-19.

Nguyen, P. B. T., & Hoang, Y. (2025). Teaching English dental fricatives to Vietnamese learners: Addressing pronunciation challenges with evidence-based methods. *Forum for Linguistic Studies*, *7*(1), 12-38. https://doi.org/10.5281/zenodo.17415878

Nogita, A. (2010). Do Japanese ESL learners' pronunciation errors come from inability to articulate or misconceptions about the target sounds? *Working Papers of the Linguistics Circle*, *20*(1), 82-116.

Pathanasin, S., Mansbridge, R. M., & Pongprairat, R. (2026). Exploring patterns and challenges in English word-final consonant pronunciation among Southern Thai EFL learners. *Asian Journal of Arts and Culture*, *26*(2), e77-e77. https://doi.org/10.48048/ajac.2026.77

Reis, M. S. (2006). *The perception and production of English interdental fricatives by Brazilian EFL learners* [Unpublished master's thesis, Federal University of Santa Catarina]. Florianópolis, SC.

Roberts , R. (2023). The effect of Japanese accented American English vowels on message conveyance and accentedness perception. *ARELE: Annual Review of English Language Education in Japan*, *34*, 145-160.

Roengpitya, R. (2025). English and Thai fricatives and affricates perceived by Thai EFL learners. *Ramkhamhaeng Journal Humanities Edition*, *44*(2), 1-22.

RStudio Team. (2026). *RStudio: Integrated Development for R (Version 2026.01.1)*. In RStudio, Inc. Retrieved from https://www.rstudio.com/

Schmidt, A. M. (1996). Cross-language identification of consonants. Part 1. Korean perception of English. *The Journal of the Acoustical Society of America*, *99*(5), 3201-3211. https://doi.org/10.1121/1.414804

Schmidt, L. B., Rodriguez, E., Vargas, C., & Cassio, A. (2025). Perception of Spanish diphthong/ei/by second language and heritage speakers of Spanish: findings from two perception tasks. *Studies in Hispanic and Lusophone Linguistics*, *18*(2), 459-492. https://doi.org/10.1515/shll-2025-2015

Sridhanyarat, K. (2017). The acquisition of L2 fricatives in Thai learners' interlanguage. *3L: Southeast Asian Journal of English Language Studies*, *23*(1). https://doi.org/10.17576/3l-2017-2301-02

Stringer, L., & Iverson, P. (2019). Accent intelligibility differences in noise across native and nonnative accents: Effects of talker–listener pairing at acoustic–phonetic and lexical levels. *Journal of Speech, Language, and Hearing Research*, *62*(7), 2213-2226. https://doi.org/10.1044/2019_jslhr-s-17-0414

Van Leussen, J. W., & Escudero, P. (2015). Learning to perceive and recognize a second language: The L2LP model revised. *Frontiers in psychology*, *6*, 1000. https://doi.org/10.3389/fpsyg.2015.01000

Watson, K. (2007). Liverpool English. *Journal of the International Phonetic Association*, *37*(3), 351-360. https://doi.org/10.1017/S0025100307003180