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English Plosive Consonants Produced by Thai Speakers: An Analysis of Voice Onset Time

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ABSTRACT

This study aims to investigate the VOT values of English word-initial plosive consonants produced by young Thai learners to understand current trends in English pronunciation among Thai speakers and its future direction. The study analyzes how phonological mismatches between Thai and English affect the pronunciation of Thai learners, using a speech corpus produced by 49 seventh-grade students. The results reveal recurring patterns of consonant pronunciation, classified into Consistent and Inconsistent groups. While voiced plosives /b/ and /d/ were mostly pronounced with voicing lead, resembling Thai phonetic norms, velar /g/ was frequently substituted with /k/ due to the absence of /g/ in the Thai sound system. However, some participants demonstrated a shift toward more native-like English pronunciation. Voiceless plosives were generally produced with long-lag VOT, aligning with both Thai and English norms, although some inconsistencies in aspiration were noted. The findings highlight the dynamic shift of English pronunciation among young Thai speakers. This research contributes to a deeper understanding of English

spoken by Thais and facilitates instructors in designing targeted pronunciation tasks.

Keywords: Voice Onset Time (VOT), Thai-accented English, pronunciation, second language acquisition

Introduction

Language learners often face challenges in pronunciation when their L1 differs from their L2, due to L1 interference during sound production (Major, 2001; Odlin, 1989). Adult learners find it more difficult to produce L2 speech resembling native speakers due to age constraints impeding the acquisition of L2 segmental and prosodic features, leading to their incorrect perception of sounds that are different than their L1 (Flege, 1995; Flege et al., 1999; Odlin, 1989).

In this regard, Thai and English also have various distinct features in their phonological systems and phonetic realization. One of the mismatched features of Thai and English is the plosive consonants which differ in terms of the number of phonemes and categories and phonotactic constraints. There are three categories of plosive consonants in Thai, namely voiced /b, d/, voiceless unaspirated /p, t, k/, and voiceless aspirated /p^h, t^h, k^h/ which are all considered contrastive phonemes. On the contrary, English plosives can be divided into two categories which are voiced /b, d, ɡ/ and voiceless /p, t, k/ with [p^h], [p], [t^h] [t], and [k^h] [k] being allophones of the same phonemes rather than contrastive ones. The different phonemic status of these voiceless plosives in the two languages can cause difficulty for Thai learners' articulation in English words with said consonants (Richards, 1969). Moreover, the lack of the /ɡ/ sound in Thai leads to the substitution of /ɡ/ with Thai /k/ (Kanokpermpoon, 2007; Peerachachayanee, 2022; Suntornsawet, 2022). Besides the number of phonemes and categories, the phonotactic constraints between Thai and English are also dissimilar. For example, in Thai, the plosive consonants in the word-final position are voiceless and unaspirated while in English, the final positions can be voiced or voiceless, released or unreleased (Luksaneeyanawin, 2005).

Based on the results of studies in which Thai and English plosives were investigated, such different features could cause difficulty in Thai learners' articulation of English words with plosive consonants and were the cause of Thai-accented English (Kanokpermpoon, 2007; Richards, 1969; Smyth, 1987; Suntornsawet, 2019). Even though these scholars argued that Thais have less difficulty in articulating word-initial plosive sounds in English than the final ones, the differing constraints and L1 interference might also

affect the pronunciation of word-initial English plosives produced by Thais such as the unpredictability of the articulation of voiceless plosives in certain English words produced by Thais, for example, <paper> can be pronounced as [ˈpʰeɪ.pɚ] or [ˈpeɪ.pɚ] while <pen> is always pronounced as [pʰen].

To investigate the intricacies of plosive articulation within a language or cross-linguistically, the acoustic analysis of Voice Onset Time or VOT has been widely used (Lisker & Abramson, 1964). VOT, defined as the time interval between the release of a stop consonant and the beginning of vocal cord vibration which initiates voicing, is a crucial acoustic cue that differentiates plosive sounds in speech visualized by their waveforms (Ladefoged & Johnson, 2015). Since Thai and English have different numbers of plosive consonants and categories, the VOT of their plosives also vary and, therefore, became the subject of interest in cross-language research (e.g., Donald, 1976; Kessinger & Blumstein, 1997; Lisker & Abramson 1964). The different VOT categories and ranges may affect the pronunciation of English plosives spoken by Thais.

Past research on the VOT value of English spoken by Thais, while foundational, may not fully capture the variations of the pronunciation of plosive consonants in the world where Thai people are exposed to more English in daily life (Jindapitak, 2019). Previous studies have primarily focused on specific types and aspects of plosives, often without controlling the English proficiency levels of participants (Shimizu, 2011; Wilaisilp & Pojprasat, 2021; Wittayasakpan, 2021). Moreover, limited word lists, which might not adequately represent the actual inconsistency in the pronunciation of plosive sounds among Thai speakers, were used. These limitations highlight a notable gap in the comprehensive understanding of Thai-accented English and the need for a more updated investigation into VOT patterns in various phonetic contexts and their effects on English pronunciation by Thai speakers.

Furthermore, the age range of participants in previous studies was quite limited, focusing mostly on university students. This presents a gap for this study to explore younger participants, specifically secondary students, to provide a more contemporary perspective on the articulation of plosive consonants among young Thai speakers of English who might be influenced by the ever-changing linguistic norms, indicating the present and future of Thai-accented English.

Literature Review

Thai and English Plosive Consonants

In Thai, there are eight plosive consonants, namely /b, d, p, t, k, pʰ, tʰ, kʰ/ from three places of articulation: bilabial, alveolar, and velar. They are divided into three categories: voiced, voiceless unaspirated, and voiceless aspirated (Lisker & Abramson, 1964) as illustrated in Table 1.

Table 1

Thai Plosive Consonants

Place of Articulation	Voiced	Voiceless unaspirated	Voiceless aspirated
Bilabial	/b/	/p/	/pʰ/
Alveolar	/d/	/t/	/tʰ/
Velar		/k/	/kʰ/

Aspiration plays an important role in distinguishing phonemes in the voiceless category, for example, /ta/ <ตา> means 'eyes' while /tʰa/ <ทา> means 'paint or apply liquid on a surface'. The minimal pair shows that voiceless unaspirated and aspirated consonants are in contrastive distribution.

Unlike Thai, English plosive consonants contain only six phonemes: /b, d, ɡ, p, t, k/ and are classified as either voiced or voiceless (Lisker & Abramson, 1964). Despite the differences in the number of phonemes and categories, the places of articulation are similar to those of Thai, falling into the categories of bilabial, alveolar, and velar (See Table 2).

Table 2

English Plosive Consonants

Place of Articulation	Voiced	Voiceless
Bilabial	/b/	/p/
Alveolar	/d/	/t/
Velar	/ɡ/	/k/

While aspiration is a contrastive feature in Thai, it does not affect the distinction between English voiceless plosive consonants. However, voiceless unaspirated [p, t, k] and voiceless aspirated [pʰ, tʰ, kʰ] still exist in English by being allophones of the same phonemes, occurring in complementary distribution. For example, /t/ in /tɪk/ is pronounced with aspiration [tʰɪk],

while /t/ in /stɪk/ is articulated without aspiration [stɪk] as it is preceded by /s/.

Furthermore, since each language has its own phonotactic constraints, Thai and English plosives also differ in this respect. While English allows a variety of clusters, Thai only allows only 11 consonant clusters: /pr/, /pl/, /pʰr/, / pʰl/, /tr/, /kr/, /kl/, /kw/, /kʰr/, /kʰl/, and /kʰw/. Consequently, this poses challenges to Thai pronunciation of English clusters such as /s/ clusters, resulting in the insertion of a short vowel after the first consonant in a cluster to facilitate pronunciation (Suntornsawet, 2019, 2022). In terms of final clusters, they do not exist in the Thai sound system.

Apart from that, in Thai, the plosive consonants in the word-final position are voiceless and always unreleased while in English, the final positions can be voiced or voiceless, released or unreleased (Abramson & Tingsabadh, 1999; Luksaneeyanawin, 2005; Suntornsawet, 2019).

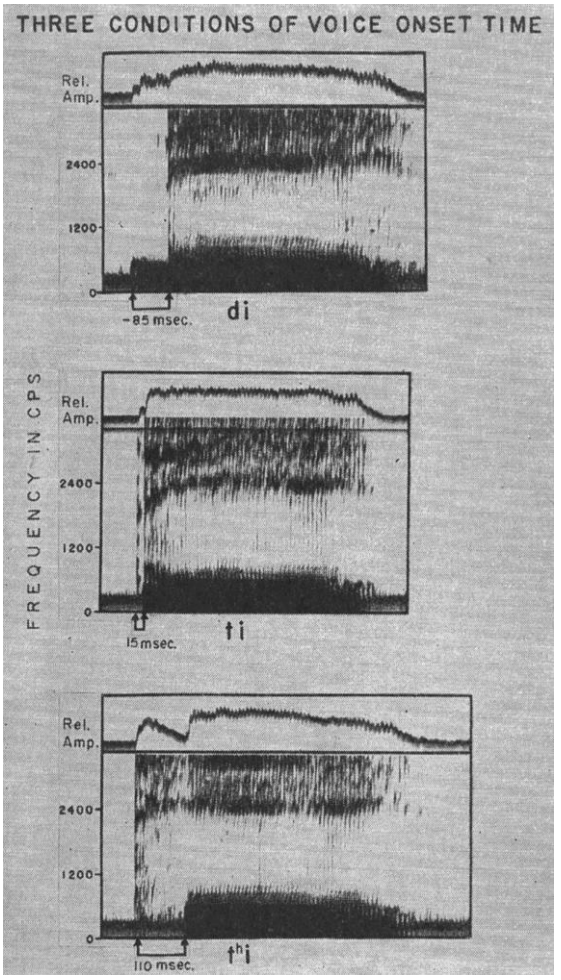
Voice Onset Time

Voice Onset Time or VOT divides plosive sounds into three main categories of voicing: voicing lead, short lag, and long lag (Lisker & Abramson, 1964). With zero milliseconds being the time of release, if the pulsing starts during the closure and before the release resulting in a negative value, it is identified as voicing lead. On the other hand, if the pulsing starts after the release, it is called voicing lag, which can be subcategorized as (1) short lag where the voicing starts shortly after the release, and (2) long lag where the voicing starts significantly after the release as shown in Figure 1 below.

Thai plosive consonants fall in all three categories of VOT. However, English plosives are categorized into two, namely, short lag and long lag (Table 3). Voiced consonants in English are produced with short-lag VOT, whereas in languages like Thai and French, consonants in this category are treated as voiceless (Kessinger & Blumstein, 1997), suggesting that even with [+voice] feature, the phonetic realization of English voiced plosives actually resemble consonants that are voiceless and without aspiration.

Figure 1

Three Main Categories of Plosive Consonants: Voicing Lead, Short Lag, and Long Lag (Example from Thai).



Note. Lisker and Abramson, 1964, p.390.

Table 3

Voice Onset Time categories for English and Thai

	Voicing Lead	Short Lag	Long Lag
Thai	+ /b, d/	+ /p, t, k/	+ /p^h,t^h,k^h/
English		+ /b, d, g/	+ /p, t, k/ [p^h,t^h,k^h]

Each language can select its zones and ranges in the VOT continuum to distinguish between categories (Abramson & Whalen, 2017; Cho & Ladefoged, 1999). Thai employed all three zones for the consonantal distinctions. However, widespread varieties of English use only two zones which are short lag and long lag (Abramson & Whalen, 2017). Therefore, besides the number of categories, the VOT distributions between English and Thai also differ (Kessinger & Blumstein, 1997).

Figure 2

The VOT continuum of Thai and English based on Lisker and Abramson (1970)

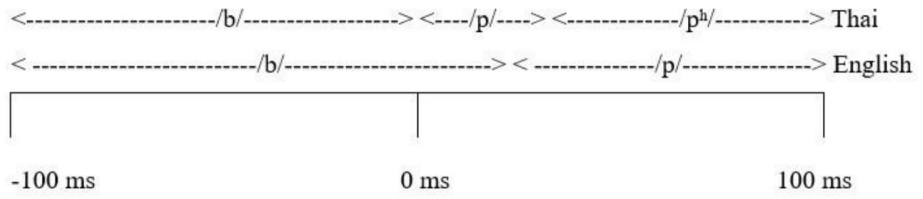


Figure 2 was created based on the findings of Lisker and Abramson (1970). It illustrates the distinct VOT continuum of English and Thai plosives. Voiced plosives in English exhibit a short lag VOT which leads to these plosives being partially voiced, as they do not always fall in the negative VOT typical of fully voiced plosives found in other languages like Thai and French (Kessinger & Blumstein, 1997). However, they can be slightly negative (Ladefoged & Johnson, 2015). According to the findings of Lisker and Abramson (1964), one participant consistently produced English voiced plosives with negative VOT values. It was concluded that such an instance did not occur randomly, rather, it should be considered an individual characteristic of a speaker. On the other hand, voiced plosives in Thai are always in the negative VOT continuum, usually with large negative values, which indicates fully voiced plosives. Furthermore, Thai voiceless unaspirated

plosives fall into the short lag category, lining up with English voiced plosives. However, Thai also has voiceless aspirated plosives, /pʰ, tʰ, kʰ/, which exhibit a long lag VOT, similar to English voiceless aspirated plosives.

It should be noted that since there is no boundary for both voiced and voiceless consonants in English, their VOT can respectively extend to a more negative or positive value along the continuum. The same is true for Thai voiced and voiceless aspirated plosives.

In this study, the criteria for pronunciations corresponding to referent pronunciation are drawn from previous studies (Kessinger & Blumstein, 1997; Lisker & Abramson, 1964, 1970). All previous studies examined the VOT values of English spoken by Americans. However, there are no variations of phonetic realization of plosives in the initial position regardless of the variety of native English since vowel sounds were not considered in the study. The VOT values of English voiced plosives /b, d, ɡ/ should be short lag, around 0-20, or voicing lead with each speaker consistently producing only a single category of voiced plosives in their speech. In contrast, the values for voiceless plosives /p, t , k/ should lie in the long lag category.

There have been several studies on the VOT of English spoken by Thais. Shimizu (2011) examined both the VOT values of all Thai and English word-initial plosive consonants produced by Thai university students in Japan. The findings indicated that Thai learners' VOT range of voiced plosive consonants was extensive; however, it did not overlap other categories. Moreover, they tended to articulate English plosive sounds with VOT values close to those of Thai. The VOT values of English voiced plosives were close to Thai voiced plosives and the values of English voiceless stops were similar to Thai voiceless aspirated plosives. This also confirmed the claim of Richards (1969) that Thai speakers would articulate English voiced and voiceless plosives with the same phonetic characteristics they have in Thai. However, in Shimizu's study, only one word was used as the representation of each consonant, which might not fully reflect the actual unsystematic pronunciation, and thus, VOT values of English spoken by Thais. Other studies mainly focused on the word-initial voiceless plosive consonants. Wittayasakpan (2021) investigated the effects of speech time categorized by long read and spontaneous monologue speech on the VOT values of voiceless plosives produced by Thai university students who studied in an international or English program during primary education, while Wilaisilp and Pojprasat (2021) compared the degrees of aspiration of English voiceless plosives produced by native speakers and Thai university students from both English and Thai majors, as well as factors contributing to the articulation of the Thai speakers.

This study is aimed at analyzing the VOT values of English plosive consonants produced by young Thai learners to understand the trend of future Thai-accented English. It is hypothesized that young Thai learners of English will demonstrate VOT values in English plosive consonants that align closely with Thai plosives. However, in comparison to previous studies, these values will more closely resemble those found in English plosives, suggesting a dynamic shift towards English patterns.

Methodology

Speech Corpus

The audio recordings were obtained from the "Edsy Thai EFL corpus" created by Education Easy (Thailand) Co., Ltd. The audio speakers were 50 seventh-grade students in an English program at public schools in Bangkok with an English proficiency level of A2 according to the CEFR standard. However, due to noises in some of one participant's utterances that caused difficulty in acoustic analysis, the audio files of 49 participants were considered in this report.

The recorded audio files in .wav format included 24 target words with initial plosive consonants embedded in carrier sentences "say…again." The word list was designed to facilitate the investigation of VOT. The target words were controlled in terms of phonetic features with all plosive consonants included. The word level is mostly aligned with the CEFR level of the participants, ensuring that they are familiar with the target words. Some of the words are present in Thai as loan words whose pronunciation has already been fossilized, namely, paper, program, tent, and title. Out of 49 participants, each delivering 24 words, a total of 1,176 tokens were analyzed.

Table 4

Plosive Consonants and Word List

Plosive Consonants	Word List
/p/	page paper poor pouch program
/b/	beach boy bush
/t/	tent title tone tour type
/d/	dare dear dish
/k/	care couch kitchen sky scone
/g/	garbage gauge gear

Data Analysis

The VOT values of initial plosive consonants were segmented in the Praat software program. The measurements were taken between the initial plosive release and the onset of the voicing, as shown by the waveform and spectrogram. The VOT values were measured in milliseconds. The expected and actual phonetic realization of each consonant, along with notes on the phonological context and other details of the sound production, were recorded.

Findings

Upon analyzing the VOT values from all target words read by 49 participants, recurring patterns emerged and were classified into two primary groups: Consistent and Inconsistent as shown in Figure 3.

Figure 3

Patterns Emerging from VOT Values

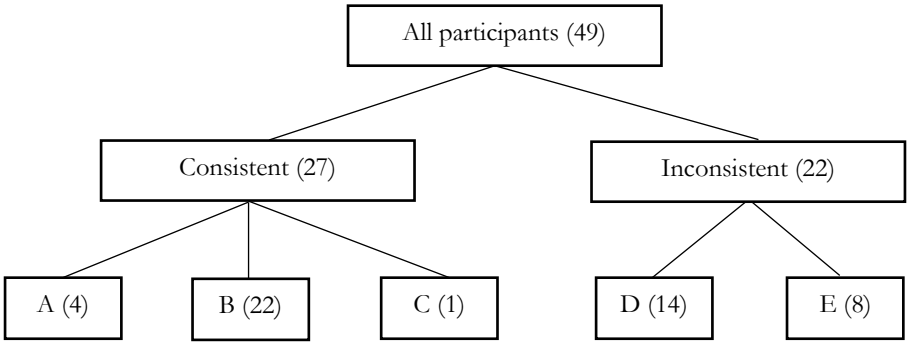


Figure 3 illuminates the patterns emerging from the VOT values obtained from each participant. The Consistent group consisted of 27 participants and was further categorized into three sub-groups. Due to limited space for the flow chart, they will be referred to as groups A, B, and C. All of the initial plosive articulation of the participants in group A closely corresponded to the referent pronunciation, meaning that they produced voiced plosives with negative VOT and voiceless ones with long lag. Those in group B also articulated all initial plosive consonants according to the referent pronunciation, except for /g/, which was consistently pronounced as [k]. Group C consisted of one participant who mispronounced all fossilized loanwords from English present in the Thai vocabulary bank. Conversely, the

Inconsistent group consisting of 22 participants was subdivided into (D) participants exhibiting inconsistent pronunciation of voiceless plosive consonants, alternating between aspirated and unaspirated, and (E) those varying between [g] and [k] for the /g/ sound.

Figures 4-8 provide examples of participants within each group, displaying the average value of each phone produced by the participant. In cases where a target word's initial plosive consonant pronunciation diverged from the participant's usual pattern, the bar showing its value was plotted separately.

Figure 4

VOT Values in the Consistent Group with All Word-initial Plosive Consonants Pronounced Corresponding to Referent Pronunciation.

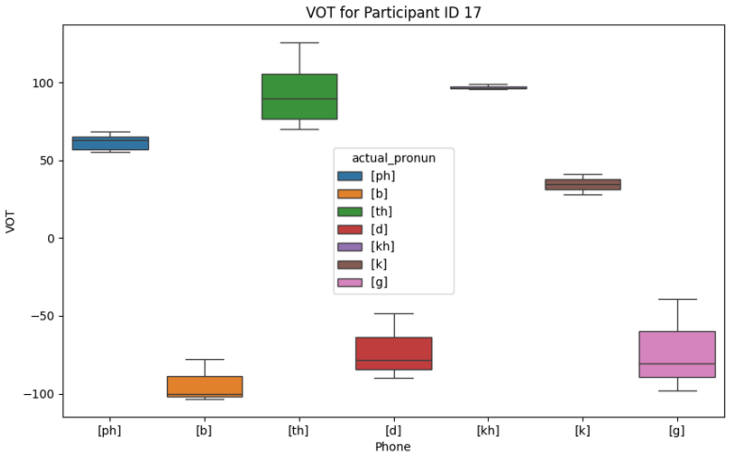


Figure 4 depicts participants in the Consistent group who pronounced word-initial plosive consonants closely corresponding to English referent pronunciation, meaning that their VOT values for voiced plosives should be in either short lag or voicing lead category and those of voiceless plosives were in the long lag category. This group comprises 8.16% of participants. The participants had minimal difficulty in pronouncing English voiceless plosives which were /p, t, k/. The initial plosives were produced with aspirated variants while the plosives in /s/ clusters were produced with unaspirated ones. As for the voiced plosive consonants which were /b, d/, all participants produced such consonants with negative values belonging to voicing lead category without alternating between voicing lead and short lag category. Surprisingly, they also pronounced /g/ with a fully voiced voicing lead, meaning that it was not the result of intervocalic voicing, or the voicing

influenced by two vowels: one from the word "say" and another from the target word. This is because voiceless consonants in the intervocalic position typically show partial voicing, where the vocal cord vibration from the preceding vowel carries over into the closure phase of the plosive but gradually fades out before the sound is released. However, in this case, the voicing for /g/ among these participants continued steadily throughout the closure. This indicated that these participants did not substitute /g/ with Thai voiceless unaspirated /k/ and could differentiate between the voicing of [g] and [k] sounds despite the absence of the /g/ phoneme in the Thai sound system.

Figure 5

VOT Values in the Consistent Group with All Word-initial Plosive Consonants Pronounced Corresponding to Referent Pronunciation, Except for /g/.

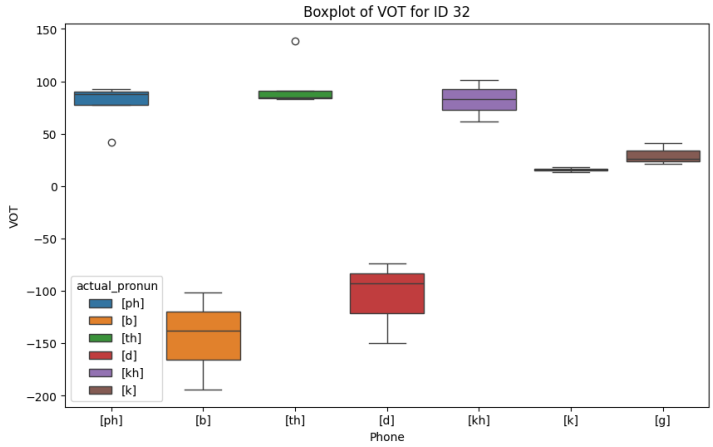
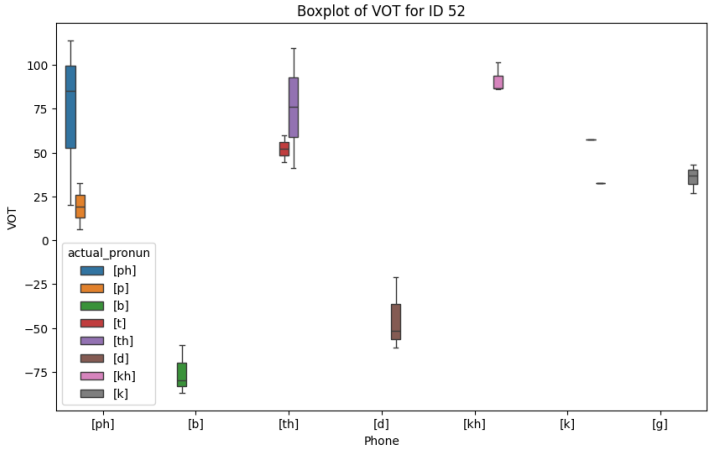


Figure 5 exemplifies the majority of participants (44.9%) who pronounced all the word-initial plosive consonants similar to the referent pronunciation, namely /b,d/ and /p,t,k/, according to the referent pronunciation. However, they substituted [g] with [k] as the phoneme /g/ does not exist in the Thai sound system and the closest substitution for such sound is the voiceless unaspirated /k/. For example, participant ID 32 in Figure 5 exhibited VOT values for /g/ that were in the same range, or even higher, than those for unaspirated [k] in /s/ clusters

Figure 6

VOT Values in the Consistent Group with All the Loanwords Pronounced Not Corresponding to Referent Pronunciation.



In Figure 6, a participant (2.04%) consistently mispronounced the word-initial voiceless plosive consonants in English loanwords borrowed into Thai, namely <paper>, <program>, <tent>, <title>, and <scone> by using the unaspirated variant. Although the participant pronounced /p, t/ in other target words with aspiration, the loanwords were pronounced as voiceless unaspirated plosives instead of aspirated ones. As for the consonant/k/ after /s/ in the word <sky>, the participant pronounced [k] without aspiration, which was correct according to the referent pronunciation and was aligned with the pronunciation commonly found in Thai. However, in the case of <scone>, the participant pronounced it as [k^{h}] with aspiration instead of [k].

Figure 7

VOT Values in the Inconsistent Group in Terms of Aspiration

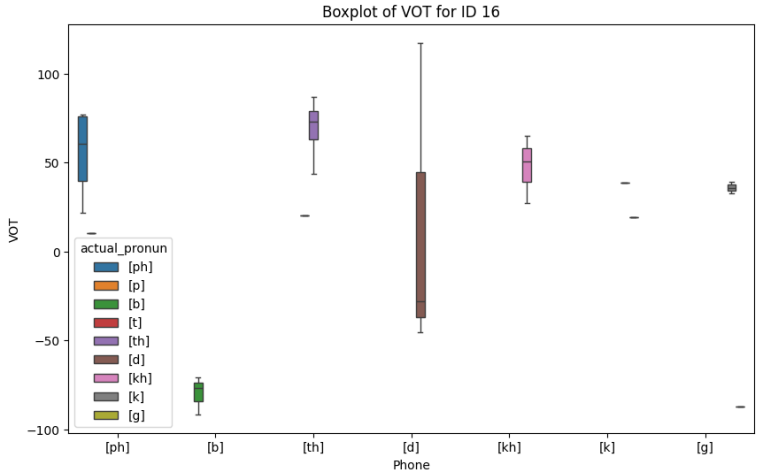
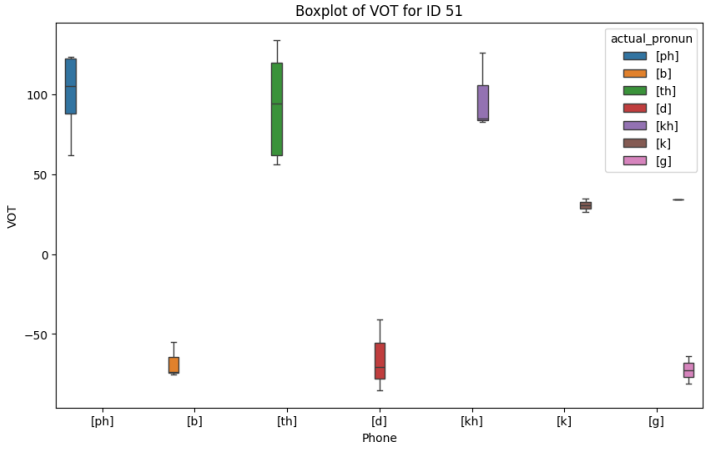


Figure 7 shows an example of participants in the Inconsistent group where the aspiration of the word-initial plosives occurred inconsistently across all target words. This group was the second largest group, with 14 participants accounting for 28.57% of all participants. With the inconsistent pronunciation, it was impossible to predict the pronunciation pattern of the participants in this group. For example, the participant in Figure 7 pronounced some words starting with the /p/ sound with an aspiration, including some loanwords, such as <pouch>, <paper>, and <page>; however, the word <program> was pronounced without aspiration.

Figure 8

VOT Values in the Inconsistent Group in Terms of the Voicing of /g/



In Figure 8, approximately 16.33% of participants exhibited inconsistent voicing of /g/. In other words, the participant produced /g/ with voicing lead [g] in some words while producing short lag [g] in others. Notably, the voiced [g] in this group varied: it was sometimes fully voiced and at other times intervocalic, likely influenced by the consonant's position between two vowels. In some cases, the voiced [g] was followed by a short aspiration. For example, the participant in Figure 8 pronounced the word <garbage> with full voicing lead and no aspiration after the closure, while pronouncing <gear> with intervocalic voicing followed by aspiration. Both values were in the negative region. For this participant, the word-initial plosive consonant in the word <gauge> was articulated as [k] with the VOT value of 34.383 ms, falling in the short lag category, closely mirroring the unaspirated [k] in /s/ clusters.

To observe the trend of plosive pronunciation among young Thai learners, the VOT values obtained from each target word pronounced by each participant were plotted on the VOT continuum and grouped by places of articulation as illustrated in Figure 9 below.

Figure 9

VOT Values of Young Thai Learners of English

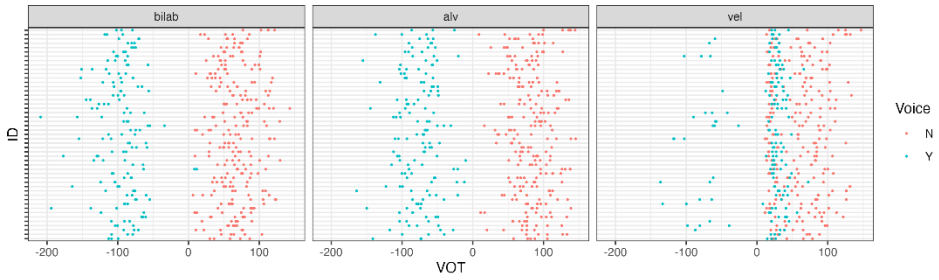


Figure 9 presents the VOT values plotted across three places of articulation: bilabial, alveolar, and velar. The X-axis represents the VOT values in milliseconds. Negative values on the left indicate voicing lead, while positive values on the right represent varying degrees of voicing lag. Voiced plosives /b, d, ɡ/ are represented by blue dots (Y) while voiceless plosives are shown in red (N). According to previous studies, English phonemic voiced segments are phonetically similar to Thai voiceless unaspirated and are often just partially voiced (Kessinger & Blumstein, 1997); therefore, English voiced plosives articulated by native speakers are usually grouped together along the short lag region, around 0-20 ms with some occasionally present in the negative region whereas Thai voiced plosives, which are fully voiced, are clustered along the negative region from -50 to -110 ms. For English voiceless and Thai voiceless aspirated, they often lie along the long lag region, with VOT around 50 ms onwards (Lisker & Abramson, 1964, 1970; Kessinger & Blumstein, 1997).

From the graph, the voiced plosives produced by Thai learners, particularly /b/ in the bilabial and /d/ in alveolar categories, largely adhered to Thai phonetic norms with VOT values distributed in the negative region and centered around -100 ms. However, while the VOT values of /b/tended to cluster in the negative region, some of them (29 out of 147 tokens or 19.73%) were partially voiced as noted from the waveform during segmentation. Unlike /b/, the values of /d/ scattered and reached closer to 0 ms or the short lag region, and 24 participants produced partially voiced /d/ (43 out of 147 tokens or 29.25%), suggesting less consistent voicing among participants.

The partial voicing of /b/ and /d/ suggests a potential shift toward standard English pronunciation. Although voicing, or the vibration of the vocal cords, was present at the beginning of the closure, it diminished during the closure, leaving a brief silent period before the release. As a result, the

production of these voiced consonants closely resembled voiceless unaspirated plosives. This partial voicing could be attributed to the influence of the preceding vowel, suggesting that the participants may have intended to produce voiceless unaspirated plosives, with partial voicing occurring due to progressive voicing assimilation. Had they intended to produce fully voiced plosives similar to those in Thai, the articulation would have been fully voiced instead of partially voiced.

Velar voiced plosives /g/ also exhibited a shift towards English norms, with some tokens reaching into the negative region, indicative of voicing. Some participants produced fully voiced plosives in all tokens, others produced partially voiced ones which could be considered as either their recognition of how English voiced plosives are articulated or an unintentional intervocalic voicing, especially in those whose /g/ values in the other tokens spread across the positive region. Moreover, even though some values were in the negative region, the participants produced a small puff of air after the release as noted during the process of segmentation. While the majority of /g/ lay along the short lag region, they did not resemble the native pronunciation as they lacked voicing and only overlapped with Thai voiceless unaspirated /k/.

The voiceless plosives across all articulatory positions showed a consistent alignment with both Thai and English norms, as Thai voiceless aspirated plosives already fall into the long lag VOT category, similar to English voiceless plosives. Thus, there is no significant shift required for voiceless plosives, as the VOT values for these sounds already match in both languages. However, the VOT of voiceless plosives ranging in the short lag category still existed. In the bilabial /p/ and alveolar /t/ categories, some participants produced voiceless unaspirated plosives, particularly among loan words, despite their usual aspiration in other English tokens. As for velar /k/, those clustering in the short lag category were the words in the cluster /sk/ which are also pronounced without aspiration in English.

Discussion

The result of the VOT analysis in this study showed considerable variations in the VOT values produced by young Thai speakers of English. The voiced stops /d, b, g/ exhibit different patterns. The phonemes /d/ and /b/ show negative VOT suggesting that Thai speakers generally produce the sounds with voicing lead, aligning still with the VOT values of these sounds in Thai. This can be due to the speakers' attempt to maximize a strong contrast between voiced and voiceless plosive (Kenstowicz & Suchato, 2006) since almost none of the voiced consonants were in the short lag category. Furthermore, according to the claim about the similarity between L1 and L2

(Flege, 1995), it might also be because of how the consonants /b/ and /d/ sound similar in both English and Thai, leading to the learners' inability to perceive the nuance difference of the voicing and thus, group them in the same category as well as articulate them in the same manner. However, despite the negative VOT values of /b/ and /d/, some participants exhibited partially voiced negative VOT values, which did not resemble the fully voiced Thai consonants. This suggests that their production was closer to the phonetic realization of English voiced plosives rather than the fully voiced ones, characteristic of Thai pronunciation. The voicing in these samples was merely the influence of the preceding vowel of the word "say" in the carrier sentence and it did not continue to the beginning of the release. This was different from the fully voiced plosives pronounced by other participants which continued throughout the closure period. Therefore, the articulation of partially voiced plosives among these participants could suggest a potential shift in English voiced plosive pronunciation among Thai speakers.

As for /ɡ/, the result of the VOT analysis in this study is in line with the findings of previous studies (Kanokpermpoon, 2007; Suntornsawet, 2022) in that the majority of the participants tended to substitute [ɡ] with [k] sound as /ɡ/ does not exist in the Thai sound system. However, it was not always the case as some participants in the Consistent group exhibited the distinction between [ɡ] and [k] by articulating it with voicing lead in all target words, and those in the Inconsistent group did so in some words containing /ɡ/, showing the potential shift in the way Thai speakers pronounce English plosive consonants. However, voiced [ɡ] in some participants in the Inconsistent group might be produced as a result of intervocalic voicing of Thai voiceless unaspirated /k/ as they are partially voiced. This was in line with the findings of Intaranuch and Jitwiriyanont (2023) that in the intervocalic context, Thai voiceless unaspirated consonants were found to be significantly more voiced than in the prevocalic context. Yet, they were only partially voiced and never fully voiced. Therefore, in the case of fully voiced [ɡ], it was likely that this was not the influence of intervocalic voicing of voiceless unaspirated /k/ in Thai because even though English voiced plosives are usually in the short lag category and are naturally partially voiced, previous studies found that stops in phrase-medial position or intervocalic position showed significantly higher voicing rates and can be fully voiced (Abramson & Whalen, 2017; Davidson, 2016; Jacewicz et al., 2009).

As for the production of other word-initial plosive consonants, the participants tended to pronounce them with less difficulty. Yet not all participants exhibited similar or uniform patterns. Although the majority of participants produced [pʰ, tʰ, kʰ] with a long lag which aligns with the Thai VOT distribution, these voiceless plosive consonants tended to vary among each participant. In some cases, unaspirated plosives were produced instead

of aspirated ones, and sometimes they were used interchangeably, especially in loanwords from English commonly used in Thai which have already been fossilized among Thai speakers. This indicated that L1 interference still plays a role in English pronunciation since those participants often pronounce the voiceless plosives in English words that were not borrowed into Thai with aspiration, yet, when encountering certain loanwords whose pronunciation had long been established as voiceless unaspirated among Thais, such as <paper> or <tent>, they immediately opted for the Thai version of pronunciation.

The difference in the phonetic status of Thai and English also influences the deviation of Thai-accented English from the referent pronunciation. The voiceless unaspirated /p, t, k/, and voiceless aspirated /pʰ, tʰ, kʰ/ are considered contrastive phonemes in Thai, but allophones in English. These distinctive categories can lead to challenges in identifying and pronouncing English allophonic variants of each plosive consonant in a different environment among Thai speakers. In the case of word-initial consonants, apart from the variations in /p/ and /t/ in loanwords, there are also variations of the voiceless plosive pronunciation following /s/. In English, the consonants can only be produced as unaspirated; however, some Thai participants in this study pronounced the /k/ in <scone> as aspirated [kʰ].

Yet, interestingly, the /k/ in the word <sky> was pronounced as [k] among all participants. This led to the consideration of another important factor in the frequency of the words that are used in the Thai language. The word <sky> is used more frequently in Thai (35 occurrences in Thai National Corpus Third Edition) while <scone> appears less frequently (3 occurrences as สโคน and 4 occurrences as สคอน in Thai National Corpus Third Edition) and is more culturally related. The pronunciation of <sky> in Thai is agreed upon and is in line with the referent pronunciation, so every participant could pronounce the word correctly. Since the pronunciation of <scone> is not explicitly established, there can be different variations. The pronunciation of /k/ in <scone> as [kʰ] in the present study did not agree with the findings of English consonants adapted in loanwords in Thai studied by Kenstowicz and Suchato (2006) which showed that English voiceless stops in word-initial position are uniformly mapped to Thai aspirated voiceless stops such as <team> [tʰiːm] and <cone> [kʰoːn], and are mapped to unaspirated ones if they occur after /s/ such as <style> [sa. taːj] and <scan> [sa. kæːn]. However, it is possible that since Thai people are used to pronouncing <cone> with [kʰ], when they see the word <scone>, they tend to pronounce it with [kʰ] as well.

Moreover, Thai orthography of loanwords from English can also affect the pronunciation of plosive sounds (Peerachachayanee, 2022). For instance, loanwords starting with the letter "c" are usually transcribed and pronounced as [kʰ] in Thai, for example, cream, clinic, or condo. There is a possibility that some Thai speakers recognize that this grapheme corresponds with the pronunciation of [kʰ]. This proves to be the same with other loan words in this study: in Thai, <paper> and <program> are transcribed using /ป/ or /p/, and <title> and <tent> have their transliteration beginning with /ต/ or /t/. More contact with Thai orthography can potentially influence the learners' choice of sound production of such English words containing initial plosives.

Conclusion and Implications

This research has provided notable insights into the production of English plosive consonants by young Thai speakers, focusing on Voice Onset Time (VOT) patterns. The analysis revealed distinct patterns of VOT values among participants, highlighting both Consistent and Inconsistent pronunciation tendencies. While some participants demonstrated pronunciation of plosive consonants according to English norms, others exhibited variations of deviation, particularly in the substitution of /g/ with /k/ and the discrepancy in the aspirated and unaspirated realization of voiceless plosive consonants which seems to be influenced by lexical familiarity and orthographic representation. Such factors may play a role in shaping pronunciation patterns among Thai learners. However, the Inconsistent pronunciation, many of which were leaning towards the native norms, reflected the ongoing change and the potential shift in how Thai speakers articulate English plosive sounds.

Instructors may benefit from this knowledge by understanding the key differences between Thai and English plosives which can help guide them in designing targeted pronunciation exercises to help students overcome the challenges associated with L1 interference. For low-proficiency Thai learners, who may rely on Thai orthography of English words or opt for L1 articulation patterns, explicit instruction on how English plosives differ from their Thai counterparts, especially in terms of aspiration and voicing, can improve pronunciation accuracy and intelligibility.

This study, however, has limitations regarding the samples. Since all participants in this study were seventh-grade students with an English proficiency level of A2, future studies might include students from different proficiency levels to determine whether the results would be similar or different. Moreover, the speech used for acoustic analysis in this study was a

target word embedded in a carrier sentence which was well-controlled to facilitate VOT analysis but could not reflect the nature of speech in daily life. Future research could explore the VOT values of target words in natural speech.

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Endnotes

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