

The comparison of degrees of aspiration of English voiceless stops
produced by native speakers and Thai university students
การเปรียบเทียบปริมาณลมของพยัญชนะกักอโหชนะในคำภาษาอังกฤษ
ของเจ้าของภาษาและนักศึกษาชาวไทย

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Sunantha Wilaisilp

สุนันทา วิลไลศิลป์

Faculty of Liberal Arts, Mahidol University, Thailand

คณะศิลปศาสตร์ มหาวิทยาลัยมหิดล ประเทศไทย

sunantha.wil@mahidol.edu

Somboon Pojprasat

สมบุญ พจน์ประสาท

Faculty of Liberal Arts, Mahidol University, Thailand

คณะศิลปศาสตร์ มหาวิทยาลัยมหิดล ประเทศไทย

somboon.poj@mahidol.ac.th

Abstract

Aspiration has always received marginal attention when one considers English pronunciation of L2 learners. Much more exploration is made at the individual segmental level. However, we argue that this sound feature not only helps nativize their pronunciation, but there might be some difficulties for listening if their production differs from that of native speakers. The present study compared Thai university students' degrees of aspiration of English voiceless stops and those of native speakers. Methodologically, thirty Thai students and eight native speakers read twelve English words in isolation and their readings were analyzed in the Praat Program to obtain the VOT values for considering the degrees of aspiration. Then, an interview with the Thai participants was conducted to identify the factors contributing to their pronunciation. The findings revealed that the degrees of aspiration produced by both groups were significantly different ($p \leq 0.01$ at least \leq), and that five most influential factors contributing to the Thai participants' pronunciation were instructional input (72.22%), correspondence (11.66%), transliteration (9.44 %), attitude (6.11%), and self-learning (4.44%). Suggestions for instruction of English pronunciation in response to the issue is given in the conclusion.

Keywords: aspiration, L2 learners, English voiceless stops, VOT

บทคัดย่อ

การศึกษาเรื่องการออกเสียงของผู้เรียนภาษาต่างประเทศมักไม่ให้ความสนใจกับลักษณะการพ่นลม (aspiration) เท่าใดนัก ส่วนมากมุ่งเน้นการศึกษาการออกเสียงระดับหน่วยเสียงรายตัวมากกว่า ผู้วิจัยมีความเห็นว่าลักษณะการพ่นลมไม่เพียงจะทำให้การออกเสียงของผู้เรียนภาษาต่างประเทศใกล้เคียงกับเจ้าของภาษาแต่ยังทำให้ลดปัญหาในการฟังการออกเสียงของเจ้าของภาษาอีกด้วย งานวิจัยนี้จึงเปรียบเทียบปริมาณลมของพยัญชนะกักอโฆซะในภาษาอังกฤษระหว่างเจ้าของภาษากับนักศึกษาชาวไทย วิธีการศึกษาคือให้นักศึกษาชาวไทยจำนวน 30 คนและเจ้าของภาษาจำนวน 8 คนออกเสียงคำภาษาอังกฤษ 18 คำที่มีเสียงพยัญชนะกักอโฆซะและนำมาหาค่าช่วงเวลาเริ่มเสียงก้อง (VOT) โดยใช้โปรแกรม Praat เพื่อมาเปรียบเทียบปริมาณลมในพยัญชนะที่ทดสอบของทั้ง 2 กลุ่ม จากนั้นสัมภาษณ์นักศึกษาชาวไทยเพื่อหาปัจจัยที่มีผลต่อการออกเสียงพยัญชนะกักอโฆซะในภาษาอังกฤษ ผลการศึกษาแสดงให้เห็นว่าปริมาณลมของพยัญชนะกักอโฆซะที่นักศึกษาชาวไทยและเจ้าของภาษาผลิตออกมาต่างกันอย่างมีนัยยะสำคัญ ($p \leq 0.01$ เป็นอย่างน้อย) และปัจจัยที่มีผลต่อการออกเสียงของนักศึกษาชาวไทย 5 ปัจจัย ได้แก่ ข้อมูลป้อนเข้าจากผู้สอน (ร้อยละ 72.22) การจับคู่เสียงกับตัวอักษร (ร้อยละ 11.66) การถอดตัวอักษร (ร้อยละ 9.44) ทศนคติ (ร้อยละ 6.11) และการเรียนรู้ด้วยตนเอง (ร้อยละ 4.44) ทั้งนี้ผู้วิจัยได้ให้ข้อเสนอแนะเกี่ยวกับการออกเสียงภาษาอังกฤษที่เกี่ยวข้องกับการพ่นลมไว้ในบทสรุปของบทความนี้

คำสำคัญ : การพ่นลม, ผู้เรียนภาษาต่างประเทศ, พยัญชนะกักอโฆซะในคำภาษาอังกฤษ, ช่วงเวลาเริ่มเสียงก้อง

1. Introduction

Production of English voiceless stops /p t k/ by Thai students is of particular interest because of their marked inconsistency, based on our pedagogical experience. While the students pronounce these consonant sounds appearing in some words such as *space*, *style* and *sky* with certain amounts of air, technically referred to as aspiration, they tend to increase its degree in the sounds in question in other words that occur in the same environment (herein after the sound /s/), for example, *express*, *system* and *school*. In a nutshell here, their pronunciation of English voiceless stops in the first set of examples can be labelled in phonological terms as unaspirated, and the second set as aspirated, according to the degrees of aspiration that come with the produced sounds.

Even though aspiration is non-distinctive in English (Fromkin, Rodman & Hyams, 2003, p. 293), and it may be hard to be pointed out in natural speech (Ashby & Maidment, p. 139), native speakers have an innate ability to identify any pronunciation deviative from theirs. That is to say, there is the norm among the natives, although varying from one to another, against which a given pronunciation can be judged natural or unnatural. To illustrate, the word *school* can be pronounced either one whose /k/ is aspirated or another with the sound being unaspirated. Both options should be understandable; however, the first will sound somewhat unnatural or even strange to most native speakers since they are more familiar with the second. The issue pertaining to Thai students lies in their varying degrees of aspiration which happen at random, especially ones which are relatively greater than those of the native speakers.

Such phonological difference may be considered trivial, but it can cause listening problems. For instance, some of our Thai students show confusion when English stops /k t/ in words like *discussed* and *sixteen* are pronounced unaspirated rather than aspirated, the latter of which is more familiar to Thai learners. Some even mistake the first word for *disgust*. Factors contributing to the different pronunciation of Thai students might be, we assume, various, ranging from a lack of complete knowledge of English phonological rules to formal instruction and the influence of transliteration of English into Thai words. This assumption, however, cannot be easily resolved because there is too little work for us to draw any conclusions from. According to our preliminary review, a number of studies on pronunciation of Thai learners of English have focused on such classic topics as consonant and vowel sounds, stress, linking and intonation (e.g. works by Sahatsathasana, 2017; Khamkhien, 2010; Jukpim, 2009; Phon-Ngam, 2008; Narksompong, 2007; Kanokpermpoom, 2007; Dee-in, 2006; Yongklang, 2006; Chomphuboot, 2005). Thus, the current

study aims to cast some light on the issue being discussed and pave the way for further research in the future.

2. Backgrounds

2.1 English voiceless stops

English has three voiceless stops, namely /p t k/. The difference between them is in the place of articulation – the first sound produced by both lips closing together, so called *bilabial*, the second by the front part of the tongue rising to the alveolar ridge, so called *alveolar*, and the last by the back of the tongue rising to the soft palate or velum, so called *velar*. The phonological environments allow each of these stops to be pronounced differently (Finegan, 2008, p. 109). First, English voiceless stops become *aspirated* (the diacritic ^h is used to show this feature, such as [p^h t^h]) when they appear in word-initial position whether or not they receive stress, such as *pill*, *paternal*, *tar*, *tenacious*, *car* and *contaminate*. Second, the sounds are often *unaspirated* (transcribed as [p t k]) when they appear elsewhere in the word such as following /s/ or internally, and must not be stressed, for instance, *spill*, *simple*, *star*, *active*, *scar* and *document*. Last, the voiceless stops can be *unreleased*, i.e. the burst of the sound does not take place, when they occur in syllable-final position, such as those in *pop*, *kit* and *back*. The actual sounds that are produced depending on where they occur are known as *allophones*, which are in complementary distribution.

2.2 Aspiration

As the names of allophony of English voiceless stops suggest, aspiration plays a vital role in making them aspirated or unaspirated in a given context. Traditionally, aspiration has been defined as “a puff of air” (Jones, 1956; Heffner 1950). The later views consider it from the more phonetic perspective “a large delay in voice onset”, first proposed by Lisker and Abramson (1964, p. 387). Kim (1970, p. 115) further explained that aspiration involved “a function of the glottal opening at the time of release of the oral closure of a stop” and pointed out “a direct correlation between the degree of the glottal opening at the time of release and the degree of aspiration” (p. 114). To put it more simply, stop sounds are burst out at different times or, technically, have different voice onset times (shortened as VOT) due to the amount of aspiration that comes with them. The greater degree of aspiration a stop has, the more it delays to be voiced out. The following diagram by Mannell (2009) shows the range of VOT values in regard to different stop release bursts. Values can be negative, zero or positive depending on the voicing of each type of stop sounds. When the VOT ranges between -20

milliseconds (ms) and + 20 ms, it can be perceptually equivalent to a zero VOT. When it falls below -20ms, it is generally considered to be negative, and when it goes higher than + 20 ms, it is considered to be positive (Mannell, 2009).

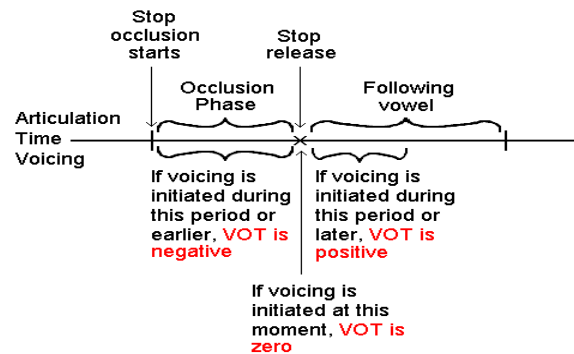


Figure 1 VOT Values Depending on the Stop Release Burst Only for Syllable-Initial Stops

In practice, however, fixed VOT values of stops, especially when they are part of the word, are difficult or perhaps impossible to set because certain factors such as phonological contexts, accents and dialects vary their degrees of aspiration. Previous studies have solved this problem by having a number of participants read words containing stops, either voiceless aspirated, voiceless unaspirated or voiced, then finding averages of VOT values measured, and comparing the obtained data (e.g. works by Cho, Whalen & Docherty, 2019; Abramson & Whalen, 2017; Kato, 2009; Cho & Ladefoged, 1999; Keating, Linker & Huffman, 1983; Lisker & Abramson, 1964). As far as English is concerned, its voiceless aspirated stops should have a greater VOT value than that of its unaspirated counterparts, as illustrated by the following diagram (Aspiration, 2005) that the former take more time prior to the release of the sounds.

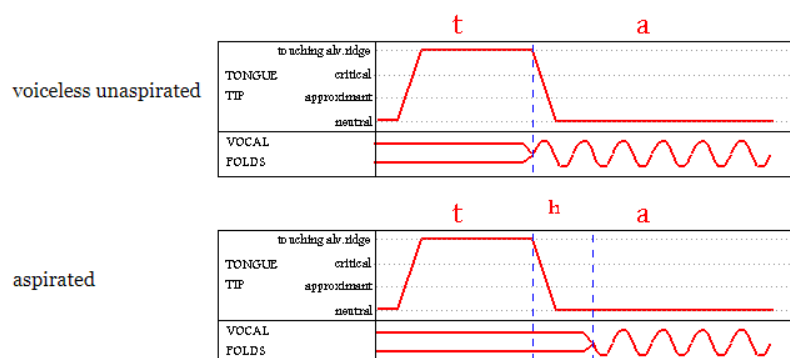


Figure 2 VOT Continuum of Voiceless Unaspirated and Aspirated Stops

Previous studies have reported some problems due to the difference in aspiration in English and other languages. In his paper entitled *Instrumental Analysis of the English Stops*

Produced by Arabic Speakers of English (2017), Abdelaal found among other findings that the Arabic speakers' degrees of aspiration of English /t k/ were lower than those of native speakers due to the interference of the mother tongue. Ekelund (2011) investigated Japanese speakers' production of aspiration in English voiceless stops by having his subjects pronounce both Japanese and English /p t k/. The findings showed the non-native speakers' higher degrees of VOT values for /t k/ in English than in their mother tongue. Conversely, when English native speakers transfer their native aspiration in another language, problems also arise. Lado (1956) found that English speakers learning Spanish tended to produce unaspirated /t p/ in words which sound aspirated in the target language, even though they perceived and used VOT duration differences in judging how close their pronunciation was to the native's (Schoonmaker-Gates, 2015). In light of this, Lord (2005) affirmed that degrees of aspiration in Spanish voiceless stops produced by English learners were not equal to those of the natives even though pronunciation training and awareness were present.

The present study applied the methodology of previous studies, especially that by Kato (2009), in order to compare VOT values of English voiceless unaspirated stops produced by native speakers and those by Thai students to examine to what extent the latter's production deviated from that of the English norm.

Another important aspect of aspiration lies in its being non-distinctive in English since it is predictable as to when it will occur and which sounds it comes with, as aforementioned. Moreover, aspiration does not alter word meaning. For example, the two allophones of /t/ in the words *tar* [tʰɑ:r], and *star* [stɑ:r] can be used interchangeably. Whether they are alternatively pronounced [tɑ:r] or [stʰɑ:r] is not a serious matter of meaning. Both pronunciations are still understandable even though they may sound unfamiliar to the native ear.

On the contrary, aspiration is distinctive in other languages including Thai; that is, it differentiates words. A number of common words illustrate this feature, such as /p/ in ปอ [pɔ:] 'hemp' vs /pʰ/ in พอ [pʰɔ:] 'enough', /t/ in ดี [tɕi:] 'hit' vs /tʰ/ in ที่ [tʰɕi:] 'time or turn', and /k/ in กาง [kɑ:ŋ] 'stretch' vs /kʰ/ in คาง [kʰɑ:ŋ] 'chin'. Therefore, 'both aspirated and unaspirated voiceless stops are [different] phonemes in Thai' (Fromkin, Rodman & Hyams, 2003, p.327; Kanchanawan, 2015, pp.319-320; Changjai, 2015, p.55). In addition, the Thai language assigns different orthographic letters to represent its aspirated and unaspirated stop phonemes. These two sounds in Thai can appear freely in any syllabic positions, but unlike English, they cannot be used interchangeably. More examples include สภา [sāpʰā:] 'parliament' and สป่า [sāpā:]

‘spa’, indicating that both of the aspirated and the unaspirated [p] can follow /s/, and they convey different meanings.

2.3 Factors contributing to second language learning

How second language learners (or L2 learners) successfully acquire second language has been an appealing research topic for many decades. In order to master an L2, scholars have pointed out certain factors that have a great impact on L2 learners. For instance, Khasinah (2014, p.256) stated the importance of age, aptitude, intelligence, cognitive style, attitudes, motivation and personality. These factors can bring success or failure to L2 learners when learning any foreign languages. Among these factors, motivation appears to be of immense importance. Motivation can in general be divided into intrinsic and extrinsic. While the former refers to the one that encourages learners to learn an L2 according to their own desire for development or satisfaction, the latter involves their learning with an expectation of reward or benefit in return (Brown, 1994). Certain studies claimed that learners with more intrinsic motivation would be more successful. Another factor that plays a vital role in L2 learning is the attitude of an individual learner. Stern (1983, pp.376-377) classified attitudes into three types: one towards native L2s’ communities and people, another towards the language to be learned, and the other towards language and language learning in general. Based on the studies, L2 learners with positive attitudes are found to be able to learn a second language better than those with negative attitudes. Moreover, having positive attitudes of the language to be learned would predict more promising success in a long term (Khasinah, 2014). Last, learning style is also considered essential. As Keefe (1979) maintained that “learning style was characteristic cognitive, affective and physiological that serve relatively stable indicators of how learners perceive, interact with, and respond to the learning environment”, an L2 learner’s success depends largely on the manner in which they adopt to acquire a given language.

Apart from the learner’s internal factors such as those mentioned above, the role of teachers is influential to their language acquisition. A language teacher should take the various factors of L2 learners into consideration so as to design appropriate instruction that can give maximal benefits to them. Lessard-Clouston (1997, pp.5-6) asserted that the more language teacher realized their learners’ goals, motivation and learning styles, the more L2 learners would be able to celebrate their learning achievement. As for L2 pronunciation in particular, the aforesaid factors are also well applicable. Moyer (2014) maintained that the cognitive, socio-affective, and experiential variables shaped the learner’s pronunciation learning outcomes. In addition, Zhang (2009, p.33) pointed out internal and external factors. Internal

factors for L2 pronunciation are similar to those of language acquisition and learning in general (e.g. age, perception, attitude, aptitude, motivation, goal setting). External factors involve L2 learning environments which relate to learners' L1, language exposure and educational factors. A number of studies confirmed the influence of the last factor in particular, especially concerning teacher instruction, on L2's speech production (Pienemann, 1987; Derwing & Munro, 2005; Saito, 2013; Lightbown & Spada, 2019; Thomas, 2019).

3. Methodology

3.1 Research Hypothesis

The degrees of aspiration of English voiceless stops produced by Thai university students were greater than those of native speakers due to their linguistic experience in Thai contexts.

3.2 Research Objectives

This study investigated Thai university students' production of aspiration in English voiceless stops in different phonological environments in order to:

3.2.1 examine to what extent Thai university students' degrees of aspiration of English voiceless stops differed from those of native speakers, and

3.2.2 find the factors contributing to the Thai university students' pronunciation.

3.3 Research Questions

3.3.1 Compared to that produced by native English speakers, what was the Thai university

students' degree of aspiration of English voiceless stops

a) when they immediately followed /s/, and

b) when they occurred in an unstressed syllable?

3.3.2 What were the significant factors contributing to the Thai university students' degrees of aspiration of English voiceless stops?

3.4 Participants

A group of 30 undergraduate students aged between 17 and 20 participated in the study. Twenty of them were female, and the rest were male. They were all native Thais who had never resided in any English-speaking country for more than six months. All of them were freshmen who were enrolled in a university. Half of them were Thai majors and the other half were English majors. Both groups had heterogeneous levels of English proficiency which could represent the vast majority of Thai students to some degree. They were reported to have no

hearing impairment or speech disorder. They were all informed about the research in detail prior to signing a consent form of participation in the study.

3.5 Informants

Eight native speakers of English were informants. They were 5 males and 3 females, all of whom were American working as instructors in a Thai university. Their ages ranged between 40 and 65. They were asked to read 12 English words that contained English voiceless stops. Their VOT values obtained from the degrees of aspiration of the sounds in question were treated as a norm with which those of the Thai participants were compared.

3.6 Instruments

There were two main research instruments: production test and interview.

3.6.1 Production test

Twelve English words in isolation were used as the material (see Appendix A for the list of words). All of them were drawn from standard English-English dictionaries and were found to be in common use. All of the words contained voiceless stops /p t k/, which occurred in the following phonological environments:

a) Immediately after the voiceless fricative /s/ in word-initial position, such as those in *spa* [spa:], *style* [stail] and *square* [skweə(r)]. The total number of test words in this set was 6.

b) In an unstressed syllable of a two-syllabic word, such as those in *cactus* ['kʰæktəs], *purple* ['pʰɜ:pəl] and *pumpkin* ['pʌmpkɪn]. The total number of test words in this set was 6.

3.6.2 Interview

The principal objective of the interview was to elicit the information regarding the factors that contributed to the participants' pronunciation of English voiceless stops. Each interview contained a set of questions that specifically asked the participants what factors contributed to their produced degrees of aspiration in the sounds in question.

3.7 Data Collection

3.7.1 Production test

Prior to the recording process, each participant was asked to complete a questionnaire providing his or her personal information and English language exposure (see Appendix B for the survey). During the test, each participant read all 12 test words one-by-one two times with a 5-second interval pause between them. They were given a signal when the next word was to be read. Their readings were recorded by the Audacity Program with the sampling rate of 48000 Hz on an ATEC Prestiga-i723 computer and a SHURE-KSM32 microphone. The recorded

files were saved as WAV files on the computer for the measurement of VOT values. This session took about 10 minutes for each participant.

3.7.2 Interview

Based on the production test, the researchers asked each Thai participant what factors contributed to their pronunciation of the tested sounds, that is, English voiceless stops /p t k/ in the test words. They were specifically asked why they made the sounds in question aspirated or unaspirated. As many reasons as they found involving their pronunciation in each word were allowed. The interview lasted about 10 minutes for each participant.

3.8 Data Analysis

3.8.1 Production test

The data from sound recording was analyzed through the following procedure:

1) All sound files both by the Thai participants and the informants were transferred into the Praat Program (Version 5.3.53) to account for the values of VOT of the English voiceless stops in each word. To obtain a VOT value, the sound in question, for example, /t/ in the word *style*, is highlighted. The highlight begins when the targeted sound starts (seen from the sound wave and the sound spectrogram that indicates phonemic characteristics of /t/) and ends before the vowel sound (seen again from the sound wave and the sound spectrogram). However, this has to be done in close cooperation with auditory consideration, which in some cases, may be slightly different from what is indicated by the spectrogram as illustrated in Figure 3. The value (0.042) appeared in the grid below.

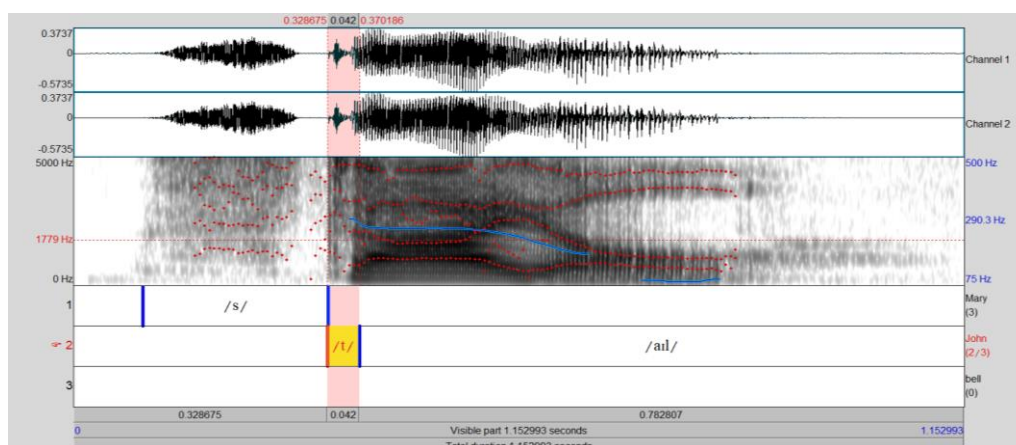


Figure 3 VOT of the English Voiceless Stop /t/ in *Style*

2) The average VOT values of the English voiceless stop in each word was calculated using the SPSS Program.

3) The participants' and the informants' average VOT values were compared to identify the similarities or differences between the two groups.

3.8.2 Interview

The data from the interview was analyzed and categorized into five categories:

1) *Instructional input* referring to the direct effects of formal instruction on the participants' pronunciation of English voiceless stops

2) *Transliteration* referring to the influence of Thai orthography that was used to transliterate English voiceless stops into Thai letters (for example, the word <square> is transcribed as <สแควร์>, in which the Thai letter <ค>, pronounced as /k^h/, is assigned to represent the English /k/)

3) *Correspondence* referring to one-to-one correspondence of English voiceless stops and Thai letters (for example, <t> in the word *system* is matched to the letter <ท>, which represents the Thai alveolar aspirated voiceless stop phoneme)

4) *Self-learning* referring to the participants' acquisition of the knowledge by their own learning from any means other than from their instructors

5) *Attitude* referring to any feelings or attitudes the participants had towards the degree of aspiration of English voiceless stops

4. Results

4.1 VOT values of English voiceless stops

Table 1 shows all statistic values of English voiceless stops /p t k/ in 12 test words both when immediately following /s/ and when appearing in an unstressed syllable, exhibited by all 30 participants and 8 informants in the experiment.

Table 1 Descriptive statistic values of English voiceless stops in each test word

Word*	Mean VOT (milliseconds)	Mean Difference	Standard Deviation	Sig. (2-tailed)**
spa	44.4333 20.6250	23.8083	27.6862 1.7677	.021 *
speed	30.7333 20.0000	10.7333	13.3800 0.0000	.030 *
star	36.1000 30.2500	5.8500	18.1000 4.6521	.375

Word*	Mean VOT (milliseconds)	Mean Difference	Standard Deviation	Sig. (2-tailed)**
style	33.3000	2.9250	15.1524	.599
	30.3750		6.0222	
school	84.2666	41.1416	31.5200	.000 ***
	43.1250		11.3696	
square	98.3333	55.8333	28.1269	.000 ***
	42.5000		9.9139	
people	72.8000	45.3000	23.4864	.000 ***
	27.5000		9.1339	
purple	71.6000	40.7250	20.5537	.000 ***
	30.8750		16.18145	
hectic	72.4137	39.1637	30.0339	.001***
	33.2500		18.4913	
cactus	63.9310	30.6810	32.0924	.012 *
	33.2500		10.1101	
marker	64.0333	13.1583	30.9933	.258
	50.8750		16.7113	
pumpkin	100.6000	48.1000	38.4381	.001 **
	52.5000		10.8100	

* Each word has two mean and standard deviation scores, the first of each belongs to the participants and the second to the informants.

** Asterisks in the Sig. Column indicate the degree of statistical significance with the use of three asterisks showing the greatest significance and one asterisk the least significance.

As illustrated in the table above, the means of VOT in English /p t k/ in all test words measured from the Thai participants were greater than those of the native English informants. The words that showed the greatest difference of VOT means between the two groups were *square* (55.8333), *pumpkin* (48.1000) and *people* (45.3000), while the words that had the least difference were *style* (2.9250), *star* (5.8500) and *speed* (10.7333), respectively. The standard deviations between the two groups were also found to be much different with that of the Thai greater than the English counterparts. Overall, the Thai participants' means of VOT in English

/p t k/ were significantly different from the natives' ($p < 0.05$), except those of the three words, *star* ($p = 0.375$), *style* ($p = 0.599$) and *marker* ($p = 0.258$). Significant p values were found in three levels: first, *spa*, *speed* and *cactus* at $p < 0.05$; second, *pumpkin* at $p < 0.01$; third, *school*, *square*, *people*, *purple* and *hectic* at $p < 0.001$.

Table 2 VOT values of English voiceless stops after /s/

Group	Number	Stop					
		/p/		/t/		/k/	
		Mean	Range	Mean	Range	Mean	Range
Thai	30	37.5833	19 - 116	34.7000	20 - 115	91.3000	31 - 158
Native (norm)	8	20.3125	20 - 25	30.3125	20 - 40	42.8125	29 - 68

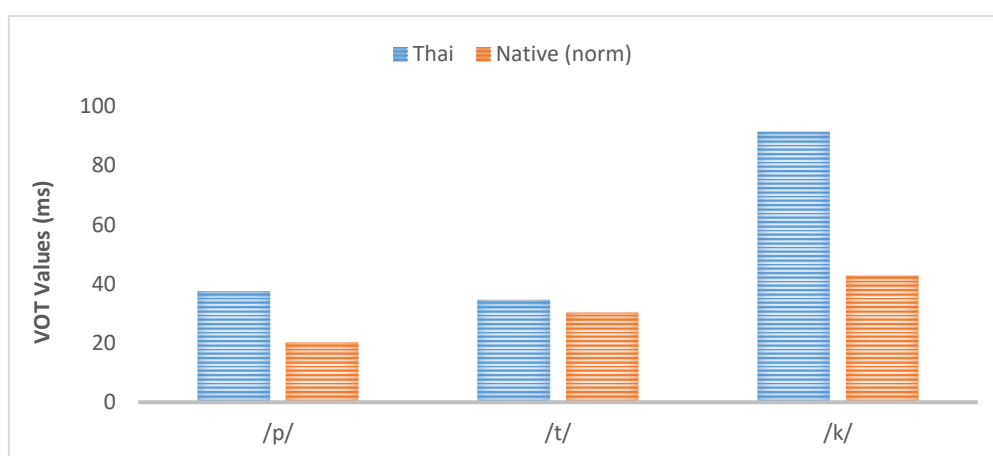


Figure 4 VOT values of English voiceless stops after /s/

When taking the syllabic position into consideration, the Thai participants' production of aspiration of English voiceless stops after the fricative /s/ had a greater VOT means than that of the native speakers. These results also showed the correlation between the degrees of aspiration of the English /p t k/ produced by the native informants and their place of articulation. That is, their velar /k/ received the highest degree of aspiration (mean=42.8125), followed by their alveolar /t/ (30.3125) and their bilabial /p/ (20.3125), respectively. However, the order of Thai participants' degrees of aspiration was different. Their alveolar /t/ received less degrees of aspiration (mean=34.7000) than their bilabial /p/ (37.5833), and their velar /k/ had the highest degree (91.3000). Moreover, it is obvious that the range of aspiration degrees produced by Thai participants was broader than the native speakers'.

Table 3 VOT values of English voiceless stops in unstressed syllable

Group	Number	Stop					
		/p/		/t/		/k/	
		Mean	Range	Mean	Range	Mean	Range
Thai	30	72.2000	20 - 129	68.1724	10 - 152	82.3166	26 - 226
Native (norm)	8	29.1875	17 - 70	33.2500	10 - 67	51.6875	30 - 79

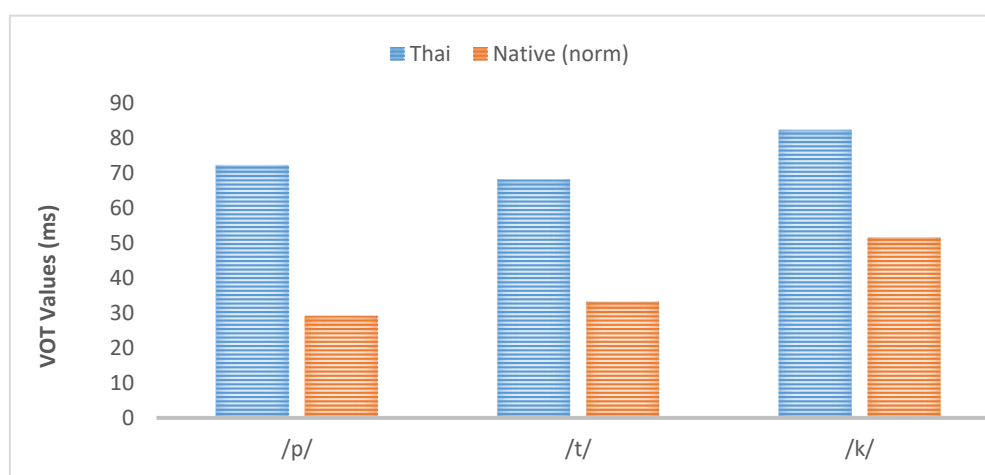


Figure 5 VOT values of English voiceless stops in unstressed syllable

When /p t k/ occurred in an unstressed syllable, the Thai participants' degree of aspiration was much greater than the native speakers'. Similar to those after /s/, these results showed the correlation between the degrees of aspiration of the English /p t k/ produced by the native informants and their place of articulation. That is, their velar /k/ received the highest degree of aspiration (mean=51.6875), followed by their alveolar /t/ (33.2500) and their bilabial /p/ (29.1875), respectively. However, the order of Thai participants' degrees of aspiration was different. Their velar /k/ had the highest degree (82.3166), followed by their bilabial /p/ (72.2000) and their alveolar /t/ (68.1724). In addition, the range of aspiration degrees produced by Thai participants was even much broader than the native speakers'.

4.2 Factors contributing to Thai university students' production of aspiration

The data from the interview revealed the influencing factors contributing to the degrees of English voiceless stops produced by Thai university students. Table 3 shows the most to the least influencing factors.

Table 4 Factors contributing to degrees of English voiceless stops produced by Thai university students

Factors	/t/	/t ^h /	/p/	/p ^h /	/k/	/k ^h /	Total (n = 180)	Percentage
Instructional input	25	20	26	28	13	27	139	72.22
Correspondence	2	6	1	5	1	6	21	11.66
Transliteration	3	1	7	1	1	4	17	9.44
Attitude	0	4	0	3	3	1	11	6.11
Self-learning	2	1	0	0	5	0	8	4.44

All responses from each of the participants were counted and calculated into percentage. Note that some participants gave more than one reason for pronouncing the tested sounds. As shown in Table 4, the most influencing factors contributing to the Thai participants' degrees of English voiceless stops was instructional input (72.22%). That is to say, most of the test words were pronounced as they were taught. According to the statistics, the number of words instructed to be pronounced with aspirated phonemes ($n=75$) was higher than those with unaspirated ones ($n=64$). The second influential factor was correspondence (11.66%). To reiterate, correspondence happened when the participants fixedly matched English voiceless stops to Thai letters, notably those representing aspirated phonemes ($n=17$) than unaspirated phonemes ($n=4$). Particular examples of one-to-one correspondence included *people*, *cactus* and *pumpkin*, where the letters <p t k> were matched to <พ ท ค>, all of which are aspirated phonemes in Thai. Thirdly, Thai transliteration played a certain role in pronouncing English voiceless stops (9.44%). The affected words included *square*, *spa* and *star*, each of which is transliterated into Thai letters <ค>, <ป> and <ต>, respectively. Next, some participants had the attitude (6.11%) that the more aspiration they produced, the more native-like their pronunciation would be, suggested by the words *cactus* and *school*, for example. The results showed more attitude towards aspirated sounds ($n=8$) than that towards unaspirated sounds ($n=3$). This particularly means that the Thai participants favored more aspiration when producing English voiceless stops. Lastly, very few participants self-learned English pronunciation by watching English video clips or soundtrack movies (4.44%). Their own learning absorbed more aspirated sounds ($n=7$) than aspirated ones ($n=1$).

5. Conclusion and suggestion

The results of the study confirm the hypothesis that the degrees of aspiration of English voiceless stops produced by Thai university students were greater than those of native speakers due to linguistic experience in Thai contexts. Regarding the aspiration degree, the average Thai participants' means of VOT values were different from the native English counterparts at a very significant level. Thus, a conclusion can be drawn that the Thai production of aspiration deviates from the English norm. The data from the interview revealed certain Thai circumstances that contributed to this deviation. To reiterate, Thai instructors, transliteration of English into Thai letters, fixed correspondence between English and Thai letters, and Thai attitudes had huge effects on their relatively higher degrees of aspiration of the sounds in question. Based on Zhang (2019), these Thai factors were primarily external. The internal factors were the students' attitude and self-learning. This implies that Thai students' English pronunciation is largely shaped by external factors, notably instructional input. As a consequence, teachers play a modelling role in and have huge impacts on learners' performance. The cases of correspondence (or sound mapping) and transliteration most probably derive from teachers' influence, where the former is made by direct teacher instruction and the latter involves learners' application of classroom knowledge to responding to the targeted language in any linguistic environments.

We, therefore, suggest that the knowledge of aspiration be included in formal instruction in order to both minimize their pronunciation problems and maximize their self-dependence. Regarding the latter issue in particular, students should also be trained to achieve a certain level of language awareness; that is, being able to observe and analyze critically, so that they can apply the knowledge for their own learning outside class. This awareness will be useful for them, at least not to be affected by transliteration of English into Thai words and to form the right attitude for English pronunciation. To demonstrate a concrete teaching method in a classroom, the teacher may start by explaining the rules for pronouncing English /p t k/ to students and then giving them a pronunciation drill. Second, having the students listen to English native speakers of different accents pronouncing the sounds in question in the different environments, and asking them to analyze what they heard and identify the similarities and differences among the speakers and from the theory they have just learned. Finally, allowing them to discuss any Thai materials that might contribute to their pronunciation deviating from the native speaker norm and the problems associated with it. This task will also promote their critical thinking.

Last but not least, we suggest a further study on the test of whether Thai students' deviating degrees of English voiceless stops have any effects on their listening comprehension of English native speakers in order to explore this special topic to a greater extent.

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Appendix A

A list of test words used as materials for the production test*

- | | | | | | |
|----------|-----------|----------|------------|------------|------------|
| 1) style | 2) cactus | 3) spa | 4) pumpkin | 5) school | 6) people |
| 7) star | 8) hectic | 9) speed | 10) marker | 11) square | 12) purple |

*Note that the words were scrambled in the production test so that the participants could not predict what was being tested.

Appendix B

A Sample of Survey on Production of English Voiceless Stops by Native Thai University

Students

Part I: Personal background

1. Gender _____
2. Age _____
3. Place of birth _____
4. Major of Study _____
5. Year of Study _____

Part II: Language ability and language exposure

6. Foreign language background

- Your first foreign language _____ Year of studying _____
- Your second foreign language _____ Year of studying _____
- Your (an)other foreign language(s) _____ Year of studying _____

7. Please rate your ability in languages.

- Your native language (_____)
___ very good ___ good ___ fair ___ poor ___ very poor
- Your first foreign language (_____)
___ very good ___ good ___ fair ___ poor ___ very poor
- Your second foreign language (_____)
___ very good ___ good ___ fair ___ poor ___ very poor
- Your (an)other foreign languages (_____)
___ very good ___ good ___ fair ___ poor ___ very poor

8. Year of studying English _____ Period of studying English _____

9. Have you ever been to an English-speaking country? ___ Yes ___ No

10. If yes, how long and for what purpose did you stay there? _____
