THE INFLUENCES OF ORTHOGRAPHIC FORMS, STRESS PLACEMENT AND CONSONANTAL MANNERS ON SYLLABIFICATION AND ACOUSTIC DURATIONS OF INTERVOCALIC CONSONANTS WITH GEMINATE GRAPHEMES BY THAI L2 SPEAKERS OF ENGLISH

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2023

อิทธิพลจากการสะกดคำ การเน้นเสียงหนัก และประเภทเสียงพยัญชนะต่อการแบ่งพยางค์และระยะเวลาในการออกเสียงพยัญชนะระหว่างสระที่มีรูปสะกดพยัญชนะซ้อนโดยผู้พูดภาษาอังกฤษชาวไทย

อนุสรณ์ แซ่จันทร์

ปริญญานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตร
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ปีการศึกษา 2566

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A Dissertation Submitted in Partial Fulfillment of the Requirements

for the Degree of DOCTOR OF PHILOSOPHY

(Linguistics)

Faculty of Humanities, Srinakharinwirot University

2023

THE DISSERTATION TITLED

THE INFLUENCES OF ORTHOGRAPHIC FORMS, STRESS PLACEMENT AND CONSONANTAL MANNERS ON SYLLABIFICATION AND ACOUSTIC DURATIONS OF INTERVOCALIC CONSONANTS WITH GEMINATE GRAPHEMES BY THAI L2 SPEAKERS OF ENGLISH

BY

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OF THE REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY
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Degree	DOCTOR OF PHILOSOPHY
Academic Year	2023
Thesis Advisor	Associate Professor Dr. Sugunya Ruangjaroon

This dissertation investigates the interplay of orthographic forms, stress, and consonantal manners in syllabification and acoustic durations of intervocalic consonants with singleton and geminate graphemes by Thai L2 speakers of English, classified into three CEFR proficiency levels: A1, A2 and B1. This study encompasses two experiments: syllabification and production. The syllabification experiment employed the word-part identification task, comprised of 64 multiple-choice questions, in which the participants were instructed to identify the first part of a word in one question and the second part of the same word in another. The findings revealed dynamic changes in syllabification preferences as L2 proficiency increased. The initial stages of acquisition displayed a strong reliance on orthographic forms for syllabification. An increase in proficiency is associated with a growing awareness of the interaction of stress placement with syllabification and declining orthographic reliance. The production experiment utilized the reading aloud task, wherein participants were asked to read aloud 32 target words in a carrier sentence. The acoustic durations of intervocalic consonants were analyzed using Praat software (Boersma & Weenink, 2021) based on waveforms and spectrograms. The results indicated that all groups of participants produced intervocalic consonants orthographically represented as geminates significantly longer than those orthographically represented as singletons. The durational ratio of orthographic singletons to geminates is on average greater for intervocalic consonants in pre-stress positions than for those in post-stress positions. Across all Thai participant groups, the ratio is greater for intervocalic sonorants than for obstruents in post-stress positions, whereas in pre-stress positions, the ratio is greater for obstruents. This ratio steadily decreases from A1, A2 and B1 to NES participant groups. The findings underscore the consistency observed in both experiments as higher English proficiency correlates with native-like syllabification and acoustic duration.

Keyword : Orthography, Consonantal manner, Stress, Syllabification, Acoustic duration

ACKNOWLEDGEMENTS

This dissertation would not have been completed without substantial support and great assistance from numerous individuals who have collaboratively played a crucial role in facilitating this research. First and foremost, my heartfelt appreciation goes to my advisor, Associate Professor Dr. Sugunya Ruanjaroon, whose invaluable academic guidance, enduring support and endless encouragement have walked me to this point of success.

My intellectual gratitude is also owed to the invited committee members, namely Assistant Professor Dr. Sujinat Jitwiriyanont, Associate Professor Dr. Nuntana Wongthai, Assistant Professor Dr. Sakulrat Worathumrong, and Dr. Attasith Boonsawasd, whose constructive and insightful comments contribute to this thesis.

I would also like to take this opportunity to extend my thanks to my colleagues at the Division of Foreign Language, Faculty of Liberal Arts, Rajamangala University of Technology, Suvarnbhumi, for their generous assistance in collecting data.

Lastly but most importantly, my deepest gratitude goes to my beloved mom and sisters, whose unwavering support and thoughtfulness have been instrumental in my success. Their comfort and encouragement have consistently lifted me up and kept me persevering throughout my Ph.D. journey.

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INTRODUCTION

Background of the Study

The acquisition of second language (L2) phonology is influenced by that of a first language (L1) (Bada, 2001; Li, 2016; Roy C. Major, 2008). The evidence is manifested in L2 learners' alteration of L2 syllabic structure when their L1 and L2 differ in mental representations of this phonological unit (Gut, 2009; Ishikawa, 2002). The influence from L1 phonology gives rise to non-target-like speech production (Jangjamras, 2011). In addition, L2 orthographic forms affect the production of L2 speech sounds, especially in initial stages of acquisition, potentially leading to non-nativelike pronunciation (Bassetti, 2008).

The emergence of *World Englishes* (WE), *English as an International* or *Global Language* (EIL/EGL), and *English as a Lingua Franca* (ELF) has led to the acceptance of English varieties other than those spoken in the inner circle or the Anglosphere for educational purposes (Hino, 2019; Jenkins, 2015; Manzouri et al., 2024; Sharifian, 2009). This global phenomenon underscores the growing importance of English diversities, where non-native accents are deemed acceptable as long as they do not result in communication breakdown and remain intelligible. This yields the fuzziness between 'nativelikeness' and 'accentedness'.

Rather than the emphasis placed upon nativelikeness, the assessment of L2 production may be centered on intelligibility and comprehensibility. Intelligibility refers to the degree to which a speaker' utterance can be understood, despite accented pronunciation (Smith & Nelson, 1985). Conversely, comprehensibility pertains to the ease with which the listener processes the meaning of the utterance in a certain context (Munro & Derwing, 1995; Munro et al., 2006). Hence, a listener may rely on contextual cues to interpret a message without precisely understanding the accent (Field, 2003).

Accented Ness is closely associated with segmental accuracy (Saito et al., 2016, 2017) and may hinder ease of understanding, as listeners may struggle to comprehend speech with an unfamiliar accent (Pennington & Rogerson-Revell, 2019).

Despite the expansion of EIL, foreign learners of English often regard non-native varieties of English as illegitimate forms of English They also hold strongly positive attitudes toward native varieties of English and aim to attain a nativelike accent. Therefore, it is imperative that reference accents, such as BrE or AmE, be adopted as a model in English Language Teaching (ELT) classroom (Manzouri et al., 2024).

This dissertation draws upon psycholinguistic and acoustic approaches to investigate how Thai L2 speakers of English syllabify and produce intervocalic consonants, orthographically alternating between singleton and geminate graphemes in di- to trisyllabic words with alternating iambic and trochaic stress.

It is important to point out at the outset that *gemination* in this dissertation pertains to the phenomenon in second language acquisition where Thai L2 learners of English geminate or lengthen English intervocalic consonants with geminate graphemes across syllables. Geminate graphemes, or more generally known as *doubled letters* or *homogeneous digraphs*, refer to a sequence of two identical consonantal letters in intervocalic positions, such as <tt> in the word *letter*, whereas singleton graphemes denote a single intervocalic letter, e.g. <t> in the word *atom*.

English syllabification has drawn substantial attention due to unclear syllabic boundaries of intervocalic consonants with no consensus among reputable dictionaries. For instance, Cambridge Dictionary syllabifies the word 'letter' as /ˈlɛt.ər/, whereas Merriam-Webster Dictionary syllabicates it as /ˈlɛ.tər/. Furthermore, the word 'color' is syllabified as /ˈkʌl.ər/ in Cambridge Dictionary but as /ˈkʌ.lər/ in Merriam-Webster Dictionary (Eddington et al., 2013). Marchand et al. (2009) also reported approximately 25% discrepancy in syllabifications between the two dictionaries.

Intervocalic consonants in English, whether orthographically represented as singletons or geminates, are underlyingly a single phoneme within native English speakers' mental representation for syllabification. Segmental lengthening occurs independently of orthographic forms in English, and geminate graphemes never indicate consonantal length within a word. Nonetheless, some English words whose intervocalic consonants are orthographically represented as geminates, albeit

ambisyllabified, are produced as singletons. This results in inconsistency between English graphemes and phonemes.

In English syllabification, several principles play integral roles, including *Sonority Sequencing Principles (SSP)*, adhered to by scholars such as Clements (1990b), Murray and Vennemann (1983), Vennemann (1972); *Maximal Onset Principle* (MOP), proposed by e.g. Clements and Keyser (1983), Kahn (1976), Pulgram (1970); *ambisyllabification*, proposed by Kahn (1976); *resyllabification,* formulated by Selkirk (1982); and *Weight-to-Stress Principle* (WSP), proposed in various versions by, e.g. Selkirk (1982), Murray and Vennemann (1983), Kager (1989), Prince (1990), Hammond (1999), and Duanmu (2000). These principles will be further detailed in Chapter 2.

Irrespective of orthography, English syllabification is influenced by stress (Suh, 2001). The MOP suggests the syllabification of disyllabic words such as *letter* with penultimate stress as [ˈlɛ.tər] and *attack* with ultimate stress as [ə.ˈtæk]. The syllabification for the latter seems legitimate; however, the syllabification for the former renders the first syllable *[ˈlɛ]$_{\sigma}$ ill-formed, in that English open syllables concluding with lax vowels are non-stressable. To avoid such ill-formed syllable, ambisyllabification proposes syllabifying the word *letter* as [ˈlɛt̲ər], and the WSP, which stipulates that English stressed syllables are to be heavy (Duanmu, 2008, pp. 58-59; Kager, 2004, p. 155), suggests syllabicating it as [ˈlɛt.ər] (Duanmu, 2008).

Thai learners of English, whose L1 stress operates only at the prosodic level without lexical stress, are presumed to base syllabification upon orthographies and their native Thai syllabic structures. Upon seeing geminate graphemes, Thai learners of English, especially in the early stages of acquisition, usually mistake the consonant in question as underlying /cc/. Even English majors frequently misconstrue such the grapheme as a geminate, as evidenced in their phonemic transcriptions, in which the words ‘happy’, ‘letter’ and ‘announce’ are perplexingly transcribed as /hæppi/, /lɛttər/, and /ænnaʊns/, respectively.

It is worth mentioning here that NESs from different dialects exhibit variation in the production of intervocalic voiceless alveolar stop [t] at the phonetic level, depending

on the phonetic context where the segment occurs. For instance, American and Canadian English speakers in some parts pronounce the consonant as an alveolar flap [ɾ], hence *letter* [ˈlɛɾər] while some British English speakers employ glottal replacement as in 'button' [ˈbʌʔn̩] or glottal reinforcement [ˈbʌʔtn̩] (Collins & Mees, 2013, pp. 269-270; Gut, 2009, p. 59; Ladefoged & Maddieson, 1996, p. 187). Besides, according to the online Cambridge English Dictionary, the consonant may be produced as a voiced alveolar stop [t̬]. In this regard, I, therefore, ruled out the voiceless alveolar stop /t/ from the stimuli.

Thai learners of English' orthographic syllabification yields the production of intervocalic consonants with geminate graphemes twice as two separate phonemes across syllables. This type of syllabification, previously termed *ambisyllabicity* in studies by Ishikawa (2002), Eddington and Elzinga (2008) and Eddington et al. (2013), is referred to in this study as *heterosyllabic gemination*. In contrast, when the intervocalic /t/ is spelled with a singleton letter <t> as in the words 'atom' /ˈætəm/ and 'atone' /əˈtoʊn/, Thai learners syllabify the words by assigning the phoneme in question to the onset of the following syllable and produce them as [ʔàʔ.tɔm] and [ʔàʔ.tʰoʊn], respectively. This sustains the orthographic effects on syllabification. The evidence for heterosyllabic gemination can also be acoustically substantiated with the relevant hypothesis that Thai English learners' production of intervocalic consonants spelled with geminate graphemes exhibit longer duration than their singleton counterparts.

Nonetheless, it is presumed that the extent to which Thai learners rely on orthographies for the syllabification of intervocalic consonants varies with their English proficiency levels. Learners with increased proficiency are hypothesized to demonstrate syllabifications and produce durational ratios of intervocalic consonants orthographically represented as singletons to those represented as geminates that align more closely with those of NESs.

To this end, this study incorporated syllabification and production experiments, manipulating *word-part identification task* and *reading aloud task*, respectively. The tasks were administered to native Thai learners of English placed at different English

proficiency levels. NESs were also invited to participate, and their syllabifications and productions of intervocalic consonants serve as a benchmark with which Thai learners' syllabifications and productions are compared.

The rest of this section proceeds to delve into the effects of syllabic structures and orthographies on English syllabification, followed by representations of ambisyllabic and geminate consonants using skeletal (including both X-slot and CV-slot) and moraic models.

Effects of Syllabic Structures and Orthographies on English Syllabification

English and Thai syllabic structures differ in complexity. The template for maximal English monosyllables is (C)(C)(C)V(C)(C)(C)(C), allowing optional onsets and codas. In contrast, Thai permits a consonantal cluster only in the onset which can maximally consist of two consonants. Maximal Thai monosyllables follow a template of $C(C)V(V)^{T}(C)$ where the superscripted ^{T} denotes *tone*. Such template also implies that the onset is obligatory in Thai syllables but optional in English (Petkla, 2020, p. 16; Ruangjaroon, 2020; Wutiwiwatchai & Furui, 2007).

While CV syllables are believed to exist in Thai, it is debatable whether they are underlying /CV/ or derived [CV] syllables. While Gandour (1974) asserts the absence of underlying CV syllables in Thai; however, based on Tumtavitikul (1998)'s analysis, I argue that CV syllables are of two different cases: being an underlying form in one case and a surface form in the other.

Citing Petkla (2020), Thai speech styles: isolative, combinative and rapid combinative, influence the realizations of underlying CV syllables in monosyllabic and polysyllabic Thai words. In the isolative style, as Thai is a monosyllabic language, syllables are pronounced as monosyllables consecutively, as found in Thai dictionaries and deliberate speech. Despite the existence of the underlying CV syllable in Thai speakers' mental grammar, it surfaces as an illicit syllable when uttered in isolation, as illustrated in (1).

(1)	a. [pàk]	‘to sew’	CVC
	b. [pàːk]	‘mouth’	CVVC
	c. [paː]	‘to throw’	CVV
	d. *[pà]	‘to patch’	*CV

Thai learners’ gemination manifests in the adaptation of English loanwords and transliterations in English-to-Thai dictionaries. Despite the underlying open CV syllables in Thai, all Thai syllables uttered in isolative style surface as bimoraic syllables to fulfill the requirement for bimoraicity of Thai syllables (Petkla, 2020; Ruangjaroon, 2020).

For native Thai words, the epenthesis of a syllable-final glottal stop, as instantiated in (2), serves as a repair strategy for any illicit monomoraic syllables; on the other hand, either gemination or vowel lengthening is preferably employed as a repair strategy to avoid violating the constraint on *bimoraicity* for monomoraic syllables in English loanwords, as shown in (3) and (4), respectively (Kenstowicz & Suchato, 2006; Petkla, 2020).

(2)	a. ‘country’	/prathe:t/	[prà?.thêːt̚]
	b. ‘rubbish’	/khaja/	[khà?.jà?]
	c. ‘watch’	/naːlikaː/	[naː.lí?.kaː]

(Bennett, 1995; Petkla, 2020, p. 19)

(3)	a. ‘happy’	/ˈhæpɪ/	[hɛ́p.pîː]
	b. ‘dinner’	/ˈdɪnər/	[dɪn.nɤ̂ː]
	c. ‘tennis’	/ˈtɛnɪs/	[tʰen.nít̚]

(Petkla, 2020, p. 77)

(4)	a. ‘column’	/ˈkɒləm/	[kʰɔː.lâm]
	b. ‘credit’	/ˈkrɛdɪt/	[kʰreː.dìt̚]
	c. ‘fashion’	/ˈfæʃən/	[fɛː.tɕʰân]

(Petkla, 2020, p. 77)

However, it is noteworthy that bimoraic syllables in Thai, as seen in (1), are not necessarily heavy syllables. The CV? syllable is treated as a light syllable in Thai, in that it is derived from an underlying CV structure. The assignment of stress in Thai, which will be further elaborated in Chapter 2, is primarily contingent on syllable quantity (Tumtavitikul, 1998).

In addition to English loanwords borrowed into Thai, the use of gemination is also evident in transliterations by most English-to-Thai dictionaries. Instead of using phonemic transcription, dictionaries transliterate the pronunciation of a word into Thai orthography. Disyllabic words with intervocalic geminate graphemes, underlyingly corresponding to a single phoneme in the source language, are transliterated by associating one of the graphemes with the coda consonantal letter of the preceding syllable and the other with the onset consonantal letter of the subsequent one. Table 1 illustrates the transliteration of the pronunciations of English words into Thai orthography. The data were extracted from two well-known English-to-Thai dictionaries.

Table 1 Transliteration of English words with geminate graphemes into Thai orthography

Word	Phonemic	Sor Sethabut		Oxford River Books	
'pepper'	/ˈpɛpə/	เพพ-เพอะ	/pɛp-pə/	ˊเพ็พเพอะ(ร)	/ˈpɛppər/
'rubber'	/ˈrʌbə/	รับ-เบอะ	/rʌb-bə/	ˊรับเบอะ(ร)	/ˈrʌbbər/
'letter'	/ˈlɛtə/	เลท-เทอะ	/lɛt-tə/	ˊเล็ทเทอะ(ร)	/ˈlɛttər/
'ladder'	/ˈlædə/	แลด-เดอะ	/læd-də/	ˊแลเดอะ(ร)	/ˈlæddər/
'funny'	/ˈfʌni/	ฟัน-นิ	/fʌn-ni/	ˊฟันนิ	/ˈfʌnni/

By the same token, two identical consonantal letters that appear syllable-medially in native Thai words are also mapped onto two separate phonemes across syllables, as demonstrated in (5).

(5)	a. สัมมนา	/săm.má.naː/	‘seminar’
	b. บุคคล	/bùk.kʰon/	‘person’
	c. ปากกา	/pàːk.kaː/	‘pen’

In certain Thai words, intervocalic consonants are, albeit orthographically represented as singletons, also geminated across syllables, as instantiated in (6).

(6)	a. บุคลิก	/bùk.kʰà.lík/	'personality'
	b. บุพบท	/bùp.pʰà.bòt/	'preposition'
	c. อัปมงคล	/ʔàp.pà.moŋ.kʰon/	‘bad luck’

Furthermore, other specific Thai words may undergo epenthesis of the CV syllable when uttered in a formal context. The consonant in the epenthetic syllable adopts the featural properties of the consonant that immediately precedes it, yielding a sequence of two homorganic adjacent consonants, as exhibited in (7).

(7)	a. ประถมศึกษา	/pra.tʰŏm.má.sùk.săː/	‘primary education’
	b. สัปดาห์	/sàp.pà.daː/	‘week’
	c. กลไก	/kon.lá.kaj/	‘mechanism’
	d. คุณค่า	/kʰun.ná.kʰâː/	‘value’

The lists of words provided in (6) and (7) suggest that gemination is not only triggered by the requirement for bimoraicity of non-final Thai syllables, but also by the obligatoriness of onset to the preceding syllables (Petkla, 2020, pp. 82-83). On this account, there are instances where intervocalic consonants orthographically represented as singletons are found to be transliterated as heterosyllabic Thai geminate letters by the Oxford River Books English-to-Thai dictionary, as shown in table 2.

Table 2 Transliteration of English words with singleton graphemes into Thai orthography

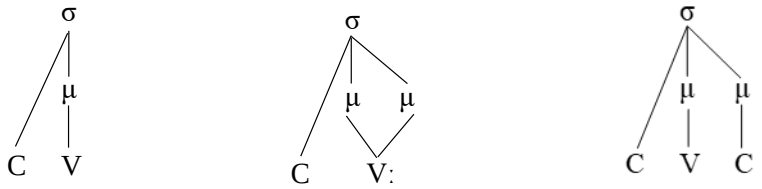
Word	Phonemic Transcription	Thai Orthographic Transliteration	
‘resident’	/ˈrɛzɪdənt /	ˊ เร็ซซิเดินทฺ	/ˈrɛzzɪdənt/
‘liberty’	/ˈlɪbərti/	ˊลิบเบอะทิ	/ˈlɪbbətɪ/
‘hesitate’	/ˈhɛzəˌteɪt/	ˊเฮ็ซซิเทท	/ˈhɛzzɪteɪt/

Syllable Weight in Skeletal and Moraic Models

Based on theories of weight, syllables can be categorized as either *heavy* or *light*. According to Gordon (2006, pp. 1-2), the two frameworks that have been widely adopted for illustrating syllabic weight encompass skeletal models, including the CV-tier representation (Clements & Keyser, 1983; McCarthy, 1979a, 1979b) and the X-slot representation (Levin, 1985), and the moraic representation (Hayes, 1989; Hyman, 1985).

In moraic theory, the units of weight are measured by a count of morae. Moraicity is confined to the segments within the rhyme constituent, whereas onsets are inherently weightless in English. Short vowels and coda consonants are assigned one mora each, while long vowels and diphthongs are assigned two morae. Bimoraicity is ascribed to heavy syllables. English syllables are classified according to moraicity into *light open*, *heavy open* and *heavy closed syllables*, as demonstrated in (8) (Davis, 2011; Gordon, 2006; Gussenhoven & Jacobs, 2017; Zec, 2007).

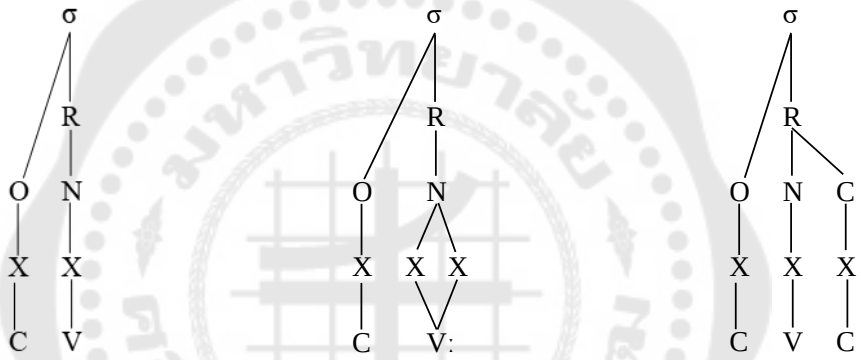
(8) a. Light open syllable b. Heavy open syllable c. Heavy closed syllable



(Zec, 2007)

In skeletal representations, the internal structure of the syllable is divided into constituents. Syllables obligatorily comprise a nucleus, typically a vowel, but optionally preceded and followed by onset and coda consonants. Only segments associated with rhyme contribute to the syllabic weight. Notably, syllables featuring branching rhymes are treated as heavy syllables. Skeletal X-slot representations for light open, heavy open, and heavy closed syllables are depicted in (9) (Davis, 2011; Gordon, 2006).

(9) a. Light Open Syllable b. Heavy Open Syllable c. Heavy Closed Syllable



(Gordon, 2006, 3)

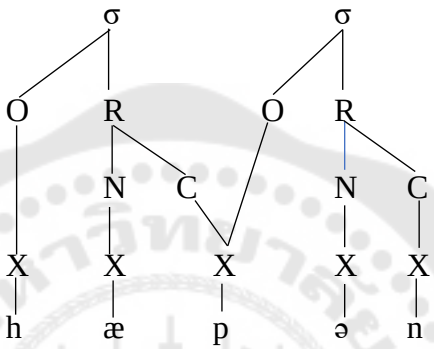
Grounded in theories of weight, the *WSP* proposed by phonologists such as Selkirk (1982), Murray and Vennemann (1983), Kager (1989), Prince (1990), Hammond (1999), and Duanmu (2000), stipulates that stress is exclusively assigned to heavy syllables, whereas light syllables are precluded from bearing stress. English falls into the category of stress-timed languages, and its isochrony is manifested in prosodic structure. In other words, stressed syllables occur roughly at regular intervals within an utterance, albeit, with some syllables intervening between them.

Gemination and Ambisyllabicity

Gemination and ambisyllabicity both stem from the theories of weight. However, as previously seen, what comes into play with English syllabification is stress, and pursuant to the WSP, stressed syllables must be heavy. On this account, intervocalic consonants, preceded by stressed lax vowels, are proposed as ambisyllabic segments, dually affiliated with the coda of the preceding syllable and the

onset of the subsequent one, as shown in (10), where heavy syllables are indicated by branching rhyme and associated with two X-slots. The notion of ambisyllabicity renders the illicit preceding syllable concluding with the lax vowel [æ] heavy and eligible to bear stress (Lee & Seo, 2019; McCully, 2009, 104; Yavas, 2011, pp. 149-151).

(10) 'happen' [hæpən]



Articulatorily, an ambisyllabic consonant is the consonant whose hold stage closes or half closes the preceding syllable, and its release stage commences the next syllable (Pulgram, 1970).

It is noteworthy that there is no conventional transcription indicating an ambisyllabic segment. An ambisyllabic consonant was found to be transcribed using underlining in works such as Durvasula and Huang (2017) and Duanmu (2008), as in the word *letter* ['lɛt̲ɚ], whereas the segment was indicated using square brackets as in ['lɛ[t]ər] (Trammel, 1989, 1991). Moreover, in works by such as Ishikawa (2002), Eddington and Elzinga (2008) and Eddington et al. (2013), an ambisyllabic consonant was represented using a sequence of two identical consonants or geminate across syllables, as in ['lɛt.tər]. This dissertation refers to such syllabification as *heterosyllabic gemination*, albeit gemination is more concerned with lengthening or doubling of a consonant other than syllabification. Using the term 'ambisyllabicity' to refer to such the doubled consonants across syllables distorts the fact that an ambisyllabic consonant underlyingly corresponds to a single phoneme.

Geminates, alternatively known as *long consonants*, exhibit a phonological contrast with singletons, or short consonants. Phonetic opposition between the two primarily manifests as a durational distinction, where geminates are produced with greater acoustic length than their singleton counterparts (Dmitrieva, 2012, p. 7). In light of prior literature, geminates are 1.5 to 3 times longer in duration than singletons in careful speech (Ladefoged & Maddieson, 1996). Besides, the ratio of singleton to geminate ranges from 1 to 1.4 in English and from 1 to 2.29 in Turkish, as reported from a cross-linguistic survey conducted by Delattre (1971) and Ham (2001).

Furthermore, geminates may be referred to as *double consonants*, a term more associated with the orthographic convention of employing two identical consonantal graphemes to indicate lengthening of the consonant in question (Dmitrieva, 2012, p. 7). The transcription of a geminate has also been a long-standing subject of debate. The discourse revolves around opposing perspectives on whether a geminate consonant is conceived as a single prolonged consonant /C:/ or a doubled consonant /CC/. This dichotomy yields two divergent syllabic structures of a geminate consonant as either a heterosyllabic geminate /C.C/, or an initial- or final-tautosyllabic geminate /C:/ (Di Benedetto et al., 2021).

Geminates are also phonologically discussed as to whether they are underlyingly or derived geminates (Kubozono, 2017). This leads to the traditional classification of geminates into 'true' and 'fake' geminates. 'Lexical' or 'underlying' geminates fall into the category of *true* geminates, as do 'assimilated' geminates, resulting from total assimilation in consonantal clusters. As their name suggests, geminates of this category are part of the phonemic inventory of a language and they are thus underlyingly geminate. The evidence for lexical geminates is derived from minimal pairs in which the substitution of a singleton with a geminate in certain words causes a change in meaning. Assimilated geminates refer to when one segment adopts the identity of the preceding or the following segment within the same word at a morpheme boundary. Fake geminates are, on the other hand, a sequence of two

identical consonants accidentally concatenated at a morpheme or a word boundary (Dmitrieva, 2012, 8; Oh, 2020).

All three types of geminates, namely 'underlying', 'concatenated' and 'assimilated', have been found in a language like Bengali, as exemplified in (11).

(11) a. Underlying: /pat̪t̪a/ [pat̪t̪a] "whereabouts"
b. Concatenated: /pat̪+t̪e/ [pat̪t̪e] "spread out" infinitive
c. Assimilated: /kor+t̪e/ [kot̪t̪e] "do" infinitive

(Lahiri & Hankamer, 1988)

Only few languages, e.g. *Italian*, *Polish* and *Finnish* exhibit a correspondence between grapheme and phoneme. That is, two identical adjacent letters indicate segmental lengthening. Geminates are phonemic in these languages, and the consonants in question are underlyingly geminated. Examples of singleton – geminate minimal pairs in *Italian*, *Polish* and *Finnish* are provided (12) to (14), respectively.

(12) a. <sete> /sete/ 'thirst'
b. <sette> /sette/ 'seven'

Italian

(13) a. <saki> /saki/ 'sacks' or 'bags'
b. <ssaki> /sˑaki/ 'mammals'

Polish

(14) a. <taka> /tɑkɑ/ 'back'
b. <takka> /ˈtɑkkɑ/ 'fireplace'

Finnish

Lengthened consonants in English and Thai are never underlying geminates, in that they are not part of phonemic inventories and consonantal length never serves as a distinctive feature contrasting singletons with geminates.

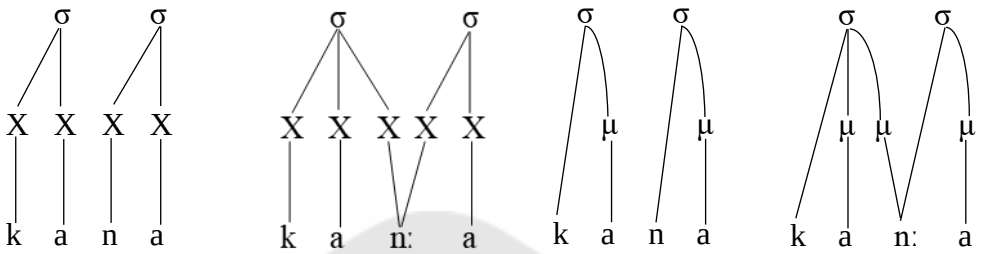
Orthographic geminates in English and Thai do not exhibit correspondence between graphemes and phonemes. As earlier discussed, gemination in Thai are constrained by *bimoraicity* and *onset obligatoriness* (Petkla, 2020). Therefore, intervocalic consonants, whether spelled with a singleton letter like <ค> in /bùk.kʰà.lík/ or a geminate letter as in <คค> /bùk.kʰon/, are prone to undergo gemination to satisfy the aforementioned constraints.

Concerning English, according to Hughes and Trudgill (1979), intervocalic consonants produced by speakers in Pontypridd, South Wales, may be geminated when preceded by stressed vowels, as in 'city' [ˈsɪtti], where the underlying phoneme /t/ phonetically surfaces as a geminate /tt/. Welsh speakers may variably produce the intervocalic /p t k m/ in post-stress positions as geminates (Koch, 1989). Different lengths of consonants in actual production are considered different realizations of the same phoneme (Bassetti, 2017). The consonantal lengthening varies depending on individual speakers' speech style and accent. Consequently, I postulate that geminates produced in English are all fake ones, albeit Tumtavitikul (1998) claimed the existence of three types of geminates in English: underlying, concatenated and assimilated geminates.

The durational lengths of geminates and ambisyllabic consonants can be captured utilizing the aforementioned skeletal and moraic models, where timing units and units of weight are encoded by X-slots on the X-tier in the former and by morae on the moraic tier in the latter. The distinction between the two models lies in how singletons and geminates are associated with timing units or morae. In the skeletal X-slot representation, singletons are linked to a single X-slot, while geminates are associated with two, as depicted in (15a) and (15b). On the other hand, singletons are not associated with morae or being non-moraic, whereas geminates are monomoraic in

the moraic representation, as in (15c) and (15d) (Gordon, 2006; Gussenhoven & Jacobs, 2017; Kotzor et al., 2017).

(15) a. /kana/ ‘blind’ b. /kanːa/ ‘tears’ c. /kana/ ‘blind’ d. /kanːa/ ‘tears’



(Kotzor et al., 2017)

Borowsky et al. (1984) suggested that ambisyllabicity could be construed as a special case of gemination. Furthermore, pursuant to van der Hulst (as cited in Gussenhoven & Jacobs, 2017, p. 143), languages do not distinguish ambisyllabicity from gemination in terms of weight. Reverting to moraicity, it is established that short vowels and coda consonants are assigned one mora each, whereas long vowels and diphthongs are assigned two morae. Hence, an ambisyllabic consonant such as [t̲] in *city* and a geminate consonant like /tː/ in Italian /ˈfatːo/ ‘fact’ may be identically represented in the moraic model, as in (16).

(16) a. English [ˈsɪtɪ] ‘city’ b. Italian /ˈfatːo/ ‘fact’

(Gussenhoven, 1986, 143)

Contrary to Bird (2002, 283), gemination and ambisyllabicity are said to be in complementary distribution, maintaining that a single language never has both gemination and ambisyllabicity. Further, geminate and ambisyllabic consonants diverge

from one another in four aspects. Firstly, geminates exhibit phonetic elongation in duration (Borowsky et al., 1984; Jensen, 2000), while ambisyllabic consonants are articulated roughly at the same length as singletons. Secondly, geminates are moraic with their length indicated by a measure of syllabic weight, represented by 'μ' (Hayes, 1989), whereas ambisyllabic consonants are nonmoraic. Thirdly, ambisyllabicity is induced by prosodic features such as stress; gemination is not prosodically initiated. Finally, geminates and their singleton counterparts are contrastive, whereas ambisyllabic segments do not contrast with non-ambisyllabic counterparts. Following McCully (2009), Yavas (2011) and Lee and Seo (2019), an ambisyllabic consonant can be distinguished from a geminate consonant in terms of quantity using the skeletal X-slot representation, as shown in (17a) and (17b).

(17) a. English [ˈsɪti] 'city' b. Italian /ˈfat:o/ 'fact'

(Lee & Seo, 2019; McCully, 2009, 104; Tanaka, 2017)

Objectives of the Study

The ultimate goal of this dissertation is to investigate whether orthographic forms, stress and consonantal manners influence Thai L2 English learners' syllabification and production of intervocalic consonants orthographically represented as singletons and geminates. The objectives can be narrowed down as follows:

1. To account for how Thai learners of English placed at different English proficiency levels syllabify intervocalic consonants orthographically alternating between geminate and singleton graphemes, and phonetically alternating between pre-stress and post-stress positions.

2. To analyze the acoustic durations of intervocalic obstruents and sonorants with two alternating orthographic forms: singleton and geminate graphemes, and with two alternating stress-related contexts: pre-stress and post-stress positions.

Statement of Hypotheses

The hypotheses formulated in this dissertation are as follows:

1. Thai L2 speakers of English exhibit reliance on orthographic forms for syllabification of intervocalic consonants orthographically represented with geminate and singleton graphemes; speakers at lower proficiency levels show a stronger reliance than those at higher levels.

2. Thai L2 speakers of English produce intervocalic consonants with geminate graphemes longer in duration than those with singleton graphemes; the durational ratios of intervocalic consonants with orthographic singletons to those with orthographic geminates obtained from Thai speakers are greater than those garnered from the NES participants.

3. Syllabification and production of intervocalic consonants by Thai L2 speakers of English at higher proficiency levels align more closely with those by native English speakers, compared to those at lower levels.

Scope of the Study

Stimuli

This dissertation centers on 'word-internal fake geminate', a term that differs in interpretation from Oh and Redford (2012). In their work, this term is defined as a sequence of two identical consonants across a morpheme boundary, as in 'u*nn*amed', whereas a word like 'pa*pp*a', the intervocalic /pp/ is treated as a true geminate.

However, 'word-internal fake geminate' in this present study is confined to an intervocalic consonant being lengthened at the phonetic level within a lexical boundary, as in 'city' /ˈsɪti/, where the underlying phoneme /t/ phonetically surfaces as [tt], and it is hence a fake geminate, not an underlying one.

Since independent variables include orthographic forms, stress placement and consonantal types, the stimuli are constructed with a total of 64 authentic English words, the first half of which are employed in the syllabification experiment and the other half of which are utilized in the production experiment. The target words contain any of the 8 intervocalic consonants, split up into four obstruents, i.e., /p/, /t/, /f/, /s/ and four sonorants, i.e., /m/, /n/, /l/, /r/[1]. Each consonant is conditioned to occur in four different contexts where the target intervocalic consonants can orthographically alternate between singleton and geminate graphemes, and phonetically alternate their occurrences in post-stress with pre-stress positions as follows:

a. $V_{[+stress]}CV_{/-stress]}$: post-stress orthographic singleton

b. $V_{[+stress]}CCV_{/-stress]}$: post-stress orthographic geminate

c. $V_{[-stress]}CV_{/+stress]}$: pre-stress orthographic singleton

d. $V_{[-stress]}CCV_{/+stress]}$: pre-stress orthographic geminate

Concatenated and assimilated geminates are ruled out from this present study, in that, the 8 intervocalic consonants across morpheme and word boundaries with specified orthographic forms and phonetic contexts are not available.

Sampling groups

Participants are split up into two primary groups as follows:

1. Experimental groups: 60 native Thai speakers of English as a second or a foreign language, classified into three groups based on their English CEFR proficiency levels, namely A1, A2 and B1 levels, each consisting of twenty participants.

2. Control group: four native American English speakers, two males, and two females.

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[1] The grounds that voiced obstruents were excluded from the stimuli are authentic English words with intervocalic voiced obstruents orthographically represented as geminates and singletons, especially <vv> and <v>, <zz> and <z>, <g> and <gg>, are scarce or even unavailable. Although words such as 'sávvy', 'dévil', revíve exist, a word with <vv> in pre-stress position does not. Similarly, words such as 'fúzzy', 'lízard' exist but their counterparts in pre-stress positions do not. Furthermore, although words such as 'Mégan', 'lúggage' and 'lagóon' exist, a word with <gg> in pre-stress position does not. Some of these examples are also words of low frequency.

Definition of Terms

1. Orthographic form: The manner in which words are spelled or the arrangement of letters of a word in a written language. It should be noted that the word 'orthography' is also equivalently used to refer to 'orthographic form' in this dissertation.

2. Stress: In English, stress may be lexical stress which refers to 'prominence' consisting of *loudness*, *length* and *pitch*, assigned to a particular syllable within a word. These auditory aspects acoustically correspond to *intensity*, *duration* and *fundamental frequency* (F_0). Additionally, it is referred to as 'accent', which is more concerned with prominence assigned to a particular syllable within a phrase or sentence. The latter kind of stress is also known as 'tonic stress' or 'nuclear stress', involving a change in pitch in an intonational phrase or tone unit.

3. Consonantal manners: Commonly known as 'consonantal types', encompassing consonantal phonemes from different manners of articulation. The consonantal stimuli selected for this present study consist of *stops* and *fricatives* from a larger consonantal category of *obstruents*, and *nasals* and *liquids* from that of *sonorants*. *Obstruents* and *sonorants* are major consonantal classifications. It is noteworthy that while *nasals* and *liquids* fall under the same category of sonorants, *liquids* in addition to *vowels* and *glides*, according to Hayes (2009), are grouped as a natural class, designated with the feature [+approx], to the exclusion of *nasals*. Consequently, in this dissertation, the liquids /r/ and /l/ are henceforth preferably termed as 'approximants' to differentiate them from nasals in terms of sonority and to avoid the fact that the category of liquid consonants may also encompass the *alveolar trills* found in languages like Thai and Spanish.

4. Syllabification: The division of words into phonological units, known as syllables. In this dissertation, syllabification principles adopted for the analysis include *MOP*, *WSP* and *heterosyllabic gemination*, where intervocalic consonants syllabified based on MOP has a syllabification template of [V.CV], those syllabified in compliance with WSP has that of [VC.V] and those heterosyllabically geminated has that of [VC.CV].

5. Acoustic duration: The length of time that a sound or speech segment lasts in terms of its duration. In acoustic phonetics, duration is used to measure the length of vowels, consonants, or entire syllables by examining waveforms in relation to spectrograms displayed in the software 'Praat' (Boersma & Weenink, 2021).

6. Intervocalic consonant: A consonant that occurs between two vowels within words, as in 'better' /ˈbɛtər/ and 'atomic' /əˈtɔmɪk/, where the phoneme /t/ appears intervocalically in a post-stress position for the former but in a pre-stress for the latter.

7. Geminate:

7.1 Geminate consonants are also known as *long* or *double* consonants produced with longer acoustic duration than their singleton counterparts, or *short* consonants. Geminates were reported to be produced 1.5 to 3 times longer than their singletons (Ladefoged & Maddieson, 1996). In geminate languages like *Italian, Polish, Finish, Japanese, Bengali*, geminates phonemically contrast with their singleton counterparts.

On the other hand, the segments are identified as geminates in English when they are perceived at least one and a half time longer than their singletons. Gemination in English occurs at a phonetic level, depending on speakers' accent and speech style, regardless of their orthographic forms, e.g. the word 'city' [ˈsɪttɪ] where the underlying /t/ surfaces as the geminate [tt].

7.2 Geminate grapheme refers to a sequence of two identical consonantal letters, e.g. <pp> in 'pepper'. In some languages such as *Italian*, *Polish* and *Finnish*, doubled letters indicate gemination or segmental lengthening. Nonetheless, in English, geminate graphemes do not indicate consonantal elongation and, when preceded by stressed lax vowel and followed by unstressed one, they are postulated to be produced as ambisyllabic consonants whose durational ratios to their non-ambisyllabic consonants or singletons are not as great as those of geminates to singletons. In this dissertation, the terms 'geminate letters', 'doubled consonantal letters' and 'orthographic geminates' are used interchangeably with 'geminate graphemes'.

8. Singleton:

8.1 Singleton consonant refers to, in this dissertation, a single consonantal phoneme, particularly when flanked by vowels. Irrespective of orthography, the orthographic <pp> in the word 'happy' is, albeit, said to be spelled with a geminate grapheme, it is considered a singleton consonantal phoneme /p/ at the underlying level.

8.2 Singleton grapheme is a single consonantal letter in the intervocalic position, for example the letter <t> in the word 'atom'. 'Single/singleton letter' and 'orthographic singleton' are also interchangeably used with 'singleton grapheme'. In contrast, the <tt> in 'letter' is considered a geminate grapheme, although it is normally produced by NESs at a length roughly equivalent to that of a singleton phoneme.

9. Heterosyllabic gemination: A linguistic phenomenon where a single consonant is repeated or doubled in pronunciation across two syllables within the same word. Correspondingly to mental representation of syllabification, the consonant in question is dually associated with the coda of the preceding syllable and the onset of the subsequent one. To illustrate, the orthographic <tt> in the word 'bitter' is articulated twice across syllables as [ˈbɪt.tər]; this kind of gemination is, thus, deemed 'heterosyllabic', rather than 'tautosyllabic', as not lengthened within the same syllable. This kind of syllabification was previously termed *ambisyllabicity* in the studies by Ishikawa (2002), Eddington and Elzinga (2008) and Eddington et al. (2013); however, it is referred to, in this dissertation, as *heterosyllabic gemination*, in that using the term 'ambisyllabicity' to indicate the consonant doubly produced across syllables plausibly distorts the fact that an ambisyllabic consonant, while dually affiliated to both the preceding coda and the following onset, singly corresponds to one underlying phoneme.

10. Ambisyllabic consonant: An intervocalic consonant is termed ambisyllabic when preceded by stressed lax vowel and followed by unstressed one, formalized in this research as $ˈV_{[lax]}\underline{C}V_{[tense]}$. The segment is allowed to serve simultaneously as the coda of the preceding syllable and the onset of the subsequent one. For instance, the

intervocalic /t/ in the word 'letter' /ˈlɛt̲ər/ is deemed *ambisyllabic* due to its dual association with the preceding coda and the following onset.

Conceptual Framework

The conceptual framework in this study is formulated as a cause-effect relationship between independent variables, i.e., orthography, stress and consonantal manners, and dependent variables, i.e., syllabification and production of intervocalic consonants, as illustrated by Figure 1.

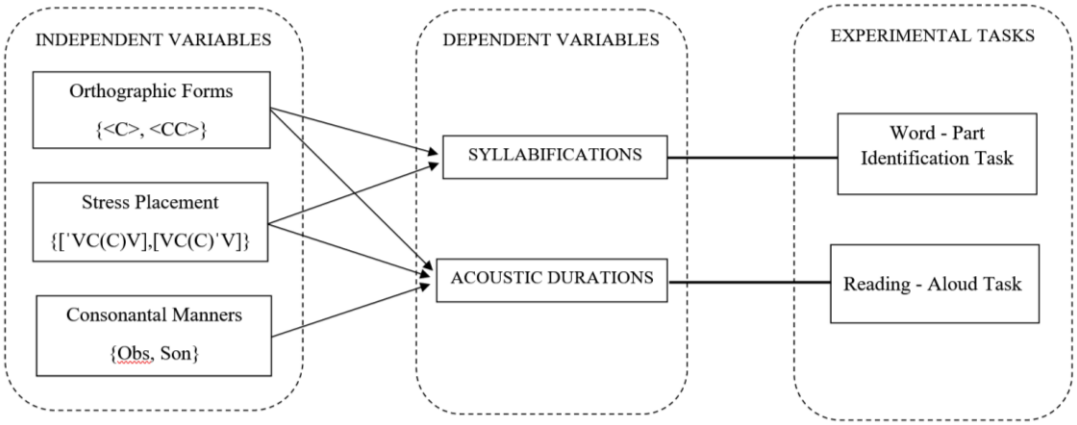


Figure 1 Conceptual Framework

Significance of the Study

This dissertation holds significant implications for enhancing our understanding of the interplay of orthographic forms, stress, consonantal manners in syllabification and production of intervocalic consonants in Thai L2 English speakers. The findings of this study contribute to both theoretical and practical aspects of second language acquisition, acoustic analysis and pedagogy.

Theoretical Implications:

1. By investigating the orthographic influence and stress on syllabification. The findings shed light on how Thai L2 speakers of English, at varied proficiency levels, navigate the orthographic intricacies in their speech production. Their reliance on orthographic forms for the syllabification of English intervocalic consonants, regardless

of lexical stress placement, underlines the influence of L1 phonology on that of the target language.

2. The examination of the durational ratios of intervocalic consonants with orthographic singletons to those with orthographic geminates contributes to a deeper understanding of L2 speech production, on which language proficiency play a role, in comparison with that of native English speakers regarding the temporal aspects of speech.

3. The investigation into how syllabification and production align with native English patterns contributes to our comprehension of the developmental stages of second language acquisition, in that this study explores whether higher proficiency levels lead to a convergence with native-like patterns, offering valuable insights into the dynamic nature of language acquisition.

Practical Implications:

1. The identification of potential differences in reliance on orthographic forms at different proficiency levels can inform language teaching strategies. Educators may tailor their approaches to address specific challenges encountered by learners in integrating orthography into their pronunciation practice.

2. Understanding the differences in durational patterns between geminate and singleton consonants in Thai L2 speakers allows for more targeted curriculum design. Educational materials can be developed to address specific phonetic challenges faced by learners, promoting more accurate and natural-sounding speech.

3. Insights into the alignment of syllabification and production with native patterns can guide the development of interventions for learners at different proficiency levels. Tailored support and targeted exercises may accelerate the process of achieving native-like speech patterns.

This study, therefore, not only advances theoretical understanding of the interaction of orthography, stress and consonantal manners with syllabification and production in second language acquisition but also provides practical implications for

educators, curriculum designers, and language learners, contributing to the enhancement of English language teaching methodologies.

Outline of the Dissertation

This dissertation is organized as follows: Chapter two provides further elucidation on the internal structure of the syllable in §1, compares English and Thai syllabic structures in §2, explores relevant principles on English syllabification in §3, and delves into the discussion of geminates based on skeletal and moraic representations in §4. Section 5 discusses English stress and intonation, while §6 focuses on the discussion of Thai stress and tones. In §7, the acquisition of L2 phonology and optimality-theoretic approach are presented. Intelligibility and comprehensibility are discussed in §8.

Chapter three outlines the research methodology, encompassing participants of the study in §1, and test materials and procedures in §2. The latter is divided into two subsections: the first of which elucidates stimuli and procedures on syllabification experiment, and the other delineates those on production experiment.

Chapter four reports the findings, where §1 reveals the results obtained from syllabification experiment and §2 presents the results from the production experiment.

Chapter five is dedicated to a summary of the study, discussion of the findings from syllabification and production experiments, and limitations of the current study and recommendations for future research.

CHAPTER 2
REVIEW OF THE LITERATURE

This chapter is segmented into seven sections. The initial section serves to introduce the internal structure of the syllable. The second section provides a comparison between English and Thai syllabic structures, whereas the third section delves into the discussion about key principles associated with English syllabification. The fourth section addresses the representations of ambisyllabic and geminate consonants. English stress and intonation are set out in §5 while stress and tone in Thai are elaborated in §6. Section 7 is dedicated to the acquisition of L2 phonology, wherein an optimality theoretic approach is also discussed. Finally, L2 pronunciation is discussed within the frameworks of intelligibility and comprehensibility in §8 as the emergence of English as a global language.

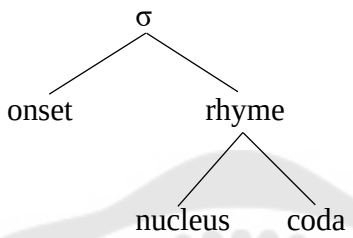
1. The Constituents within the Syllable

The syllable is a phonological unit that lies in the mental representation of a speaker. Numerous attempts have been made to provide a consensus on the definition of the syllable, drawing from both phonetic and phonological perspectives. Nonetheless, many linguists accept that phonetic definition of syllable is notoriously difficult albeit current phonetic experiments can offer compelling evidence for syllabification by examining at the relative duration of stop closures in V-Stop-V sequences. Doing this way, the entity of the syllable can be acoustically described with reference to speech timing. Still, since segmental length varies across contexts, for instance, vowels are shortened in closed syllables and are longer in open syllables, single acoustic cue for syllabification is known not to be robust across contexts. Consequently, linguists have opted for phonological models utilizing hierarchical representation to substantiate evidence for syllable structure (Anderson & Robert, 1994).

The hierarchical structure of the syllable provides a strong evidence that segments are organized into phonological constituents in the same way as words are organized into syntactic constituents (Carr, 2013). The two main constituents within the

syllable are ‘onset’ and ‘rhyme’. The rhyme is the intermediate constituent which is in turn broken down into the ‘nucleus’ and the ‘coda’. The universal syllable structure shared by all the world’s languages can be hierarchically represented as in (18) (Gut, 2009, p. 75).

(18)



The positions of the onset and the coda are generally said to be occupied by consonants. Therefore, consonants are said to be peripheral or marginal. On the other hand, the nucleus is said to be central and, in almost all cases, taken by a vowel.

There is strong evidence for the division between the onset and the rhyme constituents. Firstly, the elements in the rhyme, i.e., the nucleus and the coda, provides the potential for words to rhyme; hence the term ‘rhyme’ in poetry. Two words, such as ‘hitch’ /h<ɪʧ>/ and ‘pitch’ /p<ɪʧ>/, are said to rhyme with one another when they have identical rhymes but different onsets (Collins & Mees, 2013, p. 77; McCully, 2009, p. 77).

Another piece of evidence for such the division is the device of alliteration which depends solely on the identity of the onsets, independently of the content of the rhyme, e.g., ‘little’ /ˈ<l>ɪtəl/ and ‘light’ /<l>aɪt/, ‘poor’ /<p>ʊr/ and ‘packed’ /<p>æk/.

In addition, the type of slips of the tongue, known as ‘spoonerism’, named after an academic called ‘Spooner’, who is said to accidentally pronounce the sentence ‘you have missed my history lecture’ as ‘you have hissed my mystery lecture’, also bears the evidence that the onset is a real unit in speech production (Carr, 2013, p. 54).

Syllable structure may be described in terms of sonority. The *Sonority Sequencing Principle* (SSP), also known as *Sonority Sequencing Generalization* (SSG) was proposed for explaining how onset and coda consonants are patterned apart from

the phonotactics of a language (e.g. Clements, 1990b; Goldsmith, 2011; Murray & Vennemann, 1983; Vennemann, 1972).

The notion of sonority emerges from auditory phonetics and refers to the overall loudness of a sound relative to others of the same pitch, stress and duration (Crystal, 2008). In this view, each sound segment is said to have inherent sonority. The two factors that determine how sonorous a sound is are the degree of openness of the vocal tract during the production of a sound and voicing. Openness equates with sonority; that is, the more open in the vocal tract during the production of the sound, the more sonorous the sound in question. With this in mind, the vocal tract during the articulation of vowels is generally more open than that during the articulation of consonants and all vowels are also voiced; therefore, vowels are ranked above consonants in sonority hierarch. Sonorants, as involving less degree of obstruction, are more sonorous than obstruents (Carr, 2008). As voicing also plays a role in determining the sonority value of a sound, voiced obstruents are more sonorous than their voiceless counterparts (Collins & Mees, 2013, pp. 80-81; Gussenhoven & Jacobs, 2017, pp. 127-128; Zec, 2007).

Furthermore, Hayes (2009, p. 79) also employ the feature [±approximate] to distinguish between all steps on the sonority hierarchy. According to this classification, vowels, glides and liquids, to the exclusion of nasals and obstruents, are grouped together as a natural class. The sonority hierarchy of different classes of sounds can be depicted as in figure 2.

Most sonorous ◄ ——————————————————— Lest sonorous

Vowels	Glides	Liquids	Nasals	Vd. Obstruents	Vl. Obstruents
[+syllabic]	[-syllabic]				
[-consonantal]		[+consonantal]			
[+approximant]			[-approximant]		
[+sonorant]				[-sonorant]	

Figure 2 Sonority Hierarchy

By virtue of sonority hierarchy, sound segments in syllables are consistently patterned according to the SSP. The principle states that the syllable centers upon the most sonorous element, called the peak, usually corresponding to a vowel, and a sequence of consonants in the onset and in the coda rises in sonority from the margins towards the peak (Hooper, 1976; Kiparsky, 1979, 1981a; Selkirk, 1984a), as exemplified by the word 'grant' in figure 3.

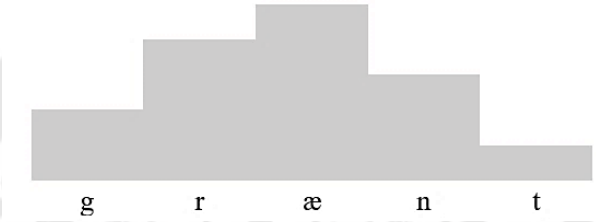


Figure 3 Syllable structure of 'grant' based on SSP

As per Vaux and Wolfe (2009), the process of syllabification universally adheres to the *Sonority Sequencing Principle* (SSP), dictating that the segments in a syllable rise in sonority from the margin to the peak. Segments that cannot be accommodated within syllabic boundaries according to this principle are said to remain *extrasyllabic*.

To illustrate, let me take for example the words 'capsule', 'lips' and 'stop'. In 'capsule', the sonority of the sound segments in both syllables conform to the SSP, and the syllable division between its first and second syllables can be clearly determined as /ˈkæp.səl/. In the first syllable, the sonority rises from the consonant /k/ at the left margin towards the peak, which is the vowel /æ/, and it decreases from the peak towards the consonant /p/ at the right margin. This also holds true for the sound segments in the second syllable. Figure 4 exhibits syllable structures of the word 'capsule' in which two peaks represent two syllables.

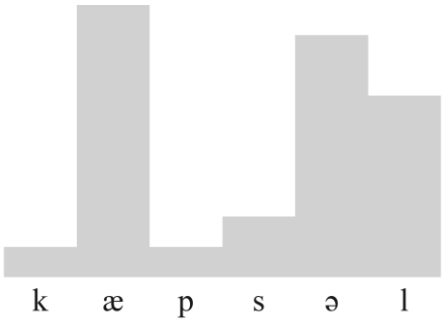


Figure 4 Syllable structure of the word ‘capsule’ based on SSP

Based on SSP, the number of sonority peaks in polysyllabic words is assumed to tally with the number of syllables. However, when it comes to words such as ‘stop’ and ‘lips’, the principle fails to elucidate why the phonetic peak formed by the word-initial consonant /s/ in ‘stop’ and by the word-final /s/ in ‘lips’ is not treated as a syllable.

In the word ‘stop’, the inherent sonority value of the voiceless fricative /s/ appearing at the leftmost margin is greater in sonority value than that of the sound /t/ which is closer to the peak, resulting in a deformed pattern of syllable structure according to SSP, as illustrated in figure 5.

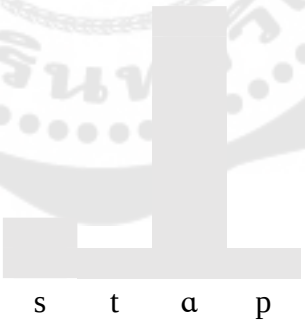


Figure 5 Syllable structure of the word ‘stop’ based on SSP

In ‘lips’, the sonority of the voiceless fricative /s/ at the rightmost margin is greater than that of its preceding voiceless stop /t/ which is closer to the peak, as shown in figure 6.

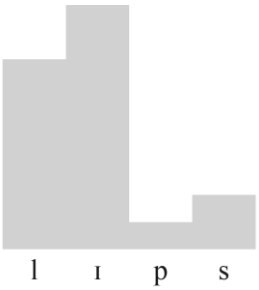


Figure 6 Syllable structure of the word 'lips' based on SSP

From the above figures, such initial-word /s/ in 'stop', and likewise, the word-final /s/ in 'lips', which cannot be legitimately grouped into a syllable are said to remain extrasyllabic.

2. English and Thai Syllabic Structures

English and Thai syllable structures differ greatly in their complexity. Thai syllabic structure can be represented as $C(C)V(V)^{T}(C)$, where the superscripted T denotes tone, and Thai tones are obligatory for Thai syllables (Jangjamras, 2011, 60). In contrast, English has a more intricate syllable structure, represented as (C)(C)(C)V(V)(C)(C)(C)(C) (Hammond, 1999, 37). It is important to note that an onset is obligatory in Thai but it is optional in English (Petkla, 2020, 16). Only nucleus is deemed compulsory for English syllables (Collins & Mees, 2013, 77; Gut, 2009, 76). That is, all English syllables must have a least a nucleus, whereas the onset and the coda are optional. Obligatoriness of the nucleus is evident in monosyllabic words containing only a single vowel, e.g. the article 'a' /ə/ or /eɪ/ pronounced in strong form, the word 'eye' /aɪ/ and the word 'owe' /oʊ/.

In Thai, the onset may consist of a single consonant or a consonant cluster. Consonants which are permitted to occur in the onset in Thai embrace /p/, /p^h/, /t/, /t^h/, /tɕ/, /$tɕ^h$/, /k/, /k^h/, /b/, /d/, /m/, /n/, /ŋ/, /f/, /s/, /h/, /r/, /l/, /w/, /j/. On the other hand, an onset cluster may begin with either one of the aspirate or unaspirated voiceless stops /p/, /p^h/, /t/, /t^h/, /k/, /k^h/, followed by lateral approximant /l/, the trill /r/ or the bilabial glide /w/. In English, it should be noted that /ŋ/ never occur in onset and /ʒ/ may be,

albeit, found to occur syllable-initially as in the word ‘genre’; initial-syllable /ʒ/ is undoubtedly scarce. English onset may consist up to three consonants, where the first consonant in a triconsonantal cluster can be only voiceless fricative /s/. For a biconsonantal cluster, English permits combinations of voiceless stops /p/, /t/, /k/ with approximants /l/, /r/ or glides /w/, /j/ (Gut, 2009, 78; Jangjamras, 2011, 60; Yavas, 2011, 139-146).

In Thai, the nucleus is exclusively occupied by vowels, whereas certain vowel-like consonants in English may serve as the nucleus, as seen in ‘captain’ /ˈkæptn̩/ (McCully, 2009, 101). Only long vowels and diphthongs are permitted to constitute the nucleus of an open syllable in Thai, as Thai monosyllabic words are required to be bimoraic, with short vowels confined to closed syllables. Likewise, a lax vowel is not allowed to conclude a monosyllabic English word to satisfy the bimoraic minimum. All stressed English monosyllables require a tense vowel, a diphthong, or a lax vowel followed by a syllable coda (Hammond, 1999; Morén & Zsiga, 2001; Petkla, 2020).

Thai permits only a single coda, which may consist of voiceless unaspirated stops /p/, /t/ /k/; nasals /m/, /n/, /ŋ/; or approximants /w/, /j/ (Jangjamras, 2011, 60-61; Petkla, 2020, 16). In English, a single coda cannot be /j/, /w/ and /h/. Nevertheless, complex codas are permitted in English, with a maximum of four consonants including inflectional suffixes, as in /tɛksts/ ‘text’ and /æŋsts/ ‘angsts’ (Collins & Mees, 2013, 78-79; Yavas, 2011, 145).

2.1 Underlying and Surface Thai Syllable Structures

The existence of underlying CV-syllables in Thai is a subject of controversy. Gandour (1974) argues against the presence of underlying CV-syllables in Thai, primarily based on the arguments as to whether the epenthetic glottal stop is a surface and an underlying form. Nonetheless, Tumtavitikul (1998) contends that underlying CV-syllables do exist in Thai. Surface CVʔ-syllables, in fact, stem from underlying /CV/ where the final glottal stop is derived from a glottal epenthesis.

(19) Glottal Stop Epenthesis

$\emptyset \rightarrow$ ʔ / CV__]$_{\sigma}$

CV-syllables may manifest as surface syllables, stemming from unstressed CVʔ surface syllables undergoing vowel reduction. The deletion of a final glottal stop is postulated to precede tone neutralization, as demonstrated in (20).

(20) a. CVʔ surface syllable: [rat.tʰàʔ.baːn]
b. Glottal stop elision: [rat.tʰà.baːn]
c. Tone neutralization: [rat.tʰa.baːn]

(adapted from Tumtavitikul, 1998)

3. English Syllabification Principles

Syllabification is language-specific and every language has its own principles of syllabification (Hayes, 2009, p. 251). In English syllabification, key principles that play an integral role encompass: the MOP (e.g. Clements & Keyser, 1983; Kahn, 1976; Pulgram, 1970), ambisyllabification (Kahn, 1976), resyllabification (Selkirk, 1982), and the WSP (Duanmu, 2000; Hammond, 1999; Kager, 1989; Murray & Vennemann, 1983; Prince, 1990).

3.1 Maximal Onset Principle (MOP)

The MOP adhered to by phonologists, such as Pulgram (1970), Kahn (1976) and Clements and Keyser (1983). The principle requires that intervocalic consonants shall be maximally assigned to the onset rather than the coda provided no violation incurred against the phonotactic constraints of a language. Examples of English words syllabified according to MOP are provided in (21).

(21) a. /ˈsɪŋ.ər/ ‘singer’
b. /ˈæt.ləs/ ‘atlas’
c. /ˈtaɪ.ni/ ‘tiny’
d. /ˈlɛ.mən/ ‘lemon’
e. /ˈkæ.nə.də/ ‘Canada’

(Duanmu, 2008, p. 57)

In (21a), the velar nasal /ŋ/ is not syllabified as the onset because its occurrence is restricted to syllable-final position. The voiceless stop /t/ in (21b) is not syllabified to the onset of the second syllable, in that, the cluster */tl/ is prohibited. In (21d) and (21e), although the intervocalic /m/ and /n/ respectively may form permissible onsets of the second syllables in the words, the vowels /ɛ/ and /æ/ distributed at the syllabic margins render the first syllables in the words ill-formed. In English, stressed open syllables are not permitted to end in lax vowels, i.e., /ɪ, ɛ, æ, ʌ, ɒ, ʊ/ (Roach, 2009, pp. 60-62).

By this principle, a sequence of consonants in two separate words may, however, yield different syllabifications. Take the sequence of medial consonants /mp/ in the words *empty* and *comprise* as examples. The corresponding syllabifications for the words can be transcribed as /ˈɛmp.ti/ and /kəm.ˈpraɪz/, respectively.

To satisfy the MOP, the /mp/ sequence shall be assigned to the onset; nonetheless, such combination of consonants in the onset is not permitted by the phonotactics of the language in question. In the word *empty,* a string of /mpt/ never occurs syllable-initially, so does a string of /pt/. The /t/ is then left to constitute the onset of the preceding syllable, whereas a string of /mp/ can be legally assigned to the coda without violating the phonotactic constraints. In the word *comprise*, a string of /mpr/ is deemed an ill-formed onset, but voiceless stop /p/ are permitted to combine with the approximant /r/ to form a maximal onset. The sound /m/ is, therefore, abandoned alone to occupy the coda of the first syllable. The MOP is treated as a fundamental universal principle, in that onsets are cross-linguistically more prevalent in the majority of the world's languages than codas, and CV syllables are more common than VC syllables (Lin, 2011).

3.2 Ambisyllabification

Kahn (1976), also other linguists such as Gussenhoven (1986), proposed the notion of ambisyllabicity. Duanmu (2010, as cited in Lee & Seo, 2019) suggested that the WSP (discussed in section 3.4) can be applied to ambisyllabicity. That is, only heavy syllables are eligible to bear stress.

It is important to note that the MOP is treated as a persistent principle and additional syllabifications must adhere to this existing syllabification (Duanmu, 2008; Gussenhoven & Jacobs, 2017; Hayes, 2009). In this regard, an intervocalic consonant such as /t/ in the word *letter* is initially syllabified as an onset to satisfy the MOP, resulting in syllabification as [ˈlɛ.tər]. Nevertheless, such syllable concluding with a stressed lax vowel like *[ˈlɛ_]$_{\sigma}$ is deemed ill-formed, in that every individual syllable of a polysyllabic word is expected to pattern a legitimate monosyllable. All monosyllables which are postulated to be stressed never conclude with a lax vowel. English lax vowels include /ɪ/, /ɛ/, /æ/, /ʊ/, /ʌ/, /ɒ/ , /ɔ/, /ɑ/ or, to be more precise, the lax vowels plus /ɔ/ and /ɑ/ (Roach, 2009).

It is claimed by Eddington et al. (2013) that syllabification may be linked to word-likeness in which lax vowels, to the exclusion of schwa /ə/, never occur word-finally. Consequently, an intervocalic consonant is created ambisyllabic segment dually affiliated with both the coda of the preceding syllable and to the onset of the subsequent one.

Hayes (2009) proposed two types of ambisyllabification, the first of which applies word-internally when the following vowel is stressless, as illustrated in (22a), while the other applies across word boundaries, as shown in (22b).

(22) a. ‘letter’ [ˈlɛt.tɚ] b. ‘get it’ [ˈgɛt.təd]

Pursuant to Gussenhoven and Jacobs (2017, p. 142), the first type of ambisyllabification is called *liaison* which applies across word boundaries so as to cause a word-final consonant to be affiliated with the onset of a subsequent vowel-initial word, as seen in (22b). The other rule creating ambisyllabic consonants is known as

‘right capture’. The first consonant in the onset of the following unstressed syllable spreads its association with the coda of the preceding stressed one, as in (22a).

It should be noted that ‘right capture’ rule applies within the domain of foot, formulated by Gussenhoven (1986). The English foot is *trochaic*, also known as ‘head-initial’ or ‘left-dominant’, in which weak syllables typically center upon /ə/, /ɪ/, /ʊ/ or, especially word-finally, /i/, /oʊ/. As a result of 19(b), the intervocalic /t/ in a word like ‘petrol’, as previously seen in 18(b) will simultaneously be the final consonant of the first syllable and the initial consonant of the second. Ambisyllabicity differs from geminate, e.g., [ss] in [ˈðɪs sup] ‘this soup’ and [tt] in [ˈðæt taɪm] ‘that time’. Geminate consonants are counted as two identical sounds, one in each syllable, and so neither part is ambisyllabic (Duanmu, 2008, p. 9).

Examples of words whose intervocalic consonants serve as ambisyllabic segments, indicated by underlining, are provided in (23). In (23a), the rule applies after an open syllable, in (23b) and (23c), it applies after a closed syllable, while (16d) shows that the left-hand syllable may be unstressed.

(23) a. /ˈsɪt̲i/ ‘city’

b. /ˈkɑn̲sərt/ ‘concert’

c. /ˈkʌn̲tri/ ‘country’

d. /əˈspɛr̲əg̲əs/ ‘asparagus’

(Gussenhoven & Jacobs, 2017, p. 143)

As pointed out by Kahn (1976), syllabification can account for allophonic rules, such as ‘aspiration’ and ‘American English flapping’. His analysis of the word ‘potato’ is presented in (24) where C̲ refers to an ambisyllabic consonant.

(24) a. [pə.ˈtɛː.toʊ] MOP

b. [pə.ˈtɛːtoʊ] Ambisyllabicity rule

c. [pʰə.ˈtʰɛːroʊ] Aspiration and flapping

(Duanmu, 2008, p. 60)

From (24), it is important to take notice that ambisyllabicity is a post-MOP rule, and the syllabification is thus based on MOP. However, since, the second /t/ precedes the unstressed vowel, the ambisyllabicity is then applied to it. The voiceless alveolar stop is aspirated when it begins a syllable, and it is flapped when ambisyllabified, as seen in (24c).

3.3 Resyllabification

Akin to ambisyllabicity, Selkirk (1982) posited *resyllabification* predicated upon the grounds that syllables terminated by a stressed lax vowel were deemed an ill-formed structure. While ambisyllabification requires an intervocalic consonant to be dually associated with the coda and the onset, Selkirk came up with an additional post-MOP rule specifying that intervocalic consonants in the onset are resyllabified to the coda of the preceding stressed syllable.

Selkirk maintains that resyllabification surpasses Kahn's ambisyllabicity, substantiating such claim through the analysis of syllabification for the word *after* with which Kahn's analysis faces a problem. Kahn's analysis yields syllabification for the word as [æf.tər], where [t] begins the second syllable, albeit, without aspiration. Resyllabification, according to Selkirk, adeptly maintains that, since a sequence of /ft/ is impermissible to commence the syllable, the [f] is thus syllabified to the coda of the preceding syllable. Additionally, under the influence of stress on the first syllable, the intervocalic [t] gravitates towards resyllabification into the coda of the preceding stressed syllable. A comparative illustration of Kahn's ambisyllabification (1976) and Selkirk's resyllabification (1982) is illustrated in (25).

(25) a. Ambisyllabification b. Resyllabification

(Suh, 2001)

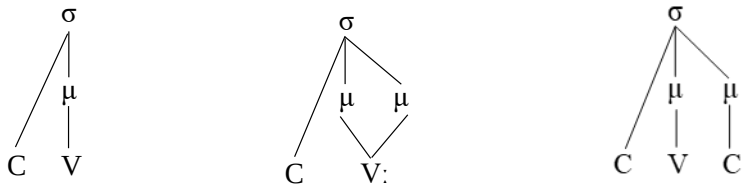
3.4 Weight-to-Stress Principle (WSP)

Stress in languages such as English is said to be sensitive to weight. Units of the syllable weight are represented by morae 'μ'. According to Gordon (2006), units of weight can also be represented by skeletal slots, including CV-slots and X-slots, in which segmental length or segmental quantity are encoded (Gussenhoven & Jacobs, 2017).

The Weight-to-Stress Principle was proposed by many linguists, such as Selkirk (1982), Kager (1989), Prince (1990), Hammond (1999) and Duanmu (2000). It postulates that stressed syllables must be heavy and unstressed syllables must be light.

Heavy and light syllables can be differentiated by a count of weight units or morae which are assigned merely to the segments within the rhyme to the exclusion of the segments in the onset. Therefore, vowels and coda consonants are said to be moraic, whereas onset consonants are non-moraic. In this regard, short vowels and coda consonants in a rhyme are assigned one mora, while long vowels, including diphthongs, are assigned two. Syllables that are bimoraic, that is to say, containing at least two moras, are judged to be heavy. English syllables classified according to moraicity into *light open*, *heavy open* and *heavy closed syllables*, as seen in (8) are repeated as (26) (Davis, 2011; Gordon, 2006; Gussenhoven & Jacobs, 2017; Zec, 2007).

(26) a. Light open syllable b. Heavy open syllable c. Heavy closed syllable



(Zec, 2007)

The WSP stipulates that stress exclusively falls on heavy syllables. Light syllables are precluded from bearing stress. English falls into the category of stress-timed languages, and its isochrony is manifested in prosodic structure. In other words, stressed syllables occur roughly at regular intervals within an utterance, albeit, with some syllables intervening between them. Examples of syllabification for English words according to WPS are provided in (27).

(27) a. /ˈsɪt.i/ 'city'
b. /ə.ˈtæk/ 'attack'
c. /ˈkæn.ə.də/ 'Canada'
d. /ˈkoʊ.lə/ 'cola'
e. /ˈwɪs.pər/ 'whisper'

(Duanmu, 2008, p. 59)

3.5 Previous Studies on English Syllabification

Numerous studies have been carried out to examine English syllabification, manipulating a range of psychological experimental tasks. Derwing (1992) utilized a *pause-break task*, wherein participants were instructed to insert a pause between syllables in production of disyllabic words. Responses such as lem-PAUSE-mon, where the intervocalic /m/ was pronounced twice, were counted as ambisyllabic segment.

In the research conducted by Treiman and Danis (1988), a *syllable reversal task* was employed to scrutinize syllabification of disyllabic English words. Participants

were directed to interchange the first syllable with the second, yielding responses like *monlem*, *monle* and *onlem*. The response with /m/ occurring twice was classified as an ambisyllabic consonant.

Furthermore, the *syllable doubling task* was reported to be used in the work by Fallow (1981). Participants were asked to repeat the first syllable of a disyllabic word twice, for instance, the first syllable of the word 'lemon' was pronounced twice as either *le-lemon* or *lem-lemon*, or repeat the second syllable, for example, the second syllable of lemon was produced twice as either *lemon-mon* or *lemon-on*. The results revealed that ambisyllabicity accounted for approximately 22% of all the responses gathered.

In contrast to the above studies whose emphasis is solely placed upon oral syllabification, Ishikawa (2002) incorporated both oral and written tasks to investigate Japanese learners of English' syllabification of English disyllables and nonwords with single intervocalic consonants. The findings revealed the preference for the MOP with the syllabification template of CV.CVC over the WSP with the template of CVC.VC and ambisyllabification with the template represented as CVC.CVC.

Elzinga and Eddington (2014) conducted a study based on the word division experiment. The data collection involved an online questionnaire where respondents were prompted to identify the first part of a disyllabic word in one item and the second part in another. The findings indicated that only 16.7% of the responses were ambisyllabic.

4. Geminates: Skeletal and Moraic Representations

4.1 Cross-Linguistic Geminates and Classifications

Geminates, also referred to as *long consonants*, phonologically contrast with their singletons or short consonants. Phonetically, the duration of geminates acoustically longer than their singleton counterparts. Articulatorily, geminates are produced with longer constriction duration than singletons (Carr, 2008; Dmitrieva, 2012). Cross-linguistically, it is crucial to note that the actual degree of consonantal lengthening varies from one language to another and depends on the distribution of geminates in a

syllable and in a word, the phonetic context where they occur and the types of geminate consonants (Dmitrieva, 2017; Ladefoged & Maddieson, 1996).

Geminates are traditionally represented by two identical consonantal graphemes. They are, therefore, also known as *double consonants*. However, this definition of geminates is more closely associated with their orthographic forms which normally indicate segmental length in some languages, such as Italian whose geminate-singleton minimal pair is exemplified in (28).

(28) a. <sete> /sete/ “thirst”

b. <sette> /sette/ “seven”

(Dmitrieva, 2012, p. 7)

The distribution of geminates in a word across languages includes ‘word-initial’, ‘word-medial’ and ‘word-final’ positions. Nonetheless, intervocalic geminates are more common than word-edge (i.e. word-initial and word-final) geminates. Word-initial geminates are said to be rare. Due to the diversities of geminates in terms of distribution, representation and derivation, transcription for geminates is also controversial. Geminate consonants may be, by and large, transcribed either as /CC/ or /C꞉/ albeit, according to Crystal (2008), /C꞉-/ or /-C꞉/ is used to represent a long consonant in the syllable-initial and syllable-final position respectively, whereas, /CC/ is employed to indicate a geminate across a syllable boundary. On the other hand, as pointed out by Blevins (2005), the IPA employs the symbol /C꞉/ other than /CC/ for geminate transcription. In light of previous literature, following Crystal (2008), I use /CC/ to represent geminates that occur across a syllable boundary and /C꞉/ to represent those that occur syllable-initially or syllable-finally. The transcriptions are enclosed by slant lines instead of square brackets when representing true lexical geminates that contrast with their singleton counterparts in the phonemic inventory of a language.

The contexts where geminates occur refer to their positions of occurrence in relation to stress, that is whether geminates occur in a pre-stress or a post-stress

position. It was reported that geminates gravitate towards stress-adjacent, especially a post-stress position. Types of geminate consonants (or consonantal quality) also affects lengthening in geminates. In addition, geminate obstruents are more common that geminate sonorants (Dmitrieva, 2012 & 2017). Ladefoged and Maddieson (1996) reported that geminate stops can be between one and a half to three times longer than their singletons in careful speech.

Geminates can be broadly classified into two types: *true* and *fake* geminates. True geminates, also known as 'lexical' or 'underlying' geminates. The consonantal lengthening occurs underlyingly, and geminate consonants are thus part of phonemic inventory. In languages with true geminates, a minimal pair of words containing geminate and singleton consonant is generally available, as previously seen in (17). Assimilated geminates are also classified as true geminates, referring to one segment adopting the identity of the preceding or the following segment within the same word at a morpheme boundary.

Fake geminates are a type of concatenated geminates, resulting from assimilation of identical consonants across a morphemic boundary. Three types of geminates are found in a language like Bengali, as previously seen in (11), repeated below as (29).

(29)

a. Underlying:	/pat̪t̪a/	[pat̪t̪a]	"whereabouts"
b. Concatenated:	/pat̪+t̪e/	[pat̪t̪e]	"spread out" infinitive
c. Assimilated:	/kor+t̪e/	[kot̪t̪e]	"do" infinitive

(Lahiri and Hankamer, 1988, as cited in Dmitrieva, 2012, p. 8)

True lexical geminates in very few languages, not to mention Italian, Polish and Finnish, exhibit phoneme-grapheme correspondence, that is, the two identical adjacent letters indicate segmental lengthening or gemination. Geminates are phonemic in these languages and the consonants in question are underlyingly geminate.

Singleton-geminate minimal pairs in *Italian*, *Polish* and *Finnish*, previously exemplified in Chapter 1, are repeated here below:

(30)	a. <se**t**e>	/sete/	‘thirst’
	b. <se**tt**e>	/sette/	‘seven’

Italian

(31)	a. <saki>	/saki/	‘sacks’ or ‘bags’
	b. <ssaki>	/sːaki/	‘mammals’

Polish

(32)	a. <taka>	/tɑkɑ/	‘back’
	b. <takka>	/ˈtɑkkɑ/	‘fireplace’

Finnish

In Norwegian, although an orthographic geminate indicates consonantal lengthening, unlike those exemplified in (30) to (32), consonant and vowel length depend on each other. That is, long consonants only appear in the coda of a stressed syllable preceded by only a short vowel. On the other hand, long vowels can only be followed by a short consonant in a stressed syllable. This leads to the conclusion that vowel and following consonant duration are in complementary distribution for stressed syllables. Minimal pairs of such kind are exhibited in (33) (Elinor et al., 2017).

(33)	a.	hat	/haːt/	'hatred'
		hatt	/hatː/	'hat'
	b.	kube	/kuːbe/	'cube'
		kubbe	/kubːe/	'log'

Norwegian

Regardless of phoneme-grapheme correspondence, geminate consonants in Swiss German (Lara et al., 2017) are part of the phonemic inventory and they are, therefore, underlyingly geminate. Consonantal length in Korean (Oh, 2017) is said to be distinctive and the long consonants in question are cases of true geminates. Geminate-singleton minimal pairs in Swiss German and Korean are exhibited in (34) and (35).

(34) a. /vɑpə/ 'honeycomb'
b. /vɑppə/ 'coat of arms'

Swiss German

(35) a. /anɛ/ 'wife'
b. /annɛ/ 'guidance'

Korean

Japanese geminates are lexical and the opposition between singleton and geminate can be established though a difference in acoustic duration. Nonetheless, the contrast is limited to obstruents and nasals, as seen in (36) (Kawagoe, 2015).

(36) a. /kata/ 'frame'
/katta/ 'brought'
b. /iso/ 'shore'
/isso/ 'rather'
c. /kona/ 'powder'
/konna/ 'such'

Japanese

Moreover, according to Ruangjaroon (2020), it is also interesting to take notice that unaspirated oral stops geminated in a word-medial position may surface as

aspirated ones. Aspiration in Japanese is, nevertheless, not distinctive. Example (37) shows free variants of the unaspirated oral stops in a word-medial position.

(37) a. [khap.pa] [khaph.pha] ‘raincoat’

b. [khit.te] [khith.the] ‘stamp’

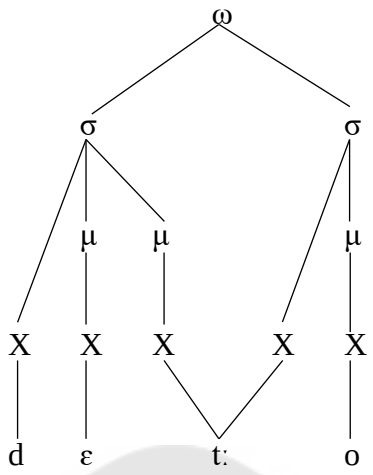
Japanese

4.2 Geminates in Phonology and Representations

In phonology, the topic of interest with regard to geminate consonants is mental representation. From a purely phonological point of view, geminates are truly long segments, not a series of two short segments (Trubetzkoy, 1939a). Hockket (1955), however, takes the opposite view, arguing that all geminates are sequences of two identical consonants.

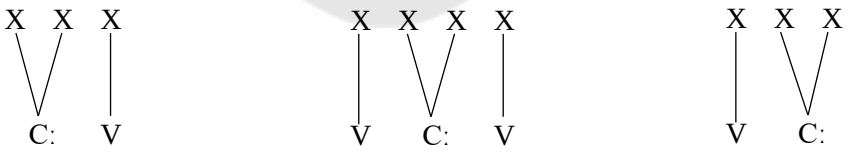
Two of the most prevalent approaches adopted to illustrate the representation of geminate consonants are the skeletal slot models, including CV-slot model developed by Clements and Keyser (1983) and X-slot model by Levin (1985), both which encodes the segmental length or segmental quantity through timing slots, and the moraic model, formulated by Hayes (1989) and then by Hyman (1985), which encodes segmental length through units of weight or moras. The discrepancy between the two models is geminates are monomoraic according to the moraic representation but they are associated with two timing slots in the skeletal-slot representation (Gordon, 2006; Gussenhoven & Jacobs, 2017; Kotzor et al., 2017). Following (Goldsmith, 2011), a mixed model, including both the skeletal X-slot tier, where a geminate in question is dually linked to two X-slots, and the moraic tier, where a geminate is monomoraic is illustrated by (38).

(38) ‘detto’



Each of the two models mentioned above has its own advantage over the other. By distribution, geminates can be classified into word-initial, word-medial or word-final geminates albeit the most common type was reported to be a word-medial or intervocalic geminate (Dmitrieva, 2017). In this regard, the skeletal-slot model is more consistent in representing geminates across three types. Non-medial geminates are not problematic for the skeletal-slot models because multiple linking does not directly involve prosodic structure (Ham, 2001). The autosegmental model (the X-slot in this example) provides the same dual linking representation for the word-initial, the word-medial and the word-final geminates, as diagrammatized (39).

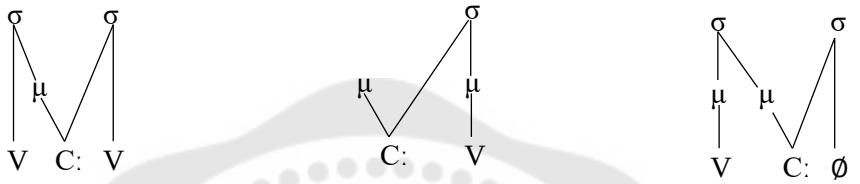
(39) a. initial b. medial c. final



However, non-medial geminates do cause a problem for the moraic model, in that the units of weight or moras are assigned solely to the segments within the rhyme to the exclusion of the onsets and moras are immediately associated with syllable nodes. The doubly linked representation in which tautosyllabic or intervocalic geminates serve as both weight-bearing coda and weightless onset applies only to medial-word

geminates, as seen (40a). Moraic model admits the presence of defective syllable structure consisting of only a mora at the left edge of the word for initial geminates, as demonstrated by (40b) or the syllable structure consisting of a mora with empty nucleus at the right edge for final geminates as illustrated in (40c) (Ham, 2001).

(40) a. medial b. initial c. final



4.3 Prior Studies on Gemination

Geminate studies have largely been carried out across different languages. The dissertation authored by Ham (2001) delved into the temporal properties of geminate consonants, examining the interplay between phonology and phonetics. The investigation encompasses Bernese, Levantine, Madurese and Hungarian. However, Ham's findings diverged from previous research suggesting that geminate stops are between one and a half to three times longer than their singleton counterparts in careful speech, contingent on the language in question (Ladefoged & Maddieson, 1996, 91-92). The present study, utilizing four languages as samples, indicated a less extensive range of durational differences. The overall singleton-to-geminate closure ratios, averaged across positions and speakers, were 1:1.43 for Bernese, 1:1.55 for Madurese, 1:1.93 for Levantine, and 1:2.16 for Hungarian.

Galea (2016) investigated syllable structure and gemination in Maltese. Previous claims about Maltese word-initial geminates posited the presence of the preceding epenthetic vowel [ɪ]. Through acoustic evidence derived from a series of production studies, it was demonstrated that this epenthesis occurs predominantly when the preceding word concludes with a consonant. In a perception experiment, it was revealed that native Maltese speakers exhibit insensitive to true word-initial geminates (#ss); they were unable to discern between true word-initial geminates [#ss_] and word-

initial singletons [#s_]. However, they were capable of distinguishing word-initial geminates preceded by the epenthetic vowel [#ɪss_] from word-initial singletons [#s_]. Nonetheless, it is arguable whether this vowel is part of the phonological representation of word-initial geminates. The vowel preceding word-medial geminates is shorter in duration than the vowel preceding word-medial singletons, demonstrating a correlation with gemination in production.

Dmitrieva (2012) explored the effects of phonetic environment (vocalic or consonantal), position within a word (medial, initial, final), stress-related positions (post-stress, pre-stress, not adjacent to stress) and the manner of articulation of geminates on the perception of the contrast between short and long consonants. The perceptual experiment, involving speakers of Russian, American English, and Italian, demonstrated that perception of the durational distinction was context-dependent. Perceptual contrast distinctiveness was higher for the consonants in the intervocalic position than for those in the preconsonantal environment, and also higher for the consonants in the word-initial position than for those in the word-final position. This study revealed that stress did not affect perception of consonant duration. Contrariwise, a survey of several languages for which a stress-geminacy relationship was reported showed a striking correlation between weight-sensitivity and tendency for gemination in the post-stress position.

The study, conducted by Thirakunkovit (2021), explored the production and perception of geminate consonants among Thai learners of English. Two tasks: reading aloud and dictation, were administered to 90 students across three levels of language proficiency, 15 Thai university instructors and eight native English speakers. Of the three types of geminates, i.e., lexical, assimilated and concatenated geminates, only the mean duration of lexical geminates exhibited statistical significance between groups. The mean duration produced by native speakers of English significantly differed from that of low and high intermediate students. While the mean durations obtained from a group of advanced students and that of English instructors did not significantly differ from that of native English speakers, the mean duration of these two groups surpassed that of native English speakers. Results from the reading aloud task has revealed the

effects of orthography on the L2 English pronunciation by native Thai speakers, with the mean length of the [p] sound in the word *floppy* being pronounced longer than that of the word *copy* across all groups of Thai learners.

4.4 Geminate Segmentation and Measurements

In this section, the segmentation and measurement of target consonants, based on the studies by Dmitrieva (2012) and Thirakunkovit (2021), are discussed. Their analyses involved utilizing by the speech analysis software Praat to examine the waveforms and the spectrograms.

4.4.1 Intervocalic voiceless stops

The length of intervocalic voiceless stops was determined by measuring the duration from the onset of the stop closure, displayed as a silent portion on the spectrogram, which coincided with the offset of the periodic signal of the preceding vowel to the point where periodic signal of the following vowel resumed. If there was a pause between the preceding and the following vowels, the duration was included in the measurement. The two figures below demonstrate how the geminate consonants were measured.

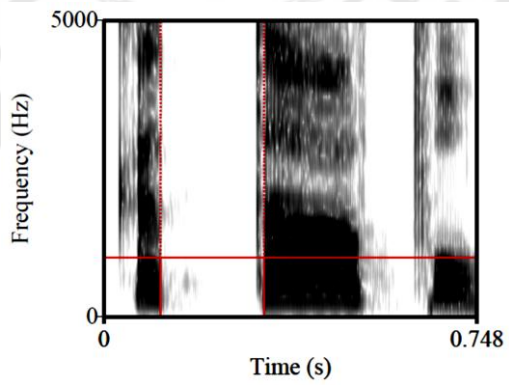


Figure 7 Segmentation for [tt] in *kóttapu*

Note. From Geminate Typology and the Perception of Consonant Duration by Olga Dmitrieva, 2012, 45.

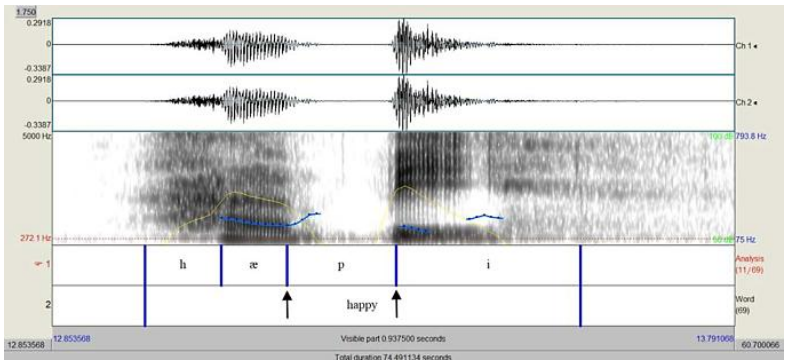


Figure 8 Waveform and Spectrogram Display for 'happy'

Note. From Production of Geminate Consonants by Thai Learners by Suthathip Thirakunkovit, 2019, Journal of Language and Culture, 39(1).

4.4.2 Intervocalic Voiceless Fricatives

The duration of the intervocalic voiceless fricatives is determined by measuring the time span from the onset of the aperiodic noise characterized by a pronounced high frequency component to the onset of the periodic vowel signal.

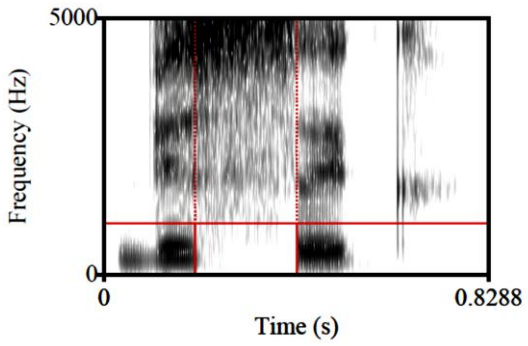


Figure 9 Segmentation for [ss] in *bissík*

Note. From Geminate Typology and the Perception of Consonant Duration by Olga Dmitrieva, 2012, 46.

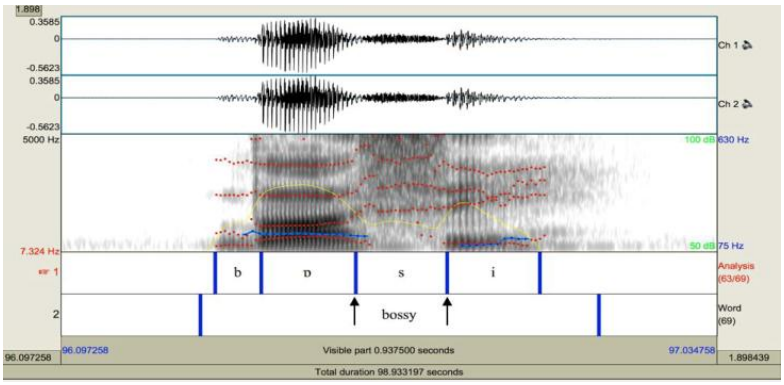


Figure 10 Waveform and Spectrogram Display for 'bossy'

Note. From Production of Geminate Consonants by Thai Learners by Suthathip Thirakunkovit, 2019, Journal of Language and Culture, 39(1).

4.4.3 Intervocalic Nasals

For intervocalic nasals, the measurement can be identified as a portion between two points marked by a sudden drop in intensity signal, characterized by the presence of antiformants, corresponding to white horizontal bands on the spectrogram, as illustrated in figure 18. These spectrographic events were also accompanied by a change in the amplitude and the shape of the waveforms.

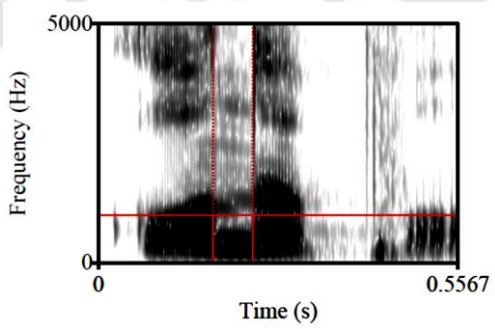


Figure 11 Segmentation for [n] in *kónapu*

Note. From Geminate Typology and the Perception of Consonant Duration by Olga Dmitrieva, 2012, 47.

4.4.4 Intervocalic Approximants

The duration of intervocalic approximants was assessed by isolating a segment of the signal characterized by abrupt changes in waveform frequency, shape, and amplitude, coinciding with a decrease in signal intensity and less visible formant structure, as in figure 19. Additionally, the onset of the lateral approximants was also marked by a pronounced drop in the frequency of the first formant.

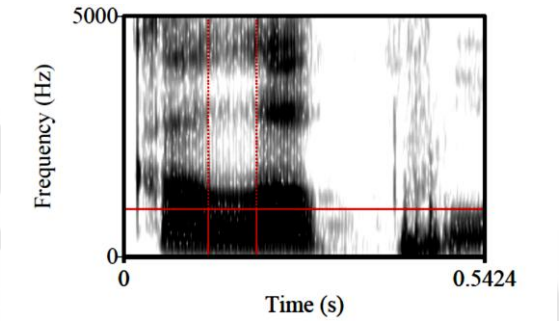


Figure 12 Segmentation for [l] in *kolapú*

Note. From Geminate Typology and the Perception of Consonant Duration by Olga Dmitrieva, 2012, 48.

5. English Stress and Intonation

5.1 Lexical Stress

English is an intonational language, as opposed to Thai which falls under the category of tonal languages, with two levels of stress: 'lexical' and 'sentential' stress. Lexical stress, or commonly referred to as 'word stress', is described as the relative prominence of a certain syllable in comparison to other neighboring syllables in a word (Jaiprasong, 2019; Jangjamras, 2011, 51; Ladefoged & Keith, 2015).

From the speaker's perspective, a stressed syllable is produced by expending a greater amount of muscular effort, while from the perceptual perspective, the prominence of stress is realized through a range of phonetic properties, such as loudness, duration, and pitch. Stressed syllables are usually louder than unstressed ones and may exhibit a higher or lower pitch. In addition, stressed syllables may be

pronounced longer, and variations in place or manner of articulation may occur. In particular, unstressed vowels may display a more central or neutral articulation, whereas those in stressed ones adopt a more peripheral articulation. Acoustic correlates of stress manifest in 'duration', 'intensity', 'fundamental frequency' and 'formant structure', perceptually corresponding to 'duration', 'loudness', 'pitch' and 'vowel quality', respectively (Jangjamras, 2011, p. 74; Jung & Rhee, 2018; Roach, 2009; Yavas, 2011, p. 156).

The terms 'stress' and 'accent' for some scholars, e.g. Carr (2008), may be synonymously used, albeit for other scholars, such as Cruttenden (1986) and Crystal (2008), the two terms are distinguished by relating prominence of 'stress' to increases in duration and loudness but not always to pitch, whereas 'accent' is more associated with an increase in pitch, hence termed 'pitch accent'. In addition, Gut (2009, p. 86) further specifies that 'stress' is an abstract property of a syllable and part of a linguistic knowledge of a speaker while 'accent' refers to a measurable physical or acoustic entity. In contrast, as per Jaiprasong (2019, 23), *accent* is associated with speakers' linguistic knowledge and the placement of stress at a phrase or sentence level, being part of prosody alongside rhythm and intonation (Roach, 2009, p. 119).

Lexical stress in English may be classified according to whether it is phonemic or non-phonemic. Stress in English, along with languages like German, Dutch, and Italian, is phonemic and its location is not entirely predictable. Phonemic stress is lexical, stored as one of the properties in a lexical item; the acquisition of phonemic stress can be executed through memorization as part of the pronunciation of an individual lexical item.

Since lexical stress in English is phonemic, it may indicate the syntactic category of words (Ladefoged & Keith, 2015, p. 120), as in (41), where disyllabic homographs syntactically serve as a noun when stressed on the penultimate syllable, and as a verb when on the ultimate syllable.

(41)

	Noun	Verb
a. record	/ˈrɛkərd/	/rɪˈkɔrd/
b. produce	/ˈprɑdjus/	/prəˈdjus/
c. protest	/ˈproʊtɛst/	/prəˈtɛst/

Moreover, it is important to note that lexical stress in English is phonemically contrastive. Minimal pairs involving some noun-verb homographs, as indicated by minimal placements of stress, allow for distinctions not only in terms of lexical category but also in semantics, as exemplified in (42).

(42)

a. 'desert'	/ˈdɛzərt/	(n.)	'land covered by sand with little water'
	/dɪˈzɜrt/	(v.)	'to abandon'
b. 'present'	/ˈprɛzənt/	(n.)	'thing given as a gift'
	/prɪˈzɛnt/	(v.)	'to show to somebody to consider'
c. 'object'	/ˈɑbdʒɪkt/	(n.)	'things that are physically visible and touchable'
	/əbˈdʒɛkt/	(v.)	'to disagree using words'

Lexical stress is typically cateorized into primary stress and secondary stress with some approaches proposing additional levels of stress like 'tertiary stress', which is, however, found, to be difficult to distinguish from the secondary stress in terms of perception (Gut, 2009, p. 90; Roach, 2009, p. 75). In disyllabic words, one syllable is generally assigned primary stress while the other remains unstressed. Nonetheless, some disyllabic words may have one syllable assigned primary stress and the other secondary stress, e.g. 'ozone' /ˈoʊˌzoʊn/, 'tempo' /ˈtɛmˌpoʊ/ and 'elbow' /ˈɛlˌboʊ/.

In polysyllabic words, primary stress, secondary stress and unstressed syllables are usually present. In this regard, the primary stress is said to be a tonic stress, as in the word 'explanation' /ˌɛkspləˈneɪʃən/, where the third syllable carries primary stress, the first one carries secondary stress and the rest are unstressed syllables with the schwa (Ladefoged & Keith, 2015, p. 123).

As earlier stated, the location of stress in several English words is unpredictable and variable, English stress is fixed for individual word which may be termed *lexically designated stress* (Collins & Mees, 2013, p. 131). Example (43) exemplifies this variability with the location of lexical stress on the antepenultimate syllable in (43a), on the penultimate syllable in (43b), and on the ultimate syllable in (43c) (Yavas, 2011, p. 156). This variability in stress placement adds to the richness and complexity of English prosody.

(43) a. Antepenultimate: 'article' /ˈɑrtəkəl/
b. Penultimate: 'tomato' /təˈmeɪˌtoʊ/
c. Ultimate: 'Korea' /kəˈrɪə/

Although the location of English lexical stress is predominantly unpredictable, it is not entirely unsystematic. Stress assignment rules formulated through generalizations about certain factors that come into play with the stress placement, including the weight of a syllable, the etymology of a word, morphological structure of a word and syntactic category that a word belongs to (Gut, 2009, p. 90 ; Jangjamras, 2011).

As exemplified in (41) and (42), generalizations about stress patterns in nouns and verbs are disyllabic nouns tend to carry stress on the penultimate syllable and verbs are more likely to bear stress on the ultimate syllable (Yavas, 2011).

With respect to the etymological factor, words of Germanic origin, which are the most frequently used words in English, have the stress on the first syllable regardless of any affixes attached to the root. This yields a trochaic stress pattern or strong-weak rhythmic pattern (Jangjamras, 2011). On the other hand, words of Latin origin are said to involve more complicated rules for stress. That is, the placement of stress depends on the number of syllables in the word, the parts of speech, the moraic structure of the rhyme constituent and the type of affixes attached to the root. Words of French origin borrowed into English preserve the original placement of stress on the final

syllable (Wennerstrom, 2001). Further details on stress placement rules can be explored in works authored by such as Collins and Mees (2013, pp. 128-135), Roach (2009, pp. 73-87), Gut (2009, pp. 89-93), Yavas (2011, pp. 156-169) and Jaiprasong (2019, pp. 26-30).

5.2 Prosodic Stress and Intonation

5.2.1 Tonic Stress and Functions of Intonation

Sentence stress, or prosodic stress, denotes the emphasis placed on a specific syllable or a monosyllabic word within phrases or sentences. Unlike lexical stress, which correlates with intensity and duration but optionally pitch, sentence stress can be primarily observed through pitch, acoustically signified by a change in F0 or fundamental frequency (Jangjamras, 2011). Therefore, a stressed syllable or monosyllabic word at a phrase or sentence level is said to be *accented*, hence the term 'pitch accent'. Prosodically, accent constitutes one of three components, alongside rhythm and intonation (Jaiprasong, 2019, p. 23).

Accent is a form of stress referred to as 'tonic stress', 'tonic accent' or 'nuclear stress', which is part of intonation involving rising and falling tones in an utterance (Gut, 2009; Ladefoged & Keith, 2015, pp. 121-122; Roach, 2009, p. 130). Syllables carrying tonic stress exhibit a major pitch change or movement within an intonational phrase or a tone unit. While lexical stress operates independently of intonation, the placement of tonic stress serves various functions of intonations, including attitudinal, accentual, and grammatical or discourse functions (Roach, 2009, p. 153).

Regarding attitudinal function, the falling intonational contour, symbolized by (\ ), suggests finality of the utterance, as in (44a). The rising and falling intonation, indicated by (∧), denotes uncertainty and doubt, as in (44b). The falling and rising intonation, represented by (∨), shows a feeling of surprise, as in (44c).

(44) a. That's the end of the \ news.

b. You ∨ may be right.

c. ∧ All of them.

Sentence stress is also used pragmatically to emphasize particular words or ideas, altering or clarifying the sentence meaning. The location of sentential stress, as opposed to lexical stress, varies in its position to deliver an emphatic function to a certain word (Jangjamras, 2011). Commonly, the placement of tonic stress is on the last content word, or the stressed syllable of the last polysyllabic word, in the intonational unit, as in (45a). Nonetheless, other words may be assigned tonic stress to draw attention to special emphasis, as in (45b) to (45d) (Roach, 2009, p. 153).

(45) a. Peter didn't study \linguistics.

b. \Peter didn't study linguistics.

c. Peter \didn't study linguistics.

d. Peter didn't \study linguistics.

In (45a), the focus is on what Peter studied in the past. It was something else other than linguistics. In sentence (45b), 'Peter' is emphasized to assert that it was Peter, not someone else, among a certain group of students who did not study linguistics. The sentence (45c) might be said to correct someone else's assertion that Peter used to study linguistics. The sentence (45d) might suggest that what Peter did was just sitting in on linguistics class or teaching linguistics.

The placement of tonic stress also serves grammatical or discourse functions. Basically, statements have a falling tone, whereas YES/NO questions have a rising tone, as seen in (46a) and (46b), respectively. Note that WH-question is marked by a falling tone, as (46b). In addition, grammatical function of intonation can indicate the listing of items with a rising tone for a non-final item in the list and a falling tone for a final one, as in (46d).

(46) a. The price is \going up.

b. Did you buy the /car?

c. Where did you park the \car?

d. I bought / a tee-shirt, /a skirt and a \handbag.

(Roach, 2009, pp. 146-159)

5.2.2 Rhythmic Structure

In the domain of rhythm, the English stress is treated as a unit of rhythm comprising a sequence of alternating strong and weak syllables. Thus, sentence stress may also be known as a *rhythmic stress*. According to rhythmic typology, languages can be classified as stressed-timed, syllable-timed, or mora-timed (Nespor et al., 2011). English falls into the category of stress-timed languages, wherein stressed syllables occur at approximately regular intervals, regardless of the number of intervening unstressed syllables, as exemplified in (47).

(47)

Walk	down	the	path	to	the	end	of	the	canal
ˈwɔlk	ˈdaʊn	ðə	ˈpæθ	tə	ðɪ	ˈɛnd	əv	ðə	kəˈnæl

(Roach, 2009, 107)

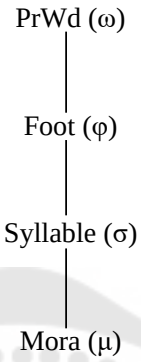
In contrast, languages like Spanish are syllable-timed, with each syllable in an utterance occurring at roughly regular intervals, whereas Japanese is an example of mora-timed languages, whose syllables or morae maintain at a constant rate, regardless of stress (Nespor et al., 2011).

5.2.3 Metrical Structure

Metrical phonology treats stress as a *metrical structure* or a *foot structure*, represented using a metrical tree (Gussenhoven & Jacobs, 2017, p. 174; Liberman & Prince, 1977; Vergnaud & Halle, 1978) or more recently known as a *metrical grid* (Hayes, 1995; Selkirk, 1978). Rhythmic patterns varies among languages based on

the foot formation at the level above the syllable and below the prosodic word (PrWd) in the prosodic hierarchy (Selkirk, 1986), as illustrated by (48).

(48)



According to Carr (2013), the stress pattern for English disyllables in most varieties of English is fundamentally trochaic. A trochee is a kind of foot with a sequence of a stressed syllable followed by an unstressed syllable, forming a rhythmic structure alternating *strong* and *weak* syllables. The stressed syllable is called the *head* in metrical structure, and English assign stress to the left-edge of the foot. The trochaic foot is, thus, known as *head-initial, left-headed* or *left-dominant* (Gussenhoven & Jacobs, 2017; Kager, 2007). The analysis of stress pattern using the metrical grid approach is shown in (49).

(49)

						level
				x		ω
(x		x		x	)	φ
(x	x)	(x	x)	(x	x)	σ
ˌæ.	pə.	ˌlæ.	tʃɪ.	ˈkoʊ.	lə	

(Kager, 2007)

6. Thai Stress and Tones

6.1 Lexical Tones

While English is an intonational language with lexical stress as a contrastive feature, Thai is a tonal language with lexical tones, causing a semantic change of words. Thai lexical tones consist of three levels and two contour tones (Nacaskul, 2013). The level tones consist of mid (ˉ), low (ˋ), and high (ˊ) tones, whereas the contour tones are falling (ˆ) and rising (ˇ) tones, as shown in (50).

(50)

Mid	/k^{h}āː/	‘to be stuck’
Low	/k^{h}àː/	‘galangal’
Falling	/k^{h}âː/	‘to kill’
High	/k^{h}áː/	‘to trade’
Rising	/k^{h}ǎː/	‘leg’

(Jangjamras, 2011, p. 61; Petkla, 2020, p. 17)

The distribution of lexical tones in Thai is influenced by syllable structure (Morén & Zsiga, 2006; Nacaskul, 2013); that is, not every syllable can bear all five tones. Only open syllables with a long vowel (CV:) or a syllable closed by a sonorant consonant (CVS and CV:S) can bear all five tones, as in /phɛː/ ‘raft’, /tàm/ ‘low’, /khâːw/ ‘rice’, /wún/ ‘jelly’, /fǎj/ ‘mole’.

On the other hand, open syllables with a long vowel or diphthong followed by an obstruent are permitted to bear solely low and falling tones, as in /mùak/ ‘hat’, /bìːp/ ‘to squeeze’, /mîːt/ ‘knife’, and /lûat/ ‘wire’. Closed syllables with a short vowel followed by a final obstruent are permissibly assigned solely low and high tones, as in /pìt/ ‘to close’, /hàk/ ‘to be broken’, and /kít/ ‘to think’.

(Petkla, 2020, p. 17)

6.2 Prosodic Stress

In the rhythmic domain, English and Thai fall into the same category of stress-timed languages (Ruangjaroon, 2020) where stresses fall at approximately regular intervals of time within an utterance; nonetheless, the two languages exhibit different stress patterns in metrical structure. While English stress pattern is trochaic or head-initial, Thai stress pattern is fundamentally iambic or phrase-final (Jaiprasong, 2019; Jangjamras, 2011).

Thai is designated as a fixed-accent language, in which content words are accented and grammatical words are unaccented. The primary accent in polysyllabic Thai words consistently falls on the last syllable, whereas the placement of the secondary accent is rule governed (Luksaneeyanawin, 1983, 1998). According to Luksaneeyanawin (1983, p. 75), the term 'accent' is employed to refer to the potentiality of syllable(s) in a word to be realized with stress either when uttered in isolation or discourse.

The majority of monosyllabic Thai words are of native origin, and a number of polysyllabic words were borrowed from languages, such as Khmer, Pali, Sanskrit and English. Stress placement rules in polysyllabic words are more complicated as a result of secondary stress. According to Luksaneeyanawin (1983), Thai distinguishes two types of syllables: *linker* and *non-linker* syllables. Linker syllables are those that center upon the short vowel /a/ with epenthetic final glottal stop; all other types of syllables are non-linker.

An alternative analysis of Thai stress assignment in polysyllabic words can be performed utilizing a metrical foot framework. Bennett (1995) proposed that Thai prosodic structure is right-headed, consisting of two prominence levels, i.e., stressed and unstressed. The right-edge of a prosodic word must not be a light syllable. Thai permits light syllables to be included in polysyllabic words without being footed, and it allows prosodic words to include more than one foot, as illustrated below.

(51) level

				x	ω
(	x			x)	φ
(x	x)	x	(x	x)	σ
ma.	nút.	sa.	ja.	tɕʰon	

(Jangjamras, 2011, 64)

The duration of vowels in Thai is influenced by stress. According to Luksaneeyanawin (1998), an accented syllable with a long vowel is consistently realized as a notably prolonged stressed syllable, in contrast to an unaccented syllable with a long vowel, which is consistently manifested as a comparatively shorter unstressed syllable (Luksaneeyanawin, 1998). In Thai, there is no equivalent to the English mid central unstressed vowel or schwa; hence, the absence of stress doesn't impact vowel quality. However, unstressed vowels in Thai exhibit reduced length (Luangthongkum, 1977).

Revert to (19), there are underlying Thai CV-syllables; however, they surface as CVʔ-syllables when uttered in isolative speech manner albeit they are considered 'light' due to their underlying form. Unstressed syllables in Thai are said to be affected by glottal stop elision if not word-final, accompanied by tone neutralization in which high and low tone become neutralized. Example (20) is reiterated below as (52).

(52) a. CVʔ surface syllable: [rat.tʰàʔ.baːn]

b. Glottal stop elision: [rat.tʰà.baːn]

c. Tone neutralization: [rat.tʰa.baːn]

(adapted from Tumtavitikul, 1998)

7. Acquisition of L2 Phonology and Optimality-Theoretic Approach

The acquisition of a native language during childhood typically outpaces that of a target language in later developmental stages of acquisition. Child learners consistently attain full proficiency in their mother tongue by engaging innate language

acquisition mechanism, proposed by Chomsky (1965) as *Language Acquisition Device* (LAD) or *Universal Grammar* (UG), whereas adult learners rarely achieve full proficiency in a target language solely through their general cognitive faculties, such as their learning aptitude and problem-solving abilities. This discrepancy is conceptualized as "the fundamental difference hypothesis" by Bley-Vroman (1988). Nonetheless, current psychological and linguistic literature maintains that child learners' L1 and adult learners' L2 acquisition is heavily influenced by cognitive capabilities applied to environmental and experiential inputs (Croft & Cruse, 2004; Tomasello, 2003).

Young children demonstrate enhanced facility in acquiring certain skills in contrast to older individuals, encompassing spatial perception (vision), manual dexterity, locomotion, and language. These abilities are naturally acquired during early childhood but challengingly during adolescence or adulthood. This phenomenon implicates brain maturation, and the corresponding SLA framework called *Critical Period Hypothesis* (CPH), initially developed by Lenneberg (1967), posits that language acquisition is most successful when initiated by the age of two years and concludes around puberty. The decline in capacity to acquire a native language during puberty is attributed to the cessation of neural plasticity, signifying the completion of hemispheric lateralization in the human brain. Pronunciation is most influenced by age effects, compared to other linguistic skills, due to its physiological basis and the demands of neuromuscular programming (Pennington & Rogerson-Revell, 2019).

There is individual variation in L2 phonological acquisition, in that some adult learners approach native-like pronunciation while some children are rated as less nativelike. There were also instances where adult learners who began learning a language later in life could attain a level of proficiency comparable to that of native speakers. Moreover, some adult learners who passed the age onset of acquisition could approach nativelikeness. This leads to the question of what factors contribute to the ability of some learners to excel in accent acquisition while others struggle. Copious studies regarding age effects on accent acquisition addressed other variables that affect the degree of nativelike pronunciation, including L1 phonological structure,

amount of L2 use (Flege et al., 1999), target language input (J. & Liu, 2001), instruction/training, residency in the L2 environment (Flege et al., 1977), aptitude for oral mimicry (Moyer, 1999), attitude (Moyer, 1999, 2004).

Numerous theoretical approaches and models which have been adopted to account for relative level of ease and difficulty in L2 phonological acquisition, as well as the relative accuracy or nativeness of L2 speech, encompass language transfer, Contrastive Analysis (CA), Interlanguage (IL), Markedness, L2 speech perception and production and Optimality Theory (OT).

7.1 Language Transfer

The essence of L1 transfer pertains to the influence of the previous L1 acquisition on the subsequent L2. L1 transfer has been recognized as a predominant influence, exhibiting both beneficial and detrimental effects, on the acquisition of an L2 phonology (Lado, 1957; Weinreich, 1953). The degree of similarity and dissimilarity between the native language and the target language elucidates the specific patterns of correct and incorrect forms. The transfer is considered positive when the phonological structures of the L1 facilitate the L2 phonological acquisition. On the other hand, the transfer is considered negative, also known as interference, when the L1 phonology hinders the mastery of the L2 phonology (Pennington & Rogerson-Revell, 2019).

Weinreich (1953) delineated several forms of phonological transfer, including: *sound substitution* wherein learners exploit the closet L1 equivalent in the L2, e.g., English [ɹ] substituted for Spanish [r]; *phonological processes* in which learner employ the L1 allophone that does not occur in the same environment in the L2, for example, French learners of English use clear [l] in coda position instead of velarized [ɬ] in L2 English; *underdifferentiation* wherein the L2 has distinctions that the L1 does not, for example, when two sounds such as [d] and [ð] are allophones in L1 Spanish but separate phonemes in L2 English; *overdifferentiation*, in which, for example, the L1 English /d/ and /ð/ are inversely separate phonemes but allophones in the L2 Spanish; *reinterpretation of distinctions* in which, for example, German learners of English reassign tense and lax features in L2 English as concomitant long and short features;

phonotactic interference, in which learners alter the syllabic structure of L2 words to conform to L1 patterns, as seen when Portuguese learners of English transform the syllabic structure of the English word 'picnic' [pɪk.nɪk] into their nativelike-Portuguese [pɪ.ki.nɪ.ki] 'piquenique'.

The field of L2 phonological acquisition is similar to that of other disciplines like syntax, with the former attempting to account for non-nativelike sound system that manifest in L2 or foreign learners' pronunciation of a target language and to predict underlying causes of such deviations, and with the latter to account for non-native syntactic constructions. The acquisition of L2 phonology is both similar to and different from that of syntax. The similarity between the two involves the use of L1 phonological/syntactic features for L2 production, and the difference is that not all of the theoretical concepts in the domain of syntactic L2 acquisition can be applicable to that phonology. For instance, avoidance is commonly used to circumvent an unfamiliar syntactic construction; learners who do not know how to construct passive sentences usually find it easy to use alternative structure to express the same idea. Notwithstanding, it is impractical for L2 learners to avoid pronouncing the voiceless interdental fricative /θ/ as in the word 'thing' /θɪŋ/. Nonnative-like pronunciation should be avoided as it is claimed to be the source of humor, as seen in comedians mimicking particular types of accents, or in cartoon characters adopting non-native accents (Gass & Selinker, 2008, p. 178).

Regarding syllabification, Gut (2009, p. 98) stated that the discrepancy between L2 learners' and native speakers' pronunciations results from the difference in mental representations of phonological units and rules speakers of a language have. Language learners, whose representations of L1 phonological units and rules deviate from those of the L2, might, at least in early stages of language learning, produce inappropriate phonological units in the L2. Some learners make errors involving alternation of the L2 syllabic structure and syllabification when their L1 and L2 differ in such phonological units (Ishikawa, 2002; Whitworth, 2003). To illustrate, some German learners of English insert a glottal stop between a vowel-final and vowel-initial words, as

in [ðɪ ʔæpl] ‘the apple’, in that German syllables without onsets are rare. Similarly, Thai learners of English usually epenthesize the glottal stop in the onset of a vowel-initial syllable and in the coda of vowel-final syllable, as in *[ʔaʔ.tɔm] ‘atom’, because of the requirement of Thai syllabic structure for onset obligatoriness and bimoraicity.

7.2 Contrastive Analysis (CA)

Studies on transfer usually conducted through systematic comparison of the native language with the target language known as *Contrastive Analysis Hypothesis* (CAH) whose aims are to elucidate and to predict errors. The CAH, in its most basic form, postulates that those features of the L2 resembling those of the L1 are anticipated to be easily acquired, while those that are dissimilar between the two languages are hypothesized to pose difficulties in acquiring them. However, errors made by many learners are not, consistently, predictable. To address this drawback, Wardhaugh (1970) introduced the *strong* versus the *weak* versions of CA, the first of which predicts errors, whereas the other of which explains errors after the fact.

The strong version, also known as a *priori* and *predictive*, as the name suggests, aims to predict errors. That is, predictions about learning and hence about the success of language-teaching materials could be made based on comparison between two languages. The weak version, also called a *posteriori* and *explanatory*, aims to account for errors after the fact. In other words, it starts with what learners do and then attempts to account for those errors on the basis of differences between L1 and L2. This version of CA, which came to be part of error analysis, largely gains credence due to the failure of predictive CA. The contribution of the weak version approach to learner data was the emphasis it placed on learners themselves, the forms they produced and the strategies they used to arrive at their interlanguage forms.

Early investigations of L2 phonology from a CA perspective (e.g., Brière, 1966; Brière, 1986; Johansson, 1973; Nemser, 1971; Stockwell & Bowen, 1965), suggested that similarities and dissimilarities between L1 and L2 could partially account for L2 learners’ performance but overall the CA was not robustly supported. It seems that ease versus difficulty of L2 learning and correct versus incorrect L2 pronunciation

are not directly or obviously related to L1– L2 similarity and difference since features of greatest difference between languages are often not those which cause the most difficulty for learners or the most serious or frequent errors.

Since CA did not accurately predict why speakers of language X learning language Y would have difficulty on a given structure, whereas speakers of language Y learning language X did not have difficulty on that same structure, Stockwell and Bowen (1965) proposed hierarchy of difficulty, as shown in the following table.

Table 3 Hierarchy of phonological difficulty

L1	L2	
0	obligatory	difficult
0	optional	
optional	obligatory	
obligatory	optional	
obligatory	0	
optional	0	
optional	optional	
obligatory	obligatory	easy

Note. From Second Language Acquisition by Gass and Selinker, 2008, 179.

This hierarchy, ranked in order of difficulty, attempts to make predictions of difficulty based on whether or not phonological categories are absent or present and, if present, whether they are obligatory or optional. Thus, if a learner comes from a language that has no phonemic contrast between two sounds, e.g., /l/ and /r/, and is learning a language where that contrast is obligatory, she or he will have difficulty.

In this regard, gemination of double identical consonantal graphemes is obligatory in Thai in order to satisfy onset obligatoriness and bimoraicity required by Thai syllabic structure. In English, geminates are said to be optional. Double consonant

graphemes have nothing to do with segmental length. Words which contain geminate graphemes are not actually geminated. Therefore, according to table 3, it could be stated that geminates are moderately difficult for Thai learners of English to acquire.

7.3 Interlanguage (IL)

CA was not infallible due to the claim that all errors stem from language transfer. Besides those due to L1 interference, L2 errors were also seen to involve learning processes that occur through stages of L1 acquisition, including simplification, approximation, and overgeneralization of forms and rules (Richards, 1974).

Since the form of language which the learner produces during these processes differs from both the mother tongue and the target language, it is termed an interlanguage, resulting from learner's interlingual system, approximative system or interim grammar. Interlanguage hypothesis stipulates that language learners possess a grammatical system distinct from both the native and the target language. These error patterns manifest as borrowing patterns from the mother tongue or L1 transfer, as well as extending patterns from the target language through analogical reasoning, such as overgeneralization of forms and rules. Interlanguages are believed to be constrained by the same linguistic principles that apply to all languages, commonly referred to as *universal generalizations*. Since these types of errors are prevalent in L1 acquisition, they were regarded as outcomes of natural language acquisition processes favoring language universals such as unmarked (simple) over marked (complex) forms.

Within the framework of interlanguage as a learner's evolving linguistic system that serves as a bridge between the native and the target language (Selinker, 1972), researchers in L2 phonology sought to identify learners' errors that could not be attributed to L1 transfer but could be described as developmental errors (Hecht & Mulford, 1987) or as evidence for natural phonological processes or language universals which were identical to those occurring in L1 acquisition (Eckman, 1987).

7.4 Markedness Differential Hypothesis (MDH)

The principle of *markedness* originated from the theories of Trubetzkoy (1939b) and (1941) within Prague School of Linguistics. This concept posited that binary

oppositions between certain linguistic representations, such as voiced and voiceless obstruents, nasalized and oral vowels, or open and closed syllables, were not merely seen as polar opposites. Instead, one member of the opposition was considered privileged, as it had a broader distribution within a given language and across languages.

The distribution of these linguistic features across languages, where there exists an implicational relationship between the occurrence of the members of the opposition, is termed *typological markedness*, developed in the work of Greenberg (1976) and can be defined as (51):

(51) A structure X is typologically marked relative to another structure, Y, (and Y is typologically unmarked relative to X) if every language that has X also has Y, but every language that has Y does not necessarily have X.

(Gundel et al., 1986)

Markedness is defined in various ways (e.g., Carr, 1993; Chomsky & Halle, 1986; Greenberg, 1976; Hyman, 1975; Lass, 1984). One approach to defining markedness involves implicational hierarchies, where *x* is judged to be more marked than *y* if the presence of *x* suggests the presence of *y*, but not vice versa. For instance, the occurrence of final voiced obstruents implies the presence of initial and medial voiced obstruents, but not vice versa (Eckman, 1984, 1985; Eckman & Iverson, 1994); the presence of onsets of length *n* suggest the presence of onsets of length *n*–1, except when *n*=1, since syllables with onset are found to exist in all languages (Greenberg, 1978); the presence of codas of length *n* imply the presence of codas of length *n*–1; however, in this case, *n* can be *0*, since syllables in some languages are found to be codaless.

Eckman (1987) proposed the Markedness Differential Hypothesis (MDH) as a supplement to Contrastive Analysis (CA). MDH brought markedness to the fore for SLA, proposing that, regardless of L1–L2 similarity or difference, unmarked linguistic

features, whether phonological or syntactic, refer to those that are more common in the world's languages and would be thus acquired earlier than the marked counterparts, which are less usual, complex and thus difficult to produce.

The MHD, in fact, reformulates the CAH by incorporating the notion of typological markedness; the prediction of difficulty is still based on a contrastive analysis with markedness serving as an additional criterion. The MDH postulates that different sounds are difficult to learn only if the sounds in question are typologically marked, whereas the sounds which are typologically unmarked are presumed not to cause learning difficulties.

Recent work of this kind has also looked at units larger than individual segments, e.g., syllables. Not only are sounds of a language transferred, but there is also evidence that learners attempt to maintain their L1 syllable structure. When the target language permits syllable structures that are not permitted in L1, learners will make errors by altering such syllable structures to those permitted in L1.

As with other areas of phonology, syllable types can be ranked in terms of markedness so that learners from a language with a less marked CV syllable to one that has a more marked CVC syllable tend to produce errors with regard to altering syllable structure. For example, native Japanese leaners of English are predicted to undergo difficulty with closed syllables because the majority of Japanese syllables are open syllables (Gass & Selinker, 2008, pp. 179-182; R. C. Major, 2008).

7.5 Speech Perception and Production Models

Transfer has also played a role in other theories on L2 phonology. Speech perception and production theories, such as Flege (1995)'s *Speech Learning Model* (SLM) and Best (1995)'s *Perceptual Assimilation Model* (PAM), are all based on the premise that the L1 influences how the learner perceives the L2.

PAM incorporates perception and production factors. In early stages of language acquisition, infant establish categories for native sounds by learning to articulate them. Once the categories have been established, non-native phonemic categories are assimilated to native categories based on articulatory similarities. The

extent to which a non-native sound can be assimilated to a native category affects its ease of perception and acquisition (Best, 1995).

SLM states that the mechanisms needed to produce new sounds remain intact, but perception changes with development. According to this model, the ability to discriminate new contrasts decreases with age, as younger learners do not have firmly established native language perceptual categories. Consequently, younger learners are more likely to perceive L2 sounds independently, without reference to the L1. L2 sounds that are more distinct from the closest L1 sounds are easier to acquire, while those that are similar or equivalent to L1 sounds are difficult to acquire because learners do not perceive them as contrastive categories. L1 perceptual categories may change with increased L2 experience (Flege, 1995).

Furthermore, Flege (1995) hypothesizes that those phones that do not contrast in the L1 will be difficult to perceive in the L2. Like Best's PAM, similar sounds that are not identical in both languages are challenging to master. Conversely, greater dissimilarity between L1 and L2 sounds increases learners' awareness of differences, reducing reliance on the L1 for L2 production.

7.6 Optimality Theory

Optimality Theory, abbreviated to OT, was developed by Alan Prince and Paul Smolensky. OT is an approach to phonological analysis which replaces the notion of rules, such as in autosegmental phonology and SPE (the sound pattern of English) phonology, with the notion of constraints (Carr, 2008).

OT provides mappings from inputs to outputs; the inputs correspond to underlying representations, and the outputs to their surface realizations. The approach is based on the rankings of universal constraints. Constraints are innate and apply across all languages. There are two types of constraints: faithfulness constraints and markedness constraints. The former requires the output which is identical to the input; the output that undergo elision, epenthesis and alteration of the distinctive features are prohibited. The latter ensures the well-formedness of the output. These conflicting constraints can be resolved by a language-specific ordering of constraints. Variation

across languages is a result of different ordering of constraints, and second language learning involves the reranking of native language constraints. Reranking of constraints are said to cease when learners no longer detect differences between their own output and the surrounding language input (Gass & Selinker, 2008, p. 184).

In this section, I draw attention to how different outputs are selected by different constraint rankings according to English and Thai phonologies. To this end, in light of the literature, i.e. Féry and Van de Vijver (2003), Gussenhoven and Jacobs (2017), Hammond (1995), Kager (2004), (Suh, 2001) and Hamann and Colombo (2017), the relevant constraints are classified into two main types: orthographic constraints and structural constraints (Hamann & Colombo, 2017). The orthographic constraints involve the mapping of written forms onto surface forms, whereas the structural constraints are concerned with the sound structure, such as phonotactic restriction, restrictions on syllable structure and syllabification, and stress pattern. The relevant orthographic constraints adopted for the analyses are presented in (53); the constraints relevant to English and Thai syllable structures and syllabifications are listed in (54); and the constraints with regard to the placement of stress in English and Thai are shown in (55).

(53) Orthographic Constraints

a. <βiβi>[C:]:

Assign a violation mark if a grapheme of two identical consonantal letters is not mapped onto a surface geminate, and vice versa.

b. <γ>[P]:

Assign a violation mark to every grapheme <γ> that is not mapped onto the surface form [P] and vice versa.

c. *<γ>[ ]:

Assign a violation mark to every grapheme <γ> that is mapped onto an empty segment in the surface form.

d. *< >[P]:

Assign a violation mark if the absence of a grapheme is mapped onto the surface form [P].

(Hamann & Colombo, 2017)

(54) Constraints relevant to Syllable Structure and Syllabification

a. Maximal Onset Principle (MOP):

Affiliate as many intervocalic consonants as possible to the onset as long as it does not violate the phonotactics of a language.

b. Weight-to-Stress Principle (WSP):

Bimoraic/heavy syllables are stressed.

c. BIMORAICITY:

Syllables are maximally bimoraic.

d. Stress-to-Weight Principle (SWP):

If any syllable is stressed, then heavy.

e. *[$_{\sigma}$ V:

Syllables must have onsets.

f. NoGeminate

Gemination is prohibited.

(Gussenhoven & Jacobs, 2017; Kager, 2004; Suh, 2001)

(55) Constraints relevant to Stress Pattern

a. PARSE-Syl:

Syllables must be parsed into a foot.

b. TROCHEE:

Feet are trochaic.

c. IAMB:

Feet are iambic.

(Gussenhoven & Jacobs, 2017; Kager, 2004)

As the emphasis of this study is the pronunciation of English words containing geminate grapheme, the word stimuli are twofold contrasted by stress placements (pre-stress versus post-stress) and by orthographic representations (singleton versus geminate grapheme). It is worth noting that English and Thai phonologies call for different sets of constraints involved in the ranking and different constraint rankings also result in different derived outputs.

Tableau (56) illustrates how the optimal output for the word 'letter' is selected according to the English phonology. It is important to take prior notice that the constraint ranking in this study consists of the constraints from different domains, including those relevant to syllabification, stress pattern and orthography albeit English orthography is said to be relatively independent of pronunciation. For this reason, orthographic constraints are not usually counted in the English grammar, and I thus place it at the bottom of the ranking. The constraint ranking proposed here for the word is as follows: TROCHEE >> PARSE-Syl >> * GEM >> WSP >> MOP >> <γ>[P].

(56)

<letter>' /ˈlɛtə˞/	TROCHEE	PARSE-Syl	*GEM	WSP	MOP	<γ>[P]
a. μ μμ (ˈlɛ.tʰər)				*!		
☞ b. μμ μ (ˈlɛt.ɻ)					*	
c. μμ μμ (ˈlɛt.tər)			*!	*		
d. μ μμ lɛ.(ˈtʰɜr)	*!	*				

Out of the orthographic constraints in (52), the constraint <γ>[P], requiring every grapheme to be mapped onto the surface form, is considered the least marked and thus included in the tableau. This constraint is in turn outranked by the MOP and the WSP constraints which are invoked for syllabification. As the intervocalic /t/ in the target word 'letter' is constrained to affiliate with the coda of the preceding syllable, the WSP

constraint is then decided to outrank the MOP. By this way of ranking, the candidate a. which exhibits onset preference is ruled out. Although there are a number of English words containing geminate grapheme, from native English speakers' perspective, the orthographic double consonant is not a geminate but a singleton with ambisyllabic status. It should be reminded that gemination is allowed only at the post-lexical level. Word-internal gemination is thus prohibited by the constraint *GEM which militates against any outputs with geminate grapheme, namely candidate c. This candidate also violates the WSP, in that its syllables are indiscriminate of weight. The highest ranked constraints are concerned with stress assignment. The PARSE-Syl is required for foot formation and ranked higher above the *GEM. Since the English foot is left-dominant, TROCHEE is employed as the highest ranked constraint in hierarchy. The candidate d. which favors IAMB is filtered out and the candidate b. is left an optimal output.

When it comes to accounting for Thai L2 learners of English' interlanguage phonology, especially that of those at the initial stage of acquisition, different constraints are involved in the constraint ranking. It is the BIMORAICITY constraint on Thai syllables that takes part in compelling Thai learners to affiliate the consonant in question with the coda. The consonantal stimuli represented with singleton grapheme are not geminated and they are always syllabified as the onset of the syllable that follows. This suggests obligatoriness of the onset for Thai syllables and the constraint *[$_{\sigma}$V is thus activated in Thai learners' L2 grammar. Although there is no gemination in English, the constraint GEMINATE may be preferred when the intervocalic consonant in the input is represented with double grapheme according to Thai phonology in which geminate grapheme always surface as double consonants. Recall that Thais are said to employ gemination as a repair strategy for the light open syllable /Ca/ in English loanwords to fulfil bimoraicity and onset preference. The orthographic constraint <βiβi>[C:] thus turns out to play a crucial role and is highly ranked in Thai learners of English' L2 grammar.

In terms of rhythm, as Thai foot structure is constructed on a sequence of alternating weak-strong syllables, the constraint IAMB is imposed for the ranking instead

of TROCHEE. The OT analyses that encompass the constraints mentioned above is presented in (57).

(57)

<letter>’ /ˈlɛtɚ/	IAMB	PARSE-Syl	<βiβi>[C:]	σ-μμ	*[σ V
a. μμ μμ (ˈlɛt.tər)	*!				
b. μ μμ (lɛ.ˈtɜr)			*!	*	
c. μμ μu (lɛt.ˈɜr)			*!		*
☞d. μμ μμ (lɛt.ˈtɜr)					

The intervocalic /t/ in ‘atom’ is orthographically opposed to that in the word ‘letter’, in that it is represented with a singleton letter. Nonetheless, according to native English speakers’ phonology, the intervocalic /t/ in both words is similarly mapped onto a singleton. The segment also occurs in the same phonetic environment, namely preceded by a stressed lax vowel and followed by a schwa. The optimal candidate can be simply pointed out by the same set of relevant constraints with the TROCHEE constraint at the top rank above PARSE-Syl. Any candidates, e.g. candidate d., exhibiting the stress pattern which is not in parallel to English trochee is fatally eliminated by such constraints. The candidate a. which favors onset is ruled out by the WSP and the candidate c. fatally violates *GEMINATE. This finally leaves candidate b. to be the optimal output, as illustrated in tableau (58).

(58)

<atom> /ˈætəm/	TROCHEE	PARSE-Syl	*GEM	WSP	MOP	<ɣ>[P]
a. μ μμ (ˈæ.tʰəm)				*!		
b. μμ μ (ˈæt.m̩)					*	
☞ c. μμ μμ (ˈæt.təm)			*!	*		
d. μ μμ (ə.ˈtɔm)	*!	*				

Thai learners of English do not generally geminate when the consonantal stimuli are represented with singleton graphemes as in the ‘atom’. Therefore, it could be concluded that only English intervocalic consonants represented with a sequence of two identical letters activate gemination when doing syllabification.

In order to account for the production of this word by Thai L2 learners of English, I further introduce the markedness orthographic constraint <a>[a]$_{\sigma}$ in which the vowel letter <a> is generally mapped onto the surface form [a] or [a:] if it occurs in an open syllable. According to (Petkla, 2020, p. 118), the English [ə] represented with the letter <a> is realized as a short low [a] in a closed syllable or with an epenthetic glottal, and when it is followed by nasals, it is realized as [æ].

(59)

<atom> /ˈætəm/	IAMB	PARSE-Syl	$_{\sigma}$-μμ	<a>[a]$_{\sigma}$	*[$_{\sigma}$ V
a. μ μμ (ˈæ.təm)	*!		*	*	*
b. μμ μ (ˈæt.m̩)	*!		*	*	*
c. μμ μμ (ˈæt.təm)	*!			*	*
e. μ μμ (a.ˈtɔm)			*!		*
☞ f. μμ μμ (aʔ.ˈtɔm)					*

English intervocalic consonants are also flanked by an unstressed and a stressed vowel. Take for example the word ‘attack’ whose stress placement falls on the ultimate syllable. The syllabic parsing for this word is different from the way it is for ‘letter’ and ‘atom’. English words have their syllables parsed into feet from the right edge of a prosodic word. For the case of ‘attack’, syllables are not exhaustively parsed into feet. The trochaic foot may be constructed on bimoraic/heavy monosyllable with the preceding unstressed syllable left unfooted, in that English permits a word-initial stray or extrametrical unstressed syllable (Carr, 2013, p. 96; Gussenhoven & Jacobs, 2017, p. 180; Kager, 2007). Such the syllable left unfooted does not find favor with the constraint PARSE-Syl. Therefore, the optimal candidate b. can be determined by demoting the PARSE-Syl to the rank lower than the WSP constraint as tabulated in (60). Doing this way, the candidate c. with two syllables of indiscriminate weight can be excluded. The candidate a. commits fatal violation of the TROCHEE as it exhibits an iambic stress pattern.

(60)

<attack> /əˈtæk/	TROCHEE	WSP	MOP	PARSE-Syl	*GEM	<γ>[P]
a. μ μμ (ə.ˈtʰæk)	*!					*
☞ b. μ μμ ə.(ˈtʰæk)				*		*
c. μμ μμ (ˈæt.tʰæk)		*!			*	

Following Anttila (2006) and Ruangjaroon (2020), second language acquisition exhibits variation in which one phonological input has more than one selected form of outputs. For this target word, the two possible optimal outputs predicted according to Thai L2 learners' grammar include the candidate c. which favors iambic stress pattern, bimoraicity and the mapping between geminate grapheme and surface geminate, and the candidate e. which satisfies all the same constraints except for the mapping between the grapheme <a> and the surface [a], as tabulated in (61).

(61)

<attack> /əˈtæk/	IAMB	PARSE-Syl	$_{\sigma}$-μμ	*/$_{\sigma}$ V	<a>[a]$_{\sigma}$	<βiβi>[C:]
a. μ μμ (ə.ˈtʰæk)			*!	*	*!	*
b. μ μμ (æ.ˈtʰæk)			*!	*		
☞ c. μμ μμ (æt.ˈtʰæk)				*	*	
d. μ μμ (a.ˈtʰæk)			*!	*		*
☞ e. μμ μμ (aʔ.ˈtʰæk)				*		*

Finally, let us consider the word ‘atone’ of which the intervocalic /t/ exhibits grapheme-phoneme correspondence, as opposed to the word ‘attack’ whose intervocalic singleton /t/ is not mapped onto double orthographic form. Nonetheless, orthographic representation does nothing to do with the native English speakers’ mental grammar. I, therefore, assume the same constraint ranking that is used for the word ‘attack’, as seen in the following tableau.

(62)

<atone> /əˈtoʊn/	TROCHEE	WSP	MOP	PARSE-Syl	*GEM	<ɣ>[P]
a. μ μμ (əˈtoʊn)	*!					*
☞ b. μ μμ ə(ˈtoʊn)				*		*
c. μμ μμ (ætˈtʰone)		*!			*	

The constraint ranking invoked in Thai L2 learners’ grammar for the selection of the optimal output for the word ‘atone’ differs from the one employed for the word ‘attack’, in that the candidate with a geminate grapheme is not selected as an optimal output. Only the double consonantal grapheme is said to activate gemination. The optimal output for the word in question is achieved through promoting the <a>[a]$_{\sigma}$ to the position above bimoraicity constraint. Doing this way, any candidates that do not map the orthographic <a> onto [a] at the surface form are fatally eliminated, as shown in tableau (63).

(63)

<atone> /əˈtoʊn/	IAMB	PARSE-Syl	<a>[a]$_{\sigma}$	$_{\sigma}$-μμ	*/$_{\sigma}$ V	<βiβi>[C:]
a. μ μμ (əˈtoʊn)			*!	*	*	*
b. μμ μμ (ætˈtʰone)			*!		*	
☞ c. μμ μμ (aʔ.tʰoun)					*	*

8. English as a Global Language: Intelligibility and Comprehensibility

The globalization of the English language has reached such extensive proportions that it is universally acknowledged as the most widely spoken language (Crystal, 2003, 2008), with the number of speakers who use it as either a first, a second, or a foreign language exceeding 1.5 billion individuals. English is also designated as an international language, as evidenced by the fact that 80% of English speakers are traditionally classified as non-native speakers who employ varieties of English spoken outside the Anglosphere or the inner circle. Consequently, the theoretical foundations of ELT, which conventionally preferred American and British English as native varieties and the sole legitimate forms of English, have come under scrutiny (Jenkins, 2002, 2015).

Partially influenced by the concentric circles of Kachru (1985), the concepts of WE, EIL or EGL, and ELF, recognize the legitimacy of all English varieties suitable for instruction in ELT classrooms. ELF primarily concerns the utilization of English as a medium of communication among individuals whose native language is not English (House, 1999), whereas EIL refers to a means of communication among all users of English, regardless of whether they are native and non-native English speakers.

Theoretical foundations of WE, EIL, ELF, and Global Englishes have led to the acceptance of all varieties of English for English teaching and learning (Hino, 2019; Sharifian, 2009). This global trend suggests that the increasing significance of English diversities is inclined to blur the distinction between the notions of ‘nativeness’ and ‘accentedness’.

While the prominence of foreign accents is well documented, lesser is known about how accentedness might affect communication. It is widely acknowledged that L2 users at times encounter difficulties in making themselves understood, sometimes due to pronunciation errors that render their speech unintelligible. Applied linguists also contend that flawless pronunciation output is not a prerequisite for communicative competence. Interlocutors are usually capable of understanding L2 utterances containing grammatical or pronunciation errors by invoking top-down or other cognitive processes. Nonetheless, a comprehensive comprehension of the circumstances under which pronunciation errors lead to breakdowns in communication remains an area requiring further investigation (Munro, 2008).

Instead of nativelikeness, the assessment of L2 production may be centered on *intelligibility,* a concept, more recently, defined in terms of speech recognition by Smith and Nelson (1985) as the extent to which a speaker' utterance can be understood, despite non-nativelikeness and accentedness in their pronunciation, depending on how strong the accent is perceived to be. Intelligibility constitutes one of three components: *intelligibility*, *comprehensibility*, and *interpretability*. Within processing framework, intelligibility denotes the extent to which a listener can apprehend a conveyed message and decipher its elements. Thus, it serves as a fundamental indicator of proficiency, given that a speaker must articulate a clear and undistorted message in order for his/her audience to be able to receive the message correctly.

As opposed, *comprehensibility* refers to the ease with which the listener grasp the meaning of the word or utterance in its given context (Munro & Derwing, 1995; Munro et al., 2006). Hence, as posited by Field (2003), a listener may rely on the context for understanding a message when precision in decoding the message is unattainable. The perception of accentedness is closely associated with segmental accuracy and other pronunciation factors other than with grammatical or lexical factors (Saito et al., 2016, 2017). Comprehensibility is a multifaceted judgement that takes into account both segmental and prosodic features, together with temporal, lexical, and grammatical aspects of L2 speech. Hesitancy or disfluency often reduce ease of understanding and

hence in judgements of comprehensibility. Listeners usually a person's speech with substantial interruptions and hesitations difficult to understand. Conversely, excessive fluency) with pronounced accentedness may also diminish ease of understanding, as listeners may experience moderate or even extreme difficulty understanding highly fluent speech if delivered in an unfamiliar accent (Pennington & Rogerson-Revell, 2019).

Interpretability denotes the listener's capa Pennington and P. Rogerson-Revellcity to discern the speaker's intended meanings with regard to the communicative function or pragmatic force of the message, necessitating proficiency in functional, situational, and language-specific contextual understanding (Pennington & Rogerson-Revell, 2019).

The emergence of English as a global language has changed the target pronunciation of English learners. Accentedness is acceptable as long as it does not cause any communication breakdowns and the utterance is still intelligible. Nonetheless, the research conducted by Manzouri et al. (2024), revealed that foreign learners of English treated non-native varieties of English as illegitimate forms of English due to not being genuine representations of the language. Foreign learners showed strong preferences for native varieties of English and aimed to attain a native-like accent. They hold highly positive attitudes towards native varieties and preferred to sound native-like. In terms of pronunciation teaching, reference accent, such as BrE or AmE, is still normally adopted as a pronunciation model.

CHAPTER 3
RESEARCH METHODOLOGY

This chapter lays out the research methods applied in this dissertation, primarily divided into two sections and organized as follows: the initial part elucidates how participants were recruited. In the subsequent part, further divided into two subsections, the first addresses the selection of the word stimuli, data collection and data analysis for syllabification experiment. The second subsection pertains to the recruitment of stimuli, data collection, segmentation and measurement and data analysis for production experiment.

1. Participants of the Study

This present study comprised two major groups of participants: a group of native Thai speakers of English as a second or a foreign language, placed into three different levels of English proficiency based on CEFR, employed as experimental group; and a group of native English speakers regarded as a control group.

1.1 Experimental Groups

Sixty native Thai speakers of English were recruited through purposive sampling from undergraduates majoring in English for Communication program at the Faculty of Liberal Arts of a state-run university in Thailand. They were invited to experimental participation using electronic flyers circulated through various social media platforms with their participation being compensated.

Prior to experiment, the Oxford Placement Test was administered to the target population. Twenty of those placed at CEFR levels A1, A2 and B1, each, were purposively selected to constitute one of the three experimental groups.

According to the CEFR descriptors for overall phonological control under the heading of linguistic competence (Council of Europe, 2018, p. 136), learners of English who are placed at levels A1, A2 and B1 are expected to exhibit the following kinds of pronunciation:

Table 4 Overall CEFR's Phonological Control

Levels	Descriptors
B1 (Threshold)	Approximate intonation and stress at both utterance and word levels, albeit there is a strong influence on stress, intonation and/or rhythm from speakers' native language.
A2 (Waystage)	Use the prosodic features (e.g. word stress) of familiar everyday words and phrases but yet with a strong influence on stress, intonation and/or rhythm from speakers' mother tongue. This L1 influence may affect the intelligibility of their pronunciations.
A1 (Breakthrough)	Use the prosodic features of a limited repertoire of simple words and phrases learnt, despite a very strong influence on stress, intonation and/or rhythm from speakers' mother tongue; their interlocutors tend to be collaborative in their efforts to understand speakers' pronunciations.

(Council of Europe, 2018)

1.2 Control Group

A group of four native English American speakers, with a range of ages between 30 and 50 years old, were personally approached and invited to research participation. At the time of the study, the three of them worked as university English instructors, while the other worked as an engineer.

2. Test Materials and Procedures

This study consisted of two experiments, i.e., *syllabification* and *production*. Both experimental and control groups participated in these experiments. All subject groups were provided with an identical procedure in syllabification and production experiments. Prior to data collection, all participants were asked to read and agree to an informed consent form to ensure that undue influence that may arise between a researcher and participants was avoided.

2.1 Syllabification Experiment

To experiment the participants' syllabification, the word-part identification was replicated from a previous study conducted by Eddington and Elzinga (2008). Its aim is to reflect the underlying phonological representation in terms of syllabification that the learners of English have in their mind. The objective of using this task was to test the first hypothesis speculating that all groups of Thai participants, regardless of stress, orthographically syllabify intervocalic consonants represented with a geminate grapheme as heterosyllabic geminate [VC.CV] and those with a singleton grapheme as either coda of the preceding [VC.V] or onset of the following syllable [V.CV]; a group of participants with low English proficiency or at an earlier stage of acquisition, albeit, are predicted to exhibit stronger reliance on orthography for syllabification than those at a later stage of acquisition.

2.1.1 Stimuli

The target consonants comprised 8 phonemes, the first four of which are voiceless obstruents: /p/, /k/, /f/, /s/, and the other four of which are sonorants: /m/, /n/, /l/, /r/[2]. The stimuli consisted of 32 authentic disyllabic English words, dichotomized by two orthographic forms and two stress-related contexts. These dichotomies yielded four distinct contexts where the target intervocalic consonants could orthographically alternate between singleton and geminate graphemes, and phonetically alternate their occurrences in post-stress with pre-stress positions.

(62) a. $V_{[+stress]}CV_{[-stress]}$: orthographic singleton in a post-stress position

b. $V_{[+stress]}CCV_{[-stress]}$: orthographic geminate in a post-stress position

c. $V_{[-stress]}CV_{[+stress]}$: orthographic singleton in a pre-stress position

d. $V_{[-stress]}CCV_{[+stress]}$: orthographic geminate in a pre-stress position

---

[2] The grounds that voiced obstruents were excluded from the stimuli are authentic English words with intervocalic voiced obstruents orthographically represented as geminates and singletons, especially <vv> and <v>, <zz> and <z>, <g> and <gg>, are scarce or unavailable. Although words such as 'sávvy', 'dévil', revíve exist, the word with <vv> in pre-stress position does not. Similarly, words such as 'fúzzy', 'lízard' exist but their counterparts in pre-stress positions do not. Furthermore, although words such as 'Mégan', 'lúggage' and 'lagóon' exist, the word with <gg> in pre-stress position does not. Some of these examples are also words of low frequency.

Thirty-two real English words selected as the stimuli in the word-part identification task are displayed in Table 5.

Table 5 List of the word stimuli exploited in syllabification task

Consonants	Post-stress		Pre-stress	
	<C>	<CC>	<C>	<CC>
p	léper	pépper	propóse	applý
k	récord	híccup	akín	occúr
s	príson	fóssil	resúme	assíst
f	déafen	éffort	refér	efféct
m	lémon	cómmon	camél	commít
n	mány	cánnon	canál	connóte
l	cólor	fóllow	alóud	allót
r	párent	párrot	aróund	arrést

2.1.2 Data Collection

The questionnaire was carried out online using Google Forms. It comprised 64 multiple-choice questions, wherein participants were instructed to identify the first part of a word in one question item and the second part of the same word in another. The experiment took place at a language laboratory within a building of the Faculty of Liberal Arts, where participants were seated at computers to complete the questionnaire. Both question and response items in the questionnaire were randomly shuffled. Prior to the data collection, participants were asked to consider and agree to an informed consent form to avoid any undue influence on participation.

Questions that asked to identify the first and the last parts of the words from a four-word set containing the same intervocalic consonant /p/, occurring in two orthographic forms alternating singleton and geminate graphemes, and in two stress-related contexts alternating post-stress and pre-stress positions was exemplified in (63).

(63) a. What is the first part of the word ‘leper’?

- O le-
- O lep-

b. What is the last part of ‘leper’?

- O -er
- O -per

c. What is the first part of the word ‘pepper’?

- O pe-
- O pep-

d. What is the last part of ‘pepper’?

- O -er
- O -per

e. What is the first part of the word ‘propose’?

- O pro-
- O prop-

f. What is the last part of ‘propose’?

- O -ose
- O -pose

g. What is the first part of the word ‘apply?

- O a-
- O ap-

h. What is the last part of ‘apply’?

- O -ly
- O -ply

2.1.3 Data Analysis

Counted as one response are the first part of a word identified in one question item and the second part of the same word identified in another. A total of

2,048 syllabification tokens obtained from 32 responses by 64 participants were classified as [V.CV], [VC.V] or [VC.CV], and each of these syllabifications was computed as a percentage of frequency separately for each subject group. Linear Logistic Regression was also performed to determine whether each of the independent variables (orthographic forms, stress positions and consonantal types) influences the nominal dependent variable (syllabification), and to what extent it is affected.

2.2 Production Experiment

The participants' production was tested using the reading-aloud task with the relevant hypothesis stipulating that intervocalic consonants across orthographic forms, stress positions and consonantal types, produced by Thai participants with increased English proficiency exhibit durational ratios more closely aligned with those of the native English participants than those with lower proficiency.

2.2.1 Stimuli

An additional set of 32 authentic di- to trisyllabic English words was employed as stimuli with the same 8 target consonants. The stimuli were constructed, in the manner akin to the previous experiment, to contrast two orthographic forms alternating singleton and geminate graphemes, and two stress-related contexts alternating post-stress and pre-stress positions. The stress placements in the word stimuli were indicated by a grave accent for avoidance of confusion that may arise among the participants between noun and verb homographs, e.g. récord /ˈrɛk.ərd/ serving as a noun versus recórd /rɪˈkɔrd/ serving as a verb. The word stimuli selected for this experiment are listed in the following table.

Table 6 List of the words employed in production task

Consonants	Post-stress		Pre-stress	
	<C>	<CC>	<C>	<CC>
p	wéapon	ápple	apártment	appéar
k	dócument	óccupy	recórd	accóunt
s	clóset	lésson	recéipt	assúme
f	réference	óffer	proféssion	affáir
m	cámera	hámmer	amóunt	ammónia
n	ténor	chánnel	banána	connéction
l	Álan	yéllow	alóne	illúsion
r	dúring	mírror	aróma	corréct

2.2.2 Data Collection

Participants were presented with a printed list of 32 real di- to trisyllabic English words, sequenced in the same order for every participant. They were instructed to read aloud each stimulus three times at a normal speech rate in the carrier sentence “What does the word _____ mean?” in which the target word carried the tonic or nuclear stress in the intonational unit. Thirty-two target words were produced three times by 64 participants, yielding a total of 6,144 audio tokens.

The recording was individually carried out by each participant one after the other and took place in a lecture room with a quiet, well-lit setting, in the same building of the faculty of liberal arts where the first experiment was conducted. The words read aloud were recorded on Praat by Boersma and Weenink (2021) using Oker-G328 headset-mounted microphone. The sampling frequency for recording monophonic sound was set at 44,100 Hz in the software Praat.

Prior to the recording, fifteen minutes were allotted for silent reading; this is to ensure that they had become familiar with the word stimuli. The three repetitions of

pronunciation were averaged for a mean duration, in that the measurement from a single pronunciation may be unreliable.

2.2.3 Segmentation and Measurement

The duration of target consonants, regardless of their orthographic forms, was acoustically measured by analyzing the waveforms with reference to spectrograms manipulating Praat (Boersma & Weenink, 2021). The segmentation and measurement are also supplemented by auditory judgement in addition to acoustic analysis.

There are two types of stimuli regarding their distributions in the target words. The segments which are preceded by a stressed lax vowel and followed by unstressed one, also known as *ambisyllabic consonants*, undergo syllabification that complies with WSP. The duration of this kind of stimuli was generally measured from the offset of the periodic signal of the preceding vowel until the onset of the periodic signal of the following vowel, as will be seen in section 2.2.3.1.

On the other hand, the type of stimuli flanked by the preceding unstressed and the following stressed vowel is syllabified to the onset of the subsequent vowel, conforming to the MOP. In this respect, any silent pauses between the signal periodicity of the preceding unstressed vowel and the onset of the initial consonant in question, i.e., the release burst for stops; the aperiodic noise for fricatives; the antiformants for nasals; and the waveform alternations with less visible formant structure for approximants, were dismissed from the measurement.

2.2.3.1 Post-stress Intervocalic Consonants

The duration of the intervocalic voiceless stops was measured from the onset of the aperiodic signal in the waveform, which coincided with the stop closure or silent portion on the spectrogram, to the point where the periodic signal of the subsequent vowel was resumed, including VOT or the duration between the release burst and the voicing onset of the following vowel, as seen in Figure 13 demonstrating the segmentation for the [p].

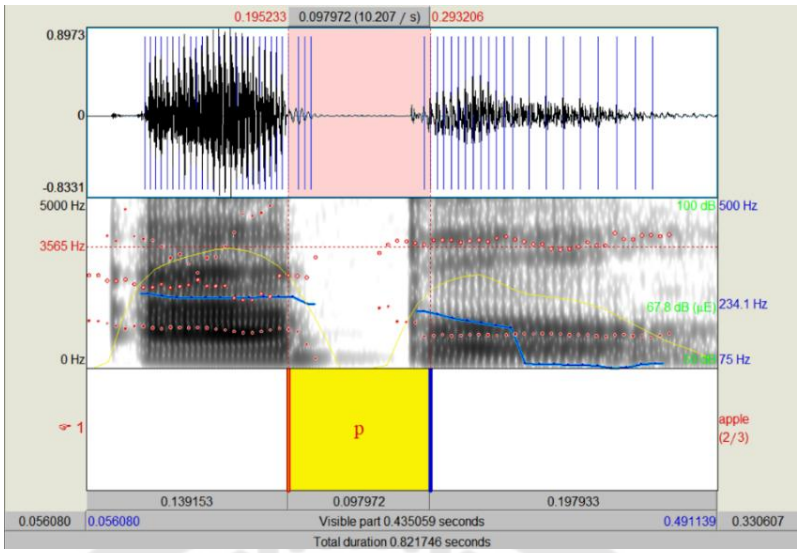


Figure 13 Segmentation for ambisyllabic [p] in 'pepper'

The duration of the intervocalic voiceless fricatives was measured from the onset of the aperiodic noise in the waveform, which coincided with a sudden drop of intensity or the white portion in the formant structure in the spectrogram, to the onset of the periodic vowel signal, as shown in Figure 14.

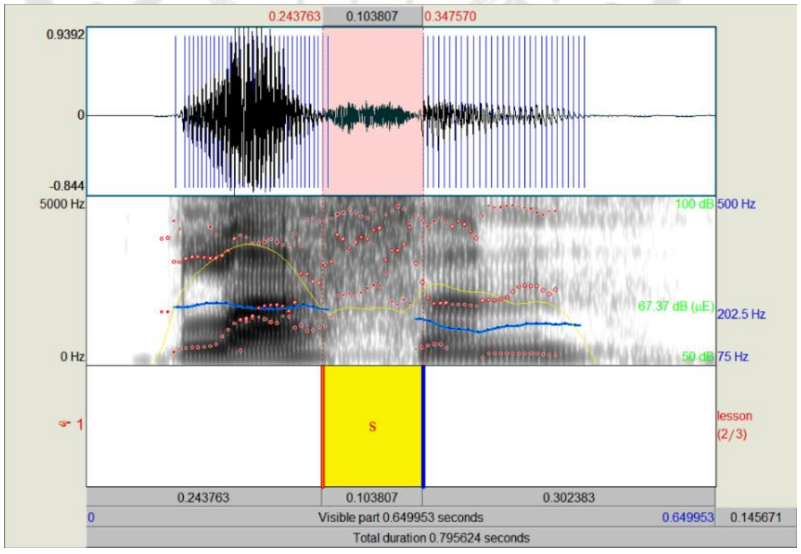


Figure 14 Segmentation for ambisyllabic [s] in 'lesson'

The duration of intervocalic nasals can be observed in the spectrogram as a portion with antiformants, characterized by the opposing white bands as the signal intensity was dampened. This coincided with the waveform alternations displaying low amplitudes.

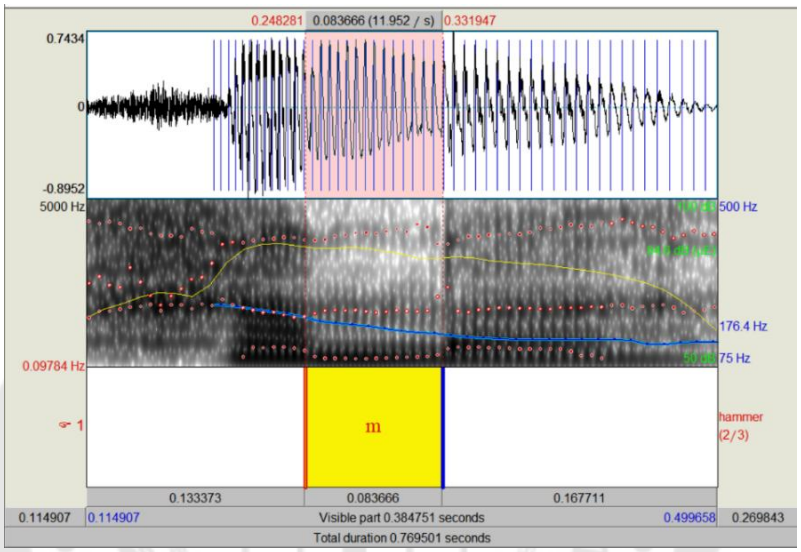


Figure 15 Segmentation for ambisyllabic [m] in 'hammer'

The duration of intervocalic approximants was measured from the onset of abrupt alternations in the waveforms and amplitude, coinciding with decreased signal intensity and less visible formant structure with the absence of antiformants. Regarding the lateral approximant, its onset can be demarcated by a pronounced reduction in the frequency of the first formant, as illustrated in Figure 16.

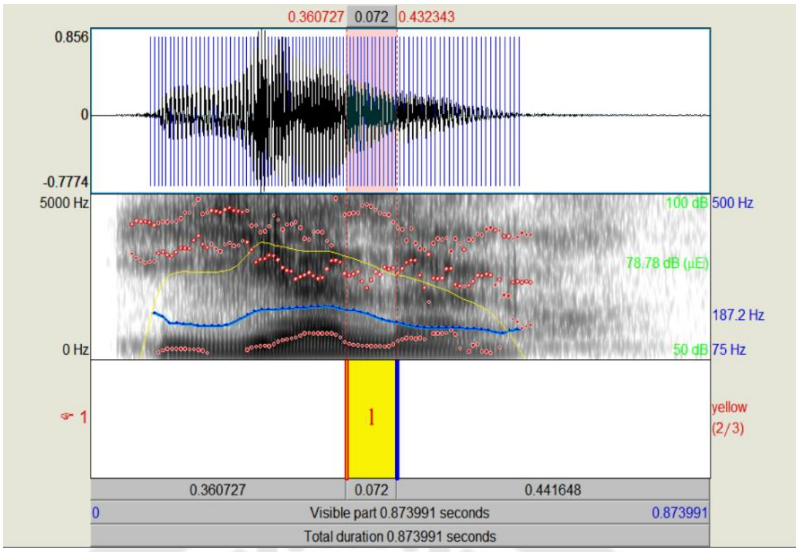


Figure 16 Segmentation for ambisyllabic [l] in 'yellow'

2.2.3.2 Pre-Stress Syllable-Initial Consonants

The measurement of the syllable-initial consonants differs from that elaborated in the previous sections, primarily due to the fact that any silent pauses intervening between the offset of the periodic signal of the preceding vowel and the onset of the release burst for voiceless stops, aperiodic noise for voiceless fricatives, antiformants for nasals, and alternations in the waveforms with less visible formant structure for approximants, were excluded from the measurement.

The duration of syllable-initial voiceless stop in the stressed syllable was determined by identifying the point where the release burst began to the point where the periodic signal of the following vowel was resumed in the waveforms. The silent portion from the end of the first vowel to the point of release burst was not included in the measurement.

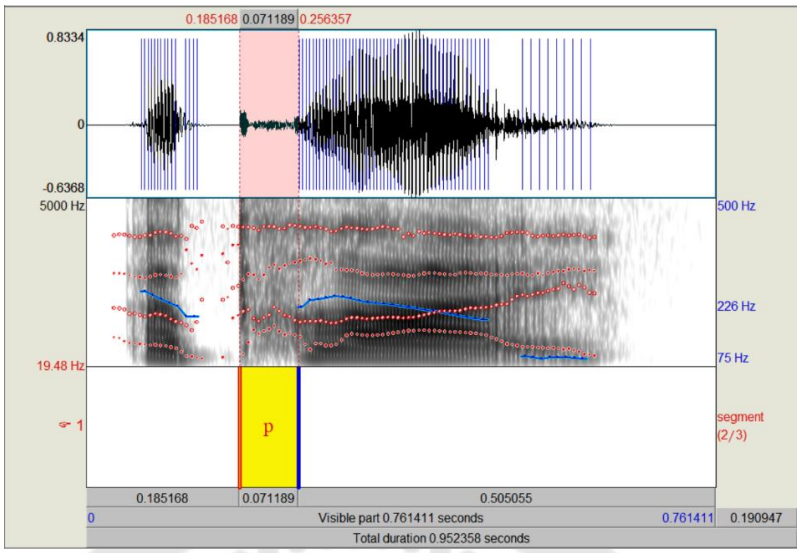


Figure 17 Segmentation for syllable-initial [p] in 'apply'

The duration of voiceless fricatives in the onset position was measured from the starting point of the aperiodicity of the waveform signal until the voicing onset of the subsequent vowel or until periodicity of the waveform signal. The silent portion before the onset of frictional aperiodicity was not included in the calculation.

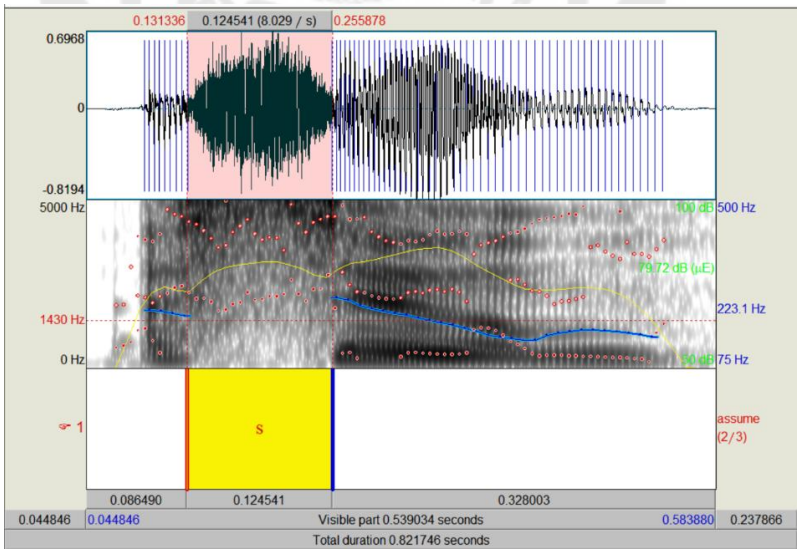


Figure 18 Segmentation for syllable-initial [s] in 'assume'

The duration of syllable-initial nasals was measured from the onset of an abrupt reduction in the intensity signal with presence of antiformants, corresponding to the opposing white bands in the spectrogram. It can also be observed from the onset of a change in the shape of waveforms with low amplitudes. Any silent intervals, if detected, between the offset of the first vowel to the onset of nasals described were excluded from measurement.

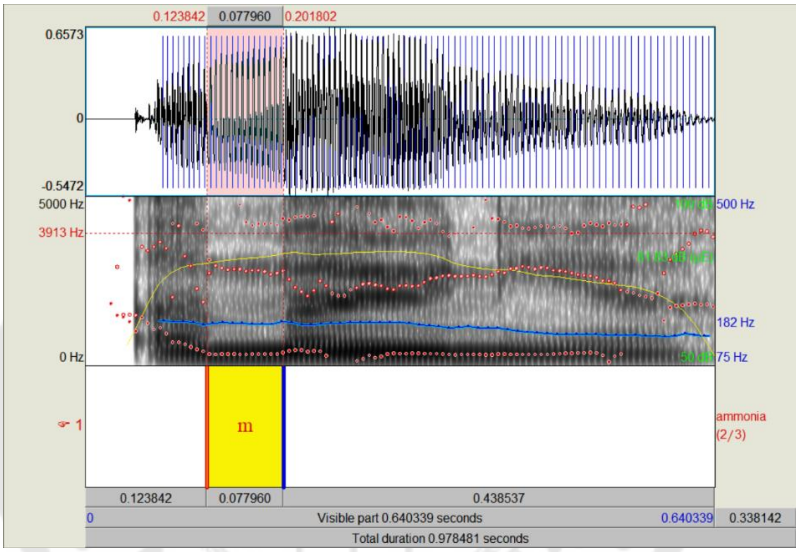


Figure 19 Segmentation for syllable-initial [m] in ‘ammonia’

The duration of syllable-initial approximants was measured from the onset of a sudden decrease in intensity, alternations of the waveforms and less visible formant structure, extending to the point where the formants stabilized in the following vowel. Any silent intervals, if detected, between the offset of the first vowel to the onset of approximants described were excluded from measurement.

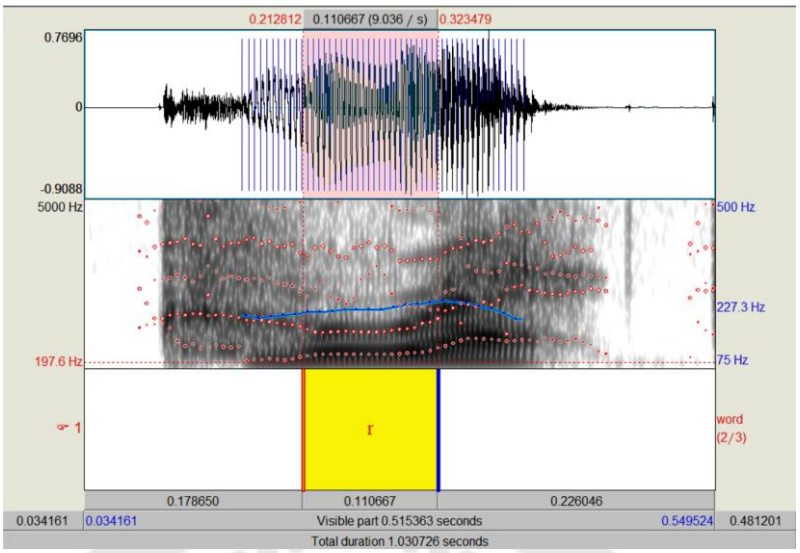


Figure 20 Segmentation for syllable-initial [r] in 'correct'

2.2.4 Data Analysis

Moreover, durational ratio of intervocalic consonants with orthographic singletons to geminates for each consonantal type was computed by dividing the geminate duration by the singleton duration.

The magnitude of impact of independent variables, namely orthographic forms, stress positions and consonantal types, on the acoustic duration coded as a dependent variable were also examined using Linear Mixed Model.

CHAPTER 4
FINDINGS

This chapter reports the outcomes derived from syllabification and production experiments participated by 60 native Thai speakers of English, classified according to CEFR English proficiency into A1, A2 and B1 cohorts, and a control group, consisting of four native American English speakers. The chapter is outlined as follows:

1. Results from syllabification experiment
    1.1 Frequency of each syllabification type
    1.2 Effects of orthographies and stress on syllabification
2. Results from production experiment
    2.1 Post-stress singleton-geminate ratios across consonantal manners
    2.2 Pre-stress singleton-geminate ratios across consonantal manners
    2.3 Comparison between post-stress and pre-stress singleton-geminate durational rations
    2.4 Effects of orthographies, stress and consonantal manners on acoustic durations

1. Syllabification Results

With regard to syllabification experiment, it is postulated that Thai L2 speakers of English, across all CEFR proficiency levels, rely on orthographic forms for the syllabification of intervocalic consonants, irrespective of stress interaction; more proficient individuals are anticipated to exhibit a reduced reliance on orthographies, compared to their counterparts at lower proficiency levels. Further, the frequency distribution of each syllabification type among the higher proficiency group will approach that of NESs.

A total of 2,048 responses[3] were collected from 64 participants, each syllabicating 32 target words presented in 64 multiple-choice question items. The frequency of each syllabification types, i.e., [V.CV], [VC.V], [VC.CV], was computed as an average percentage separately for each of the categories of word stimuli.

1.1. Frequency of Each Syllabification Type

Regarding participants at the CEFR level A1, their responses to stimuli with singleton graphemes exhibit a preference for the MOP. As delineated by Table 7, they principally assigned intervocalic consonants, orthographically represented as singletons, in both post-stress and pre-stress contexts, as the onset of the subsequent syllable, denoted as [V.CV], with substantial mean frequencies of 75% and 90.05%, respectively.

In contrast, when the stimuli are represented with geminate graphemes, the subject group exhibits a distinct inclination towards syllabifying the consonants as heterosyllabic geminates, represented as [VC.CV]. They did so at a rate of 60.05% for the consonants preceded by a stressed lax vowel and with a frequency of 53.8% for those followed by a stressed vowel. This suggests that this subject group who is in an early stage of acquisition tends to base their syllabification upon orthographic forms.

Table 7 Frequency of each syllabification type by A1-CEFR-level group

DV	<V́CV>	<V́CCV>	<VCV́>	<VCCV́>
[V.CV]	75	32.5	90.05	32.5
[VC.V]	7.5	13.8	4.4	7.55
[VC.CV]	17.5	53.8	5.65	60.05

[3] It is important to note that two participants unexpectedly paired the first part and the second part of the word without intervocalic consonant. For instance, they identified 'le-' as the first part and '-er' as the second part of the word 'leper'. Two unexpected responses were found from two separate participants, one from each, and both responses were found among singleton stimuli. These two participants were placed at A1 CEFR level. The two unanticipated responses account for 0.146 % of all tokens and were statistically excluded.

Consistent with the findings from the aforementioned participant group, Table 8 reveals that participants at CEFR level A2 predominantly applied the MOP for the syllabication of intervocalic consonants represented with a singleton grapheme in both post-stress and pre-stress contexts at the average rates of 67.5% and 88.75%, respectively.

Furthermore, participants in this proficiency level demonstrate a reliance on orthographic syllabification by assigning one of the geminate graphemes to the coda of the preceding and the other to the onset of the subsequent syllable, yielding heterosyllabic geminates. The responses counted as heterosyllabic geminates account for an average of 55.05% of all stimuli with geminate graphemes in pre-stress positions and an average of 51.25% of those in post-stress positions.

Table 8 Frequency of each syllabification type by A2-CEFR-level group

DV	<V́CV>	<V́CCV>	<VCV́>	<VCCV́>
[V.CV]	67.5	23.75	88.75	35
[VC.V]	13.75	25	5.05	10.05
[VC.CV]	18.75	51.25	6.3	55.05

Unlike the two preceding groups, the B1-CEFR-level group, who is at a more advanced stage of acquisition, exhibits a less pronounced reliance upon orthographic forms for the syllabification of intervocalic consonants. This is evident in the noticeable decrease in the frequency of heterosyllabic geminates [VC.CV], dropping from above 50% in the first two groups down to below 23%, as illustrated in Table 9.

Moreover, the frequency of syllabification responses in alignment with the WSP, denoted as [VC.V], soared up to 30.05% for post-stress stimuli with orthographic singletons and 26.90% for those with orthographic geminates.

Nevertheless, it can be inferred that the participants' syllabification remains predominantly influenced by the MOP, as borne out by consistently high percentages of the frequency of [V.CV] surpassing 50% across all categories of stimuli.

Table 9 Frequency of each syllabification type by B1-CEFR-level group

DV	<VCV>	<VCCV>	<VCV>	<VCCV>
[V.CV]	55.00	60.65	96.90	77.50
[VC.V]	30.05	26.90	0.00	0.00
[VC.CV]	15.00	12.55	3.15	22.50

In comparison to a group of NESs, participants with increased English proficiency demonstrated syllabification patterns closely resembled those of the native speakers for almost all response types. Specifically, the mean frequency of responses regarding post-stress stimuli, whether spelled with singleton or geminate letters, predominantly adhered to the MOP, followed by the WSP and heterosyllabic gemination, respectively. Thai speakers of English whose mother tongue language is stressless, but at a later stage of acquisition, tend to develop increasing awareness that intervocalic consonants are attracted to a stressed syllable, while orthographic forms of consonants have no influence upon syllabification. Table 10 presents the frequency of each syllabification response type, categorized by stress positions, orthographic forms and consonantal types, gathered from the NES group.

Table 10 Frequency of each syllabification type by NES group

DV	<VCV>	<VCCV>	<VCV>	<VCCV>
[V.CV]	53.15	46.9	100	100
[VC.V]	43.75	43.75	0	0
[VC.CV]	3.15	9.4	0	0

1.2 Effects of Stress and Orthographies on Syllabification

Linear Logistic Regression is performed to determine whether the independent variables, particularly orthographies and stress locations, influence each of the nominal dependent variables, i.e., [V.CV], [VC.V], [VC.CV], and to what extent they

are affected. Nonetheless, consonantal types are omitted as an independent variable in this analysis due to lack of relevance.

Table 11 Logistic regression analysis of effects of independent variables on syllabification by A1-CEFR-level group

DV	IV	β	Std. Error	Wald	df	*p*-value	Exp(β)
V.CV	Orthographies	-2.106	.182	11.962	1	0.001	.122
	Stress	.650	.183	122.576	1	<0.001	1.916
VC.V	Orthographies	.179	.268	.447	1	0.504	1.197
	Stress	-.927	.287	10.436	1	0.001	.396
VC.CV	Orthographies	2.247	.201	117.077	1	<0.001	9.455
	Stress	-.252	.187	1.701	1	0.192	.777

The data presented in Table 11 underscores the significant influences of stress positions and orthographic forms on the [V.CV] syllabification within the A1-CEFR-level group. The positive coefficient associated with stress positions suggests that intervocalic consonants in pre-stress positions are inclined to be syllabicated as the onset of the subsequent syllable. An exponentiated coefficient or odds ratio exceeding 1 signifies that the likelihood of intervocalic consonants being assigned as onsets is approximately twice as high in pre-stress positions compared to post-stress ($\beta = 0.65$, $p < 0.001$, $\exp(\beta) = 1.916$). A negative coefficient and an exponentiated coefficient less than 1 regarding orthographic forms indicate that orthographic singletons, as opposed to orthographic geminates, are prone to be syllabified as onsets. The likelihood of intervocalic consonants being syllabicated as onsets decreases by 12.2% when orthographically represented as geminates ($\beta = -2.106$, $p < 0.001$, $\exp(\beta) = 0.122$).

The syllabification [VC.V] is significantly influenced by stress placement ($p < 0.001$). A negative coefficient ($\beta = -0.927$) and an exponentiated coefficient ($\exp(\beta) = 0.396$) pertaining to stress positions indicate a 39.6% decrease in the probability of stimuli in pre-stress positions being syllabicated as the coda of the

preceding syllable. This type of syllabification is also impacted, albeit insignificantly, by the presence of geminate graphemes. The positive coefficient and the exponentiated coefficient greater than 1 reveal that intervocalic consonants with geminate letters, rather than those with singleton letters, are more likely to be associated with the coda of the preceding syllable (β = 0.180, p = 0.504, exp(β) =1.197).

Heterosyllabic gemination, denoted as [VC.CV], exhibits a robust dependence on orthography. Intervocalic consonants with geminate graphemes display a pronounced tendency for heterosyllabic gemination. The likelihood of responses regarding heterosyllabic gemination is estimated to be 9.5 times higher for the stimuli with orthographic geminates than for those with orthographic singletons (β = 2.247, p < 0.001, exp(β) = 9.455).

Table 12 Logistic regression analysis of effects of independent variables on syllabification by A2-CEFR-level group

DV	IV	β	Std. Error	Wald	df	*p*-value	Exp(β)
V.CV	Orthographies	-2.468	.190	139.186	1	<0.001	.085
	Stress	.764	.190	21.703	1	<0.001	2.147
VC.V	Orthographies	.741	.245	9.103	1	0.005	2.098
	Stress	-1.102	.257	18.411	1	<0.001	.332
VC.CV	Orthographies	2.276	.203	104.468	1	<0.001	9.737
	Stress	-.162	.187	1.706	1	0.395	.850

The results obtained from participants placed at CEFR level A2, as exhibited in Table 12, demonstrate significant impacts of orthographies and stress positions on the [V.CV] syllabification. A coefficient value of -2.468 and an exponentiated coefficient value of 0.085, along with a *p*-value of <0.001, associated with orthographies, imply that intervocalic consonants, when orthographically represented as singletons, are inclined to be syllabified as onsets. The likelihood of syllabification as an

onset is reduced by 8.5% when orthographically represented as geminates. Intervocalic consonants in pre-stress positions exhibit a greater propensity to be syllabicated as the onset of the subsequent syllable than those in post-stress positions. The odds of syllabification as onsets are approximately twice as high for stimuli in pre-stress positions as opposed to those in post-stress positions ($\beta = 0.764$, $p < 0.001$, $\exp(\beta) = 2.147$).

On the [VC.V] syllabification, stress exerts a statistically significant effect ($p < 0.001$). Intervocalic consonants in post-stress positions are more likely to be syllabified as the coda of the preceding syllable. The negative coefficient value of -1.102 and the exponentiated coefficient value of 0.332 concerning stress placement suggests a 33.2% decline in the likelihood of syllabification as a coda when they are in pre-stress positions. Stress is also found, albeit insignificantly, to have an effect on this syllabification type. Intervocalic consonants represented by geminate graphemes are inclined to be syllabicated as the coda. The probability of [VC.V] is approximately two times higher for orthographic geminates than for orthographic singletons ($\beta = 0.741$, $p = 0.005$, $\exp(\beta) = 2.098$).

Consistent with the preceding participant group, the findings from the A2-CEFR-level cohort demonstrate that orthographic forms have a considerable influence on heterosyllabic gemination. That is, there is a strong propensity for intervocalic consonants represented by geminate graphemes to be heterosyllabically geminated. The probability of stimuli undergoing heterosyllabic gemination is almost tenfold higher for those with geminate graphemes than for those with singleton graphemes ($\beta = 2.276$, $p < 0.001$, $\exp(\beta) = 9.737$).

Concerning participants placed at CEFR level B1, only stress placement exerts a significant impact on the [V.CV] syllabification, as demonstrated by Table 13. Intervocalic consonants followed by a stressed vowel are inclined to be syllabicated as an onset of the subsequent syllable, and the likelihood of syllabication as an onset is roughly fivefold greater for the stimuli in pre-stress positions than for those in post-stress positions ($\beta = 1.614$, $p < 0.001$, $\exp(\beta) = 5.021$). The impact of orthographic forms on

this syllabification type is statistically insignificant with a *p*-value of 0.040, a negative coefficient value of -0.389 and an exponentiated coefficient value of 0.678, intimating that the likelihood of intervocalic consonants being syllabicated as onsets diminishes by 67.8% when they are orthographically represented as geminates.

Table 13 Logistic regression analysis of effects of independent variables on syllabification by B1-CEFR-level group

DV	IV	β	Std. Error	Wald	df	*p*-value	Exp(β)
V.CV	Orthographies	-.389	.189	4.232	1	0.040	.678
	Stress	1.614	.203	63.295	1	<0.001	5.021
VC.V	Orthographies	-.154	.248	.384	1	0.536	.858
	Stress	-19.120	.000	.	1	.	4.968E-9
VC.CV	Orthographies	.756	.244	9.583	1	0.002	2.129
	Stress	-.083	.235	.124	1	0.725	.912

The [VC.V] syllabification is solely influenced by stress, with a highly negative coefficient and exponentiated coefficient values of -19.120 and 4.968E-9, respectively, indicating a strong inclination for intervocalic consonants in post-stress positions to be syllabified as codas, while those in pre-stress ones are associated with a 0.000000004968% decline in the odds of syllabification as codas.

The influence of orthographies on the [VC.CV] syllabification almost reaches statistical significance with a *p*-value of 0.002. Intervocalic consonants orthographically represented as geminates are twice as liable to undergo heterosyllabic gemination than those represented as singletons (β = 0.756, exp(β) = 2.129).

Table 14 reports effects of the orthographic forms and stress placement on syllabification among the NES group. The [V.CV] syllabification by the NES cohort is strongly influenced by stress, as indicated by the vast coefficient and exponentiated coefficient values (β = 20.571, exp(β) = 858,778,236.626), suggesting that intervocalic

consonants in pre-stress positions are approximately 850 million times more prone to be syllabified as onsets. This substantial influence aligns with the 100% average frequencies of [V.CV] syllabification responses in the pre-stress positions, as earlier seen in Table 10.

Table 14 Logistic regression analysis of effects of independent variables on syllabification by NES group

DV	IV	β	Std. Error	Wald	df	*p*-value	Exp(β)
V.CV	Orthographies	-.250	.501	.250	1	0.617	.779
	Stress	20.571	.000	.	1	.	858778236.626
VC.V	Orthographies	.000	.504	.000	1	1.000	1.000
	Stress	-20.421	.000	.	1	.	1.353E-9
VC.CV	Orthographies	1.165	1.183	.970	1	0.325	3.207
	Stress	-18.672	.000	.	1	.	7.7752E-9

Similarly, the [VC.V] syllabification is strongly affected by stress, as indicated by the highly negative coefficient value of -20.421 and the exponentiated coefficient value of 1.353E-9, signifying that intervocalic consonants in post-stress positions exhibit a pronounced tendency to be syllabified as codas. The findings from the B1-CEFR-level group, as hypothesized, more closely resemble those from the NES group than other Thai participant groups.

Heterosyllabic geminates produced by the NES group are more inclined to occur when preceded by stressed lax vowels, as pointed out by the high negative coefficient value of -18.675 and the exponentiated coefficient value of 7.7752E-9, suggesting a 0.00000077752% decrease in the likelihood of heterosyllabic gemination for pre-stress stimuli. Thus far, it can be inferred that stress is the primary factor influencing NESs' syllabification.

2. Production Results

Regarding production experiment, it is hypothesized that Thai L2 speakers of English produce intervocalic consonants with geminate graphemes longer in duration than those with singleton graphemes; the durational ratios of intervocalic consonants with orthographic singletons to those with orthographic geminates obtained from Thai speakers are greater than those obtained from NESs; the durational ratios of intervocalic consonants produced by Thai L2 speakers of English at higher proficiency levels align more closely with those by NESs, compared to Thai speakers at lower levels.

2.1 Post-Stress Geminate-Singleton Ratios across Consonantal Manners

Table 15 compares the average durations of post-stress intervocalic consonants orthographically represented as singletons with those represented as geminates across two consonantal manners and four groups of participants, whereas Table 16 sets out the singleton-geminate durational ratios between obstruents and sonorants in post-stress positions across two major classes of consonants and four different groups of participants.

Overall, post-stress intervocalic consonants with geminate letters are consistently produced longer in duration than those with singleton letters, as indicated by the average of consonantal durations of orthographic geminates higher than that of orthographic singletons across all participant groups, as demonstrated in Table 15.

Table 15 Average durations of intervocalic obstruents and sonorants with singleton and geminate graphemes in post-stress positions

	A1		A2		B1		NES	
	<VCV>	<VCCV>	<VCV>	<VCCV>	<VCV>	<VCCV>	<VCV>	<VCCV>
Obs	152.07	162.08	148.46	158.13	132.00	140.37	113.75	122.11
Sor	92.99	113.62	85.65	109.84	86.03	97.78	77.67	72.27
Avg.	122.53	137.85	117.05	133.98	109.01	119.07	95.71	97.19

On average, the durational ratios between the two types of orthographic forms slightly increase from participants at CEFR level A1 to A2 and steadily decrease from participants at level A2, B1 to native English participants, as seen in the Table below.

Table 16 Durational ratios of intervocalic obstruents and sonorants with singleton and geminate graphemes in post-stress positions

Manners	Ratio	A1	A2	B1	NES
Obs	<V́CV> <V́CCV>	1.07	1.07	1.06	1.07
Sor	<V́CV> <V́CCV>	1.22	1.28	1.14	0.93
Avg.	<V́CV> <V́CCV>	1.13	1.14	1.09	1.02

In addition, the orthographic singleton-geminate durational ratios from all groups of Thai participants are greater for sonorants than for obstruents, whereas, among the native English participants, the converse is observed with temporal ratios for obstruents higher than those for sonorants. Figure 21 provides comparison between the durational ratios of orthographic singletons to geminates for post-stress obstruents and those for sonorant counterparts.

Figure 21 Duration ratios of post-stress intervocalic obstruents and sonorants with singleton and geminate graphemes

Table 17 Average durations of intervocalic consonants with singleton and geminate graphemes in post-stress positions across four consonantal manners

	A1		A2		B1		NES	
	<VCV>	<VCCV>	<VCV>	<VCCV>	<VCV>	<VCCV>	<VCV>	<VCCV>
stop	179.31	185.78	165.35	174.44	144.06	145.63	119.00	119.67
fricative	124.82	138.38	131.56	141.81	119.94	135.11	108.50	124.54
nasal	87.22	108.39	81.68	103.96	86.17	95.19	72.42	62.21
approx	98.75	118.85	89.61	115.72	85.89	100.37	82.92	82.33

When taking into account each individual group of participants separately, as detailed in Table 17, the results gathered from the A1-CEFR-level cohort show that the lengths of the intervocalic consonants with both singleton and geminate graphemes increase from nasals, approximants, fricatives to stops. Similarly, the durations of intervocalic consonants with both singleton and geminate graphemes obtained from the A2-CEFR-level group also rise from nasals, approximants, fricatives to stops. The average durations with orthographic geminates produced by the B1-CEFR-level participants also rank in order of length from stops, fricatives, approximants to nasals,

whereas approximants and nasals are reversed in order of length for those with orthographic singletons. The durations of consonants with orthographic singletons gained from the NES participant group similarly range from nasals, approximants, fricatives to stops; however, for those with orthographic geminates, fricatives are instead found to be longest.

As Illustrated in Table 18, the durational ratio of singleton to geminate graphemes derived from the A1-CEFR-level cohort is greatest at 1.24 for intervocalic nasals, followed by 1.20 for approximants, 1.11 for fricatives and 1.04 for stops, whereas those produced by the A2-CEFR-level group of participants increase from 1.05 for the least vowel-like stops to 1.29 for the most vowel-like approximants. The durational ratios produced by the participants placed at B1 CEFR level soar from 1.01 for stops, 1.10 for nasals, 1.13 for fricatives up to 1.17 for approximants. Conversely, the durational ratios obtained from the NES group differently range from 0.86 for nasals, 0.99 for approximants, 1.01 for stops to 1.15 for fricatives.

Table 18 Durational ratios of intervocalic consonants with singleton and geminate graphemes in post-stress positions across four consonantal manners

Manners	Ratio	A1	A2	B1	NES
stop	<V́CV> <V́CCV>	1.04	1.05	1.01	1.01
fricative	<V́CV> <V́CCV>	1.11	1.08	1.13	1.15
nasal	<V́CV> <V́CCV>	1.24	1.27	1.10	0.86
approx	<V́CV> <V́CCV>	1.20	1.29	1.17	0.99

The hypothesis concerning post-stress stimuli is partially substantiated, in that the durational ratios obtained from the B1-CRFR-level group align more closely with those from the NES group across all consonantal categories despite different rankings; nonetheless, the durational ratios of the A2-CEFR-level group are less congruent with those of the NES than the A1-CEFR-level group.

2.2 Pre-Stress Geminate-Singleton Ratios across Consonantal Manners

The average durations of pre-stress intervocalic consonants orthographically represented as singletons in comparison to those represented as geminates across two consonantal manners and four groups of participants, as shown in Table 18, and the durational ratios of pre-stress orthographic singletons to geminates across two orthographic forms and four different groups of participants, are presented in Table 19.

On average, pre-stress intervocalic consonants orthographically represented as geminates are consistently produced with an average duration longer than those represented as singletons across all English proficiency levels including a group of NES participants, as seen in Table 19.

Table 19 Average durations of intervocalic obstruents and sonorants with singleton and geminate graphemes in pre-stress positions

	A1		A2		B1		NES	
	<VCV́>	<VCCV́>	<VCV́>	<VCCV́>	<VCV́>	<VCCV́>	<VCV́>	<VCCV́>
Obs	84.96	156.20	85.43	139.92	90.55	135.84	100.04	125.19
Sor	99.51	110.72	107.03	106.82	102.51	104.03	99.50	98.23
Avg.	92.23	133.45	96.23	123.37	96.53	119.93	99.77	111.71

The durational ratios of pre-stress orthographic singletons to geminates exhibit a consistent decrease from participants at CEFR level A1 to the NES participant group, and the pre-stress orthographic singleton-geminate durational ratios across all

cohorts of participants are greater for obstruents than for sonorants, as illustrated in Table 20 and Figure 22.

Table 20 Durational ratios of intervocalic obstruents and sonorants with singleton and geminate graphemes in pre-stress positions

Manners	Ratio	A1	A2	B1	NES
Obs	<VCV́> <VCCV́>	1.84	1.64	1.50	1.25
Sor	<VCV́> <VCCV́>	1.11	1.00	1.01	0.99
Avg.	<VCV́> <VCCV́>	1.45	1.28	1.24	1.12

Figure 22 Durational ratios of pre-stress intervocalic obstruents and sonorants with singleton and geminate graphemes

At a closer look, it can be seen, from Table 21, that intervocalic consonants with singleton graphemes produced by participants at CEFR level A1 rank in order of length from the most vowel-like approximants to the least vowel-like stops, whereas those with geminate graphemes exhibit an inverse ranking from the least vowel-like

stops to the most-vowel-like approximants. In a similar vein, the lengths of the intervocalic consonants orthographically depicted as singletons produced by the A2 CEFR level rank in order of length from the most-vowel-like approximants to the least vowel-like stops, albeit with those orthographically represented as geminates ranking from less vowel-like fricatives and stops, followed by nasals to the most vowel-like approximants. Participants at the B1 CEFR proficiency level produced the intervocalic consonants with singleton graphemes that exhibit an increase in length from stops, nasals, fricatives, to approximants, and produced those with geminate graphemes that exhibit an increase from approximants, nasals, stops to fricatives. The NES group produced the intervocalic consonants with orthographic singletons that increase from stops, nasals, approximants to fricatives, and those with orthographic geminates that increase from stops, approximants, nasals and fricatives.

Table 21 Average durations of intervocalic consonants with singleton and geminate graphemes in pre-stress positions across four consonantal manners

	A1		A2		B1		NES	
	<VCV́>	<VCCV́>	<VCV́>	<VCCV́>	<VCV́>	<VCCV́>	<VCV́>	<VCCV́>
stop	76.61	159.33	72.33	131.28	76.20	116.33	70.83	90.08
fricative	93.31	153.06	98.53	148.56	104.89	155.35	129.25	160.29
nasal	93.63	115.67	105.06	126.58	96.36	109.08	95.33	100.58
approx	105.39	105.76	108.99	87.06	108.65	98.97	103.67	95.88

Furthermore, as illustrated in Table 22, among the A1-CEFR-level participants, the durational ratio of the singleton to geminate graphemes is highest at 2.08 for intervocalic stops, followed by 1.64 for fricatives, 1.24 for nasals and 1.00 for approximants. Akin to the A1 group, the highest durational ratio produced by the A2 participants stands at 1.81 for stops, followed by 1.51 for fricatives, 1.20 for nasals, and 0.80 for approximants. By the same token, the durational ratios of orthographic singletons to geminates, obtained from the B1-CEFR-level cohort, rank in order of height

from 1.53 for stops, 1.43 for fricatives, 1.13 for nasals to 0.91 for approximants. Consistent to all the preceding groups of participants, the NES group exhibit durational ratios of orthographic singletons to geminates which range from the most vowel-like approximants to the least vowel-like stops.

Table 22 Durational ratios of intervocalic consonants with singleton and geminate graphemes in pre-stress positions across four consonantal manners

Manners	Ratio	A1	A2	B1	NES
stop	<VCV́> <VCCV́>	2.08	1.81	1.53	1.27
fricative	<VCV́> <VCCV́>	1.64	1.51	1.43	1.24
nasal	<VCV́> <VCCV́>	1.24	1.20	1.13	1.06
approx	<VCV́> <VCCV́>	1.00	0.80	0.91	0.92

Regarding the pre-stress stimuli, the hypothesis is validated as the durational ratios between two orthographic forms of all consonantal categories derived from participants with higher English proficiency are mostly more parallel to those obtained from the NES group, compared to lower proficient participants.

2.3 Comparison between Singleton-Geminate Ratios in Post-Stress and Pre-stress Positions

Table 23 compares the average durations of intervocalic consonants orthographically represented as singletons with those represented as geminates, and the durational ratios of orthographic singletons to orthographic geminates in pre-stress positions with those in post-stress positions.

Table 23 Singleton-geminate ratios in post-stress and pre-stress positions

	A1		A2		B1		NES	
	Duration	Ratio	Duration	Ratio	Duration	Ratio	Duration	Ratio
<VCV>	122.53	1.13	117.05	1.14	109.01	1.09	95.71	1.02
<VCCV>	137.85		133.98		119.07		97.19	
Avg.	130.19		125.52		114.04		96.45	
<VCV>	92.23	1.45	96.23	1.28	96.53	1.24	99.77	1.12
<VCCV>	133.45		123.37		119.93		111.71	
Avg.	112.84		109.8		108.23		105.74	

Overall, the participants at all proficiency levels consistently produced both pre-stress and post-stress intervocalic consonants with geminate letters longer than those with singleton letters, as indicated by averages of consonantal durations higher for orthographic geminates than for orthographic singletons and by the durational ratios between orthographic singletons and geminates exceeding 1.

In addition, as can be seen in Figure 23, the singleton-geminate ratios associated with post-stress positions slightly increase from participants at CEFR level A1 to A2 and steadily decrease from participants at level A2, B1 to native English participants. On the other hand, the ratios concerning pre-stress positions consistently decrease from participants at CEFR level A1, A2, B1 to native English participants. Regardless of orthographic forms, intervocalic consonants in post-stress positions are produced longer in duration than those in pre-stress positions across all Thai participant groups. Nonetheless, the NES group produced the intervocalic consonants longer in duration for pre-stress positions than for post-stress ones.

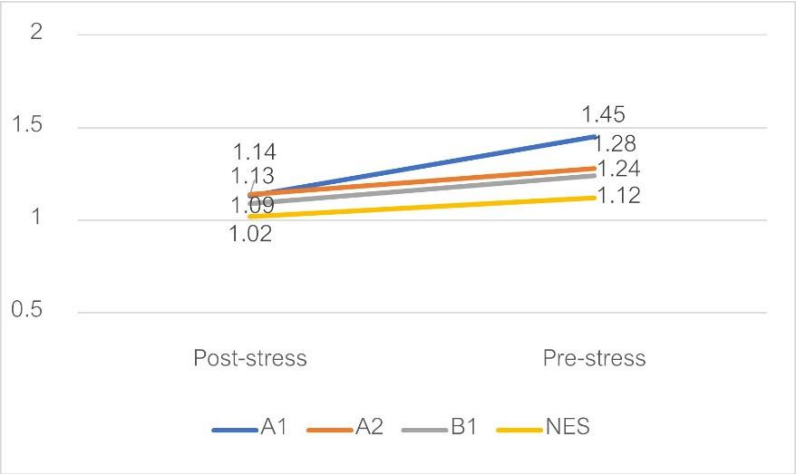


Figure 23 Durational ratios of pre-stress and post-stress intervocalic consonants with singleton and geminate graphemes

2.4 Effects of Orthographies, Consonantal Types and Stress on Acoustic Duration

The influences of orthographic forms, stress placements and consonantal categories on acoustic durations were examined utilizing Linear Mixed Model. Table 24 illustrates that, among the cohort of participants at CEFR level A1, the three independent variables exert a statistically significant impact on acoustic durations of intervocalic consonants, denoting that these variables can potentially elucidate the extent of variability in acoustic duration with the consonantal types being the strongest explanatory factor, followed by orthographies, and stress placement.

Table 24 Effects of independent variables on duration within A1-CEFR-level group

	Numerator df	Denominator df	F	*p*-value
Stress Placement	1	636	29.426	<0.001
Orthographies	1	636	70.122	<0.001
Consonantal Manners	1	636	137.884	<0.001

Upon closer examination through one-way ANOVA analysis, the stimuli orthographically represented by geminate graphemes with an average duration of

135.65 ms are produced significantly longer in duration than those represented by singleton graphemes with a mean duration of 107.135 ms ($F = 55.692$, $p < 0.001$). The stimuli preceded by stressed vowels with an average duration of 130.185 ms are also found to be significantly longer than those followed by stress with a mean duration of 112.84 ms ($F = 22.244$, $p < 0.001$). Intervocalic obstruents whose average duration is 138.825 ms are pronounced with a length significantly greater than intervocalic sonorants whose average duration is 104.208 ms ($F = 119.598$, $p < 0.001$).

Akin to the preceding cohort of participants, conspicuous effects of the three independent variables on the consonantal durations are also evident within A2-CEFR-level participants. Nonetheless, stress placement is identified as the most influential factor in explaining the variance in acoustic durations, followed by consonantal types, and orthographies, as demonstrated in Table 25.

Table 25 Effects of independent variables on duration within A2-CEFR-level group

	Numerator df	Denominator df	F	*p*-value
Stress Placement	1	636	95.899	<0.001
Orthographies	1	636	11.071	<0.001
Consonantal Manners	1	636	94.163	<0.001

Furthermore, one-way ANOVA analysis reveals that stimuli with geminate graphemes with an average duration of 128.675 ms are produced longer in duration, albeit insignificantly, than those with singleton graphemes with a mean duration of 106.64 ms ($F = 8.551$, $p = 0.004$). The stimuli preceded by stress with an average duration of 125.515 ms are found to be significantly longer than those followed by stress with a mean duration of 109.8 ms ($F = 82.543$, $p < 0.001$). The obstruent stimuli with a mean duration of 132.983 ms is significantly longer than the sonorant ones with a mean duration of 102.332 ms ($F = 80.860$, $p < 0.001$).

The Linear Mixed Model analysis, gained from participants at CEFR level B1, insinuates that, among the three independent variables, the strongest factor that can

explain variance in acoustic durations is consonantal types, followed by orthographies and stress placement, as shown in Table 26.

Table 26 Effects of independent variables on duration within B1-CEFR-level group

	Numerator df	Denominator df	F	*p*-value
Stress Placement	1	636	6.985	0.008
Orthographies	1	636	72.557	<0.001
Consonantal Manners	1	636	78.944	<0.001

The statistical analysis performed by one-way ANOVA suggests that the stimuli spelled with orthographic geminates whose average length is 119.5 ms are pronounced significantly longer in duration than those with orthographic singletons which exhibits a mean length of 102.77 ms ($F = 64.122$, $p<0.001$). Stimuli in post-stress positions whose average length measures 114.04 ms are not produced significantly longer than those in pre-stress positions with a mean length of 108.23 ms ($F = 5.659$, $p = 0.018$). The participants produced obstruent stimuli with an average duration of 124.69 ms significantly greater than sonorant counterparts whose mean duration measures 97.59 ms ($F = 70.389$, $p < 0.001$).

Regarding the NES group, it is evident that only consonantal types exert a statistically significant effect on acoustic durations of intervocalic consonants ($p<0.001$), as displayed in Table 27. Conversely, stress and orthographic forms do not potentially serve as explanatory factors accounting for the variance in the dependent variable.

Table 27 Effects of independent variables on duration within NES group

	Numerator df	Denominator df	F	*p*-value
Stress Placement	1	124	3.020	.085
Orthographies	1	124	.892	.347
Consonantal Manners	1	124	25.367	<.001

The one-way ANOVA analysis shows that there is no statistically significant difference in mean durations between intervocalic consonants with singleton graphemes whose average duration measures 97.74 ms and those with geminate graphemes whose average duration measures 104.45 ms ($F = 0.738$, $p = 0.392$). Similarly, the average duration of the stimuli in post-stress positions measuring 96.45 ms and that of the stimuli in pre-stress positions measuring 105.74 ms do not differ significantly ($F = 2.532$, $p = 0.114$). Nonetheless, the obstruent stimuli whose average duration measures 115.27 ms differ significantly in length from their sonorant counterparts whose mean duration measures 86.917 ms ($F = 24.988$, $p < 0.001$).

CHAPTER 5
CONCLUSION AND DISCUSSION

This chapter is bifurcated into two segments. The initial part provides a recapitulation and discussion of the current findings, in relation to the hypotheses formulated, the results from previous studies and prior literature. The findings are derived from both syllabification experiment, through the word-part identification task, and production experiment, using the reading-aloud task. The subsequent section addresses the limitations of the current study and provides recommendations for future research.

Summarization and Discussion of the Current Findings

Findings from Syllabification Experiment

The findings from this study unveils a dynamic, evolving pattern of syllabification preferences among Thai speakers of English at different CEFR proficiency levels, influenced by stress placement and orthographic forms. These preferences evolve as participants proceed through stages of L2 acquisition towards nativelikeness.

At the initial stage of acquisition, the A1-CEFR-level participants exhibit a strong reliance on orthographic forms for syllabification. They prefer the MOP over other syllabification principles when intervocalic consonants are orthographically represented singletons. They most frequently syllabify the orthographic singletons, whether preceded or followed by stress, as [V.CV]. On the other hand, when intervocalic consonants are orthographically represented as geminates, they prefer heterosyllabic gemination. Consequently, they most frequently syllabify orthographic geminates as [VC.CV].

Within this group, the [V.CV] syllabification, based on MOP, is significantly influenced by stress positions and orthographic forms. Regarding the former, Intervocalic consonants in pre-stress positions are inclined to be syllabicated as the onset of the subsequent syllable other than those in post-stress positions. Concerning the latter, orthographic singletons are prone to be syllabified as onsets, as opposed to

orthographic geminates. The [VC.V] syllabification is significantly affected by stress positions. The post-stress stimuli are more likely to be syllabicated as the coda of the preceding syllable. The heterosyllabic gemination is significantly influenced by orthographic forms. Orthographic geminates display a pronounced tendency for being syllabicated as [VC.CV].

Syllabification of intervocalic consonants with singleton graphemes remains predominantly aligned with the MOP among the A2-CEFR-level participants. They frequently syllabify the orthographic singletons, whether preceded or followed by stress, as [V.CV]. Nonetheless, their L2 acquisition of syllabification shows a slight decrease in reliance on orthography, as indicated by a lower average frequency of heterosyllabic geminates. It also demonstrates a slight increase in reliance on the WSP, as evidenced by a higher mean frequency of syllabification of stimuli preceded by stress as codas.

Among this group, orthographies and stress positions significantly affect the [V.CV] syllabification. Regarding the former independent variable, intervocalic consonants, when orthographically represented as singletons, are inclined to be syllabified as onsets. With respect to the latter, Intervocalic consonants in pre-stress positions exhibit a greater propensity to be syllabicated as the onset of the subsequent syllable than those in post-stress positions. The [VC.V] syllabification is strongly affected by orthographic forms. Intervocalic consonants represented by geminate graphemes are inclined to be syllabicated as the coda. There is also a significant impact of stress placement on this syllabification. The stimuli in post-stress positions are more likely to be syllabified as the coda of the preceding syllable. Heterosyllabic gemination is significantly influenced by orthographic forms. Intervocalic consonants represented by geminate graphemes demonstrate a strong propensity to be heterosyllabically geminated.

Syllabication by participants placed at CEFR level B1, whose L2 acquisition further progresses towards nativelikeness, demonstrates a substantial decline in their preference for heterosyllabic gemination, with a growing inclination towards

syllabification in line with the WSP. This suggests increased awareness of the interaction of stress placement with syllabification.

The [V.CV] syllabification is affected by stress placement. Intervocalic consonants followed by a stressed vowel are inclined to be syllabicated as an onset of the subsequent syllable. Similarly, the [VC.V] syllabification is solely influenced by stress. There is a strong inclination for intervocalic consonants in post-stress positions to be syllabified as codas, while those in pre-stress ones are less likely to be syllabicated as codas. The influence of orthographies on the [VC.CV] syllabification is not significant. Intervocalic consonants orthographically represented as geminates are slightly liable to undergo heterosyllabic gemination than those represented as singletons.

Hypothetically, the syllabification preferences of participants with higher English proficiency more closely align with those of the NES, reflecting a maturation of linguistic competence in terms of syllabification through stages of L2 acquisition. Gemination among Thai participants serves as compelling evidence that L1 orthography and phonology interfere with the acquisition of English syllabification. This L1 interference weakens as participants advance in their L2 acquisition.

The results from this current research replicate those of earlier studies, conducted by researchers such as Eddington et al. (2013), Elzinga and Eddington (2014) and Ishikawa (2002), revealing that intervocalic consonants preceded by stress are more liable to be syllabicated as codas, especially by NES and L2 speakers of English with increased English proficiency, and less likely as ambisyllabic segments. On the contrary, intervocalic consonants that occur in pre-stress positions are more inclined to be syllabified as onsets. Such findings collaboratively support the notion that stressed syllables attract consonants that appear intervocalically into their coda or onset (Derwing, 1992; Fallow, 1981; Treiman & Zukowski, 1990).

Non-native speakers of English as an L2, such as Japanese participants in Ishikawa (2002) tend to prefer syllabification as an onset following MOP, regardless of stress placement, whereas Thai participants in this study displayed a preference for syllabification as an onset when intervocalic consonants are orthographically

represented as singletons and as heterosyllabic geminates, or known as *ambisyllabic consonants* in other studies, when the consonants are orthographically represented as geminates. The findings from both studies are in common as the acquisition of L2 phonology appears to be interfered by that of the L1.

Furthermore, the fact that orthographic forms influence syllabification has also been consistently supported by prior studies by Treiman and Danis (1988), Derwing (1992) and Treiman et al. (2002). Nonetheless, the current findings regarding consonantal types are not in accordance with the previous ones suggesting that sonorants tend to be attracted to the coda of the preceding syllable rather than obstruents (e.g. Derwing & Neary, 1991; Treiman et al., 1992).

Finally, native speakers in previous studies were reported to ambisyllabify, referred to in this study as 'to heterosyllabically geminate', intervocalic consonants more frequently than the NES in the present study do. Elzinga and Eddington (2014) and Ishikawa (2002) found that a relatively large number of responses from NES and trained Japanese speakers were associated with ambisyllabicity.

Findings from Production Experiment

The study also examined the acoustic durations of intervocalic consonants, shedding light on the relationship between phonological and acoustic analyses. Participants from all CEFR levels consistently produced intervocalic consonants orthographically represented as geminates in both post-stress and pre-stress positions longer in duration than those represented as singletons. The durational ratios of orthographic singletons to geminates in post-stress positions slightly increased from CEFR level A1 to A2 and steadily decreased from A2 to B1, approaching NESs' patterns. The durational ratios between the two orthographic forms in pre-stress positions exhibited a decrease from A1 to NES participant group.

The acoustic duration of intervocalic consonants is influenced by orthographic representations (Thirakunkovit, 2019). As hypothesized, consonants orthographically represented with geminate graphemes, assumed to be syllabified and produced as heterosyllabic geminates by Thai participants, are on average acoustically

longer than those produced by NES. The durational ratio of orthographic singletons to geminates, especially in post-stress positions, obtained from the NES group, which is close to 1, suggests that intervocalic consonants, whether orthographically surfacing as singleton graphemes or as geminate graphemes, are produced at roughly equal lengths. This finding reflects NESs' mental representation of syllabification in which stress interacts with syllabification rather than orthographic forms, and consonants preceded by stressed lax vowels are assumed to be ambisyllabic consonants, albeit, with their length being the same as that of non-ambisyllabic singleton consonants.

On the other hand, heterosyllabic gemination reflects native Thai speakers of English' mental representation of syllabification where geminate graphemes are syllabified as two separate phonemes across syllables. This finding is, however, not supported by acoustic evidence, in that the ratio of consonants with singleton graphemes to those with geminate graphemes which roughly ranges between 1.1 and 1.5 suggests that the consonants assumed to be heterosyllabic geminates are actually shorter than true lexical geminates, found in languages such as Russian, Italian, Japanese and Bengali, which were reported to be one and a half to three times longer than singleton counterparts (Ladefoged & Maddieson, 1996).

With respect to the types of consonants, the results from this research are consistent with those found in the works of Dmitrieva (2012) and Dmitrieva (2017) where singleton and geminate obstruents were on average reported to exhibit longer duration than sonorants. This indicates a cross-linguistic similarity in which length of consonants decreases from voiceless obstruents, voiced obstruents, nasals to liquids. However, it is noteworthy that the results should be interpreted with caution as consonants are known to have intrinsically different durations. For example, voiceless obstruents are typically longer than voiced ones, and obstruents in general tend to be longer than sonorants (Crystal & House, 1988; Klatt, 1976).

In conclusion, the study demonstrates that syllabification preferences among Thai speakers of English evolve with increasing proficiency, influenced by both stress placement and orthographic forms. Acoustic durations of intervocalic consonants

are also affected by orthographic forms, stress positions and consonantal types. As participants advance in their L2 acquisition, they exhibit greater alignment with native speakers in terms of both syllabification patterns and acoustic durations of intervocalic consonants.

These findings have implications for language teaching and learning, as they highlight the importance of both phonological and acoustic aspects when teaching English syllabification to non-native speakers. The study underscores the dynamic nature of language acquisition and the role of stress patterns and orthographic forms in shaping phonological and acoustic features in second language acquisition.

Limitations and Recommendations for Future Research

The current investigation exhibits certain shortcomings with regard to experimental design, participant quantity, data analysis, and practical application. Consequently, the following recommendations for future research are provided:

1. Studies addressing geminates involving native Thai speakers are scarce, and, to the best of my knowledge, these studies have exclusively utilized authentic English words as stimuli. However, forthcoming research may incorporate nonwords or nonces as stimuli in experimental tasks administered to Thai participants to eliminate prior familiarity with the words. The exploitation of nonwords as stimuli with singleton-geminate contrast can be found in Dmitrieva (2012), Ham (2001) and as syllabification stimuli in Ishikawa (2002) and as stimuli related to lexical stress in Jangjamras (2011).

2. Consonantal stimuli in this study are twofold: (1) intervocalic consonants preceded by a stressed lax vowel and followed by an unstressed vowel, denoted as $V_{[+lax,\ +stress]}C(C)V_{[-stress]}$, which are treated as ambisyllabic segments, and (2) intervocalic consonants flanked by an unstressed vowel and a stressed vowel, represented as $V_{[-stress]}C(C)V_{[+stress]}$. Prospective researchers may extend the study by including intervocalic consonants preceded by a stressed tense vowel and followed by an unstressed vowel, encoded as $V_{[+tense,\ +stress]}C(C)V_{[-stress]}$.

3. The group of native English participants in the current study is relatively small, consisting of only four native American English speakers. Future research should take into account the appropriate sampling size for native English speakers.

4. Participants with higher levels of English proficiency such as those placed at CEFR level B2 and those at level C1 may also be recruited. By doing so, sorn8861differences in syllabifications and acoustic durations between lower and higher proficiency groups could be more noticeable.

5. Further research of this kind may consider carrying out production experiment prior to syllabification experiment; otherwise, participants may transfer what they have learned from the perception experiment to their performance, potentially leading to more accurate production. Nonetheless, the sequencing of the tasks should be guided by research questions and hypotheses being investigated.

6. Finally, those who are interested in English instruction may base a further study in relation to teaching method upon the current findings; in addition, teachers whose interest is in material development may create instructional materials on syllabification and pronunciation of intervocalic consonants based on the results of the current study.

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