



Articulation Timing and Orthographical Representation of Consonant Gemination in Sinhala¹

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Abstract

Consonant gemination, in general, has two major aspects: either lengthening or doubling the pronunciation of the consonant. This study mainly focuses on articulation and orthography in Sinhala, the two parts of the language where consonant gemination occurs. It examines the pronunciation time ratios of 16 pairs of singleton and geminated Sinhala consonants in order to analyze the relationship that exists between their articulation and orthography. The research problem was stated as 'what relationship is disclosed by the articulation time ratios and orthography of consonant gemination in Sinhala'. To answer it, the articulation timings of the singleton and geminated consonants were measured with the ratios between them being calculated. Then, as the second step, the ratios and the orthographic symbolization were compared and contrasted. A group of ten adult participants contributed to the data: five males and five females. Praat.exe was the main technical instrument used to measure pronunciation timings. The data revealed that the ratios lie between a minimum of 1:1.6 and a maximum of 1:2.4 times. Therefore, consonant gemination in Sinhala is a lengthening process. Moreover, the alpha-syllabic writing system ignores the length ratios of the geminated consonants.

Keywords: Consonant gemination, Pronunciation time ratio, Pronunciation timing, Singletons, Sinhala

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INTRODUCTION

Sinhala (Sinhalese) is an Indo-Aryan language used in Sri Lanka situated in the Indian Ocean. It is the native language of the Sinhalese people who live in and outside of Sri Lanka. Language diglossia is a special feature of Sinhala as its spoken and written forms show significant differences in sounds, vocabulary, and grammar. Consonant gemination in Sinhala is

clearly visible both in the colloquial and written varieties. In other words, it is visible in speech production and orthography. Sinhala has an alpha-syllabic writing system, “in which successive characters sometimes represent a single consonant or vowel, as in an alphabet, and sometimes a syllable, as in a syllabary” (Mathews, 2007, p.16). Table 1 illustrates how such systems work.

Table 1: *The Sinhala Alpha-Syllabary System- Example with [k]- IA*

Pure Consonant	Short Vowel	Short Consonant	Pure Consonant	Long Vowel	Long Consonant
[k] ක්					
[k] ක්+	[ə] අ=	[kə] ක			
[k] ක්+	[a] අ=	[ka] ක	[k] ක් +	[a:] ආ =	[ka:] කා
[k] ක් +	[æ] ඇ=	[kæ] කැ	[k] ක් +	[æ:] ඈ =	[kæ:] කෑ
[k] ක් +	[i] ඉ=	[ki] කී	[k] ක්+	[i:] ඊ =	[ki:] කී
[k] ක්+	[u] උ =	[ku] කූ	[k] ක් +	[u:] ඉ =	[ku:] කූ
[k] ක් +	[e] එ =	[ke] කෙ	[k] ක් +	[e:] ඒ =	[ke:] කේ
[k] ක්+	[o] ඔ =	[ko] කො	[k] ක් +	[o:] ඔ =	[ko:] කෝ
With Diphthongs					
[k] ක්+	[ai] ඔඑ =	[kai] කොඔ			
[k] ක් +	[au] ඔඉ =	[kau] කොඉ			

The pronunciation of the central-low (/a/) and central-mid (/ə/ -schwa) vowels, which are also known as open /a/ and close /ə/, form minimal pairs whereas in Sinhala orthography no distinction exists. Therefore, consonant combinations using these two vowel sounds may be represented by the same script: /ka/ -ක and /kə/ - ක. Wasala and Gamage (2005) argue that “in the absence of a diacritic for a particular consonant should be associated with either schwa or vowel ‘a’. Generally, in Sinhala words, the tendency of associating a schwa is

high”. (p.479) According to convention, native speakers know the appropriate use of /a/ and /ə/ even though the distinction is not present in writing (ex: i, j, k, n, o, p). When a central vowel sound appears at the word onset position, it is always pronounced with central low /a/, except for a few examples such as [kəɾənəva:] කරනවා ‘do’.

In addition to consonants, vowel gemination also produces a huge number of minimal pairs in Sinhala. However, this paper focuses only on the pronunciation time ratios of



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geminated consonants in Sinhala with their singleton sounds and the relationship that they have with Sinhala orthography.

Consonant gemination

According to the Oxford Dictionary of Difficult Words, “a consonant is a basic speech sound in which the breath is at least partly obstructed and which can be combined with a vowel to form a syllable” (Hobson 2001, p.94). Consonant gemination is defined as “a change or process by which consonants are doubled” (Matthews, 2005, p. 141). However, this is not just a phonemic level phenomenon; it also is influential at the lexical and semantic levels. For this reason, Delattre (2007) introduces gemination as a “meaningful perceptual doubling of a consonant phoneme” (p.01).

In Linguistics, long or doubled consonant sounds are called geminated consonants but the terms geminate and double consonant overlap. Lehiste, Morton, & Tatham (1973) explain the difference between the two concepts suggesting that “geminate consonants differ from long consonants in that their production involves a re-articulation of the consonant, which thus consists of two phases” (p.01). They appear at a syllable boundary as the first consonant is placed at the final syllable position of the first phrase while the other consonant is placed at the onset position of the re-articulated second phrase. “The opposing view denies the existence of two phases and

refuses to recognize any difference between geminates and long consonants” (Lehiste, et all 1973, p.131). Moreover, by using the two concepts together, “geminate (long) consonants” (p.77), Davis (2003) shows that gemination of consonants is a lengthening process but not a moraic and bimoraic process as it occurs with both short and long vowels.

The placement of the lengthened consonant (within or at the word boundary) is another crucial fact that adds importance to consonant gemination. “164ill lend’ vs ‘will end’ in English and ‘stiehl loden’ vs ‘stiehl oden’ in German are two of the given examples for consonant gemination occurring at word boundaries, especially in natural and rapid speech. Apart from the many examples given from the Sinhala language discussed in this paper, ‘perro’ (dog) vs ‘pero’ (but) in Spanish and ‘starr’ (rigid) vs ‘star’ (star) in German are other instances of consonant gemination occurring within the word boundary. Moreover, comparing Italian geminates with those in English, Ladefoged states:

“The difference is that in Italian a long consonant can occur within a single morpheme... But in English, geminate consonants can occur only across word boundaries, as in the previous example [white tie], or in a word containing two morphemes, such as unknown [ʌn'noun] or guileless ['gajl.ləs]”. (Kaye, 2005, p. 45)



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Kaye calls it a “fake gemination” if gemination occurs at a word boundary due to rapid speech and because it happens unbeknown to the speaker. In the production of languages such as Sinhala and Tamil, the consonant becomes longer and results in minimal pairs while in the orthography, consonant gemination is symbolized by repeating the consonant letter. In contrast “it has long been known that English does not have contrastive CG [consonant gemination] as is recognized” (Kaye, 2005, p. 43). In English, minimal pairs do not occur as a result of consonant gemination and doubling the consonant letter in English orthography has no connection to the length of the consonant.

Relevant examples from languages other than Sinhala have been used in this paper because comparison and contrast may assist readers to understand how this linguistic phenomenon works in Sinhala language.

Consonant gemination in Sinhala speech

This section discusses the different positions where consonant germination occurs in Sinhala words and different grammatical environments (nouns, verbs etc.). The sentence pairs below illustrate how the perception and production of the contrast between geminated and non-geminated sounds directly affect the clarity of communication.

- a) [attə kapannə.] – ‘cut the branch of the tree’ vs
- b) [atə kapannə.] – ‘cut the arm’
- c) [e:kə niyəmə pasak.] – ‘it is a rich soil’ vs
- d) [e:kə niyəmə passak.] – ‘it is a lovely bum’.

An addition of a single consonant to the existing utterance may bring a totally different idea, which may lead the speaker or the listener into an uncomfortable situation. This supports the opinion of Delattre: “gemination always seems to make a major contribution to the distinction of meaning” (2005, p.1).

The presence of consonant gemination as a phonemic contrast is another feature that adds to the uniqueness of the Sinhala language. Consonant gemination occurs within the stem

- e) gassə + nəva: = gassənəva: (jerk)
(v. root + present tense marker),
in phonemic boundaries
- f) kolu + a: > kolu w a: > kol wa > kolla:
(boy)
(boy-stem + sin. def. suffix) > /w/
semi-vowel Insertion > /u/
deletion > /l/ gemination), and in
word boundaries
- g) mal + a:sənə > malla:sənə (flower +
seat) > (altar to offer flowers)
(flower – stem + seat – stem) > /l/
gemination.

There is no evidence that the /r/ in Sinhala is geminated producing minimal pairs. However, the Sinhala language adds [ekə] (definite) or [ekak] (indefinite), which means ‘one’,



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following an inanimate- singular-countable English noun in order to Sinhalize the loan word taken from English. The number of syllables in the noun does not seem to influence the word- final alveolar trill /r/ to get geminated. For instance,

- h) [ka:r ekə] 'the car', [ba:r ekə] 'the bar',
 i) [o:ɖər ekə] 'the order', [tuwər ekə] 'the tour', [iyər ekə] 'the year', [kaɖər ekə], 'the cutter', [bo:ɖər ekə] 'the boarder', [kænsər ekə] 'the cancer', [ca:jər ekə] 'the charger', [filɖər ekə] 'the filter', [printər ekə] 'the printer', [ha:bər ekə] 'the haurbour',
 j) [dayəpər ekə], 'the diaper', [hængər ekə] 'the hanger',

- k) [ekskæve:ɖər ekə] 'excavator' and [helikoɖər ekə] 'the helicopter'

At the word boundary, /r/ is geminated in rapid speech as [ka:rrekə], [o:ɖərrekə] and [ekskæve:ɖərrekə] etc. Gunasinghe (1983) also highlighted the above point.

As a phonological feature, gemination serves to create phonemic contrasts for 16 different pairs of geminate and non-geminate consonants, and there is a considerable number of minimal pairs differing only by the presence or absence of gemination, as exemplified in the table below. It shows the association that exists between the gemination of nouns, verbs, adjectives, and adverbs.

Table 2: Different grammatical environments where geminated and non- geminated minimal pairs occur

		Nouns		Verbs		Adj. / Adv.
1	p/pp	ta:pəyə (heat)	ta:ppəjə (wall)	hapənəva (munch)	happənəva (strike against)	
2	b/bb	sabə (audience)				sabbə (every)
3	t/tt	kaɖə (mouth)	kaɖɖə (pin)			
4	ɖ/ɖɖ	kaɖə (shops)	kaɖɖə (English - Colloquial)			
5	ɖ/ɖɖ	paɖə (lie)	paɖɖə (tattoos)			
6	ɖʒ/ɖʒɖʒ	raɖʒu (king)	raɖʒɖʒu (chain)			
7	k/kk	bakə (croak)	bakkə (everything- colloquial)			
8	g/gg		vaggə (chapter in Buddhist tripitaka)			vagə (about)
9	m/mm	bəmə (eye brow)	bəmmə (wall)			
10	n/nn	kanə (ear)		kanə (eat-v.adj)	kannə (eat-inf)	
11	v/vv	tawwə (bore)				tavə (more)
12	t/tt	pavə (sin)	pawwə (rock)			
		atə (hand)	attə (branch of a tree)			



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13	d/dd	hadə (heart)		vadənəva: (bear- a child)	vaddənəva: (hit purposely)	haddə (very)
14	s/ss	pasə (soil)	passə (back)	gasənəva: (remove-dust)	gassənəva: (jerk)	yasə (excellent) yassə (demon)
15	l/ll	malə (flower)	mallə (bag)			
16	j/jj	kajə (body) hajə (six) hajaji (six)	kajjə (chat) hajjə (strength)			hajjaji (strong)

Consonant gemination in Sinhala orthography

In the Sinhala script, a particular consonant letter is written twice in a row to symbolize gemination. Geminated consonant sounds are always represented in a CCV syllable cluster (llə, ssə, jjə etc.). The first part of the sound (C--) is always written as a consonant (l- ළ, s- ස්, y- ය් n-න්, w- ව්). The second part (CV), which is a

combination of the consonant with a vowel, comes in a compound formation (la-ල, sa-ස, ya-ය, na-න, va-ව). According to orthographic conventions, Sinhala uses two kinds of diacritics to symbolize a consonant sound: the 'udu pillə' (top diacritic as in ක් ක් ළ ඊ) and the 'us pillə' (high diacritic as in ඩ ඹ ඵ). Table 3 shows the written format of singleton and geminated word pairs with their transcriptions and meanings.

Table 3: The Written Format of Four Singleton and Geminated Minimal Pairs

	Word with the Singleton consonant			Word with the geminated consonant		
	In Sinhala Script	IPA	Meaning	In Sinhala Script	IPA	Meaning
a)	දත	[datə]	Tooth	දත්ත	[dattə]	data
b)	හද	[hadə]	Heart	හද්ද	[haddə]	Very
c)	රජු	[raju]	King	රජ්ජු	[radʒdʒu]	Rope
d)	පොල	[polə]	Fair	පොල්ල	[pollə]	Batton
e)	කොකු	[koku]	hooks	කොක්කු	[kokku]	crane birds
f)	කට	[katə]	Mouth	කට්ට	[kattə]	pin
g)	පව	[patʃə]	Lie	පව්ව	[patʃʃə]	Tattoos
h)	අමා	[ama:]	divine	අම්මා	[amma:]	Mother
i)	ගව	[gavə]	Bovine	ගව්ව	[gawwə]	League

Vowel letters in Sinhala orthography stand-alone only at the word onset position but never in the middle or final positions of a word. In the IPA transcription, vowels appear at the word-middle and word-final positions. However, they are always combined with a consonant (CV or CCV) and

symbolized by a single letter with diacritics. There are rarely irregular presentations in village names, which are sometimes written as ගල්මය [galoyə], හල්මය [haloyə] and හල්මලුව [haloluwə]. In actual speech, they are pronounced with geminated consonant clusters [galloyə], [halloyə] and



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[halloluwə] but not mentioned, alpha-syllabically as ග්ලොය, හ්ලොය, හ්ලොලුව in the official documents. This shows that there are differences between consonant gemination conventions, actual pronunciation and alpha-syllabic writing regularities in Sinhala.

Linguistically, gemination means the lengthening or doubling of a speech sound. Therefore, the specific objective of this study is to reveal whether singleton consonant sounds in Sinhala are exactly doubled or lengthened (more or less than doubling) in speech as they are in Sinhala orthography.

Significance of the Study

This linguistic study contributes to Sinhala phonetics. The findings of this study are based on numerical values. Measuring the pronunciation timing of each geminate consonant and exploring the ratios between singleton and geminated consonant pairs, bring a novel experience to Sinhala studies. This study could strengthen the genre of quantitative language research in Sinhala that needs to be improved. The raw data presented in the appendix will support future research in Sinhala phonetics or comparative linguistics.

A REVIEW OF THE PREVIOUS STUDIES

Theory-oriented examinations of different grammatical aspects related to consonant gemination in Sinhala are commonly found in previous studies

(Gunasinghe 1983, Suthadhara 1993, Parawahera 2001, Pyatt 1993, Davis 2003). Consonant geminates related to Sinhala nouns (Parawahera 2001), syllable structure process (Gunasinghe 1983), and syllable optimality theory (Davis 2003) are some of them. Karunarathna's (2017) applied linguistics study focused on the perception of native English L2 Sinhala learners of consonant gemination.

Even though gemination is a linguistic feature, as Gunasinghe (1983) argues, its presence in the Sinhala language was a result of socio-political circumstances, particularly those that took place during the 11th and 12th centuries AD. Sri Lanka has been influenced politically by its South Indian neighbors throughout history. Chola invasions greatly influenced Sinhala society and Sinhala language during the Polonnaruwa era. According to Gunasinghe (1983), consonant gemination is one of the linguistic features that arrived due to the influence of Tamil, the language of the Chola people. Contradicting this opinion, Suthadhara (1996) states that the oldest visible orthographic evidence of consonant gemination appears in the 8th century AD.

Gunasinghe (1983) discusses two processes of gemination: reduplication and assimilation (progressive and regressive). He shows the different situations where gemination occurs in Sinhala:



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k) Inter-morphemically

[pæti +a:] > [pæti y a:] > [pæt ya:] > [pætt a:]

young of animal- stem + def. sing. suffix
> cons. insertion > vow. deletion > cons.
gemination

l) Inter-verbal

[mal + a:sənəyə] > [malla:sənəyə]
flower – stem + seat > cons.
gemination

m) Borrowed words

[ko:t + ekə] > [k:ttəkə]
Coat – English noun + one – def. >
the coat (borrowed Sinhalaized noun
version)

n) Rapid speech

These examples supported the hypothesis that “gemination in Sinhala is a syllable structure process....and the primary function of this process seems to meet with SSC in Sinhala” (Specified Subject Condition) (Gunasinghe,1983, p.101).

Parawahera (2001) discusses consonant gemination occurring as a result of suffixation in the process of making nouns in Sinhala. He presents four processes considering end result of suffixation. The final sound of the stem (vowel-final or consonant-final), and animate and inanimate binary are introduced as the two main factors related to suffixation in Sinhala. As Parawahera explains, due to the absence of double consonants at the word-final position, consonant lengthening is not a predictable occurrence morphologically nor

lexically. However, according to Parawahera (2001), by losing the final vowel of the stem, the final consonant is lengthened through syllabifying the vowel of the suffix, as in [ibi]+[a] > [ib]+[a] > [ibb]+[a] > [ibba] (tortoise). The insertion of semi-vowels (/y/, /v/) at morpheme boundaries and consonant lengthening are the two main changes that result in the suffixation of noun stems in Sinhala. Davis (2003) has explained this insertion as a ‘predictable occurrence in hiatus’. Moreover, he argues that the reason that [iba] becomes [ibba] and [koku] becomes [kokku] is the ‘melodically empty timing slot’ that has a tendency to associate with the adjoining melodic unit.

Suthadhara (1993) uses examples that represent diverse grammatical functions such as number (singular and plural), animacy (animate and inanimate) and compound words. Suthadhara’s study supports the fact that a considerable amount of the Sinhala lexicon and its grammatical functions show consonant gemination. Moreover, maintaining a lower number of syllables in a word and connecting to stress patterns are two reasons for the consonant gemination that is employed in Sinhala.

Pyatt (1993) focuses on pre-nasalized stops (b̃, d̃, ñ̃, g̃) to examine how gemination occurs in Sinhala. Exemplifying minimal and non-minimal pairs from the colloquial lexicon, Pyatt shows that pre-nasalized stops and nasal stops in Sinhala show



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'true gemination,' as they are used in minimal pairs.

Studies have identified the languages in which consonant gemination is not a prominent feature. Especially, in the field of second language acquisition, presence and absence of this feature has led to many comparative studies. Glides in English have been a controversial topic in phonology. One group of literature, including Laver (1994), Kenyon (1924), Jones (1956), Gimson (1962), and Catford (1977) argue that due to the brevity and rapidity of glides, they are incapable of becoming geminated. However, another group of studies argues that those two characteristics are not inherent to glides. Studies conducted by O'Connor (1973), Clark and Yallop (1995), Ladefoged and Maddieson (1996), and Maddieson and Emmorey (1985) support the second opinion. Maddieson (2008) also supports the second argument through an examination of the pronunciation timings of glides in various languages. Maddieson finds that pronunciation time ratios between /j/ and /jj/ in Kannada (1:1.8), Saami (1:1.8), Madurese (1:1.5) and Guinaang Bontoc (1:1.4) are below two. The ratios between /w/ and /ww/ is 1:2 in Saami, 1:1.5 in Madurese and 1:1.7 in Guinaang Bontoc, but this phenomenon does not exist in Kannada. Therefore, Maddieson (2008) concludes that glides are not inherently short or transitional; instead, he argues,

the margins between geminate and singleton glides are hard to define.

To examine the common and unique patterns of consonant gemination, Podesva (2002) gathered data from more than 40 languages representing various language families. He sorted the consonants according to their tendency to become geminated. He suggests a sequence of consonant clusters: the sounds in the left cluster show a higher tendency to be geminated compared to the cluster in the right. The probability that a sound is geminated decreases as it moves to the right side of the sequence.

Stops > Nasals > Fricatives > Liquids > Glides > and the voiceless approximant /h/

(Podesva 2008, p. 1929)

Podesva's study arranges the languages examined in a hierarchy of fourteen levels according to what geminate sounds are present in each language. Sinhala fits into the fourth level from the top of the hierarchy, as /h/ is the only cluster that is not geminated in Sinhala. Sinhala belongs to the "Stops > Nasals > Fricatives > Liquids > Vocalic Glides" (Podesva 2008, p. 1928) level of Podesva's hierarchy. Japanese consonant gemination occurs in voiceless stops (/p, t, k/), fricatives (/s, ʃ/), and the affricate ʧ. Takeuchi calculated the acoustic duration ratio of native Japanese speakers between singleton and geminated consonants at roughly 1:2.5 to 1:3.2. Other studies have



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claimed that Japanese geminates never exceed three times the length of a singleton (Fukui, 1978; Beckman, 1982). The present study attempts to show the compatibility of glides in Sinhala with the time ratios of Maddieson (1996).

RESEARCH METHODOLOGY

After stating the research problem and research questions the next phase was to select the relevant consonant sounds and prepare the data collection instrument. Subsequently, the participants were selected and their pronunciations of the target words were recorded. Pronunciation timings of the target sound environments were measured and analyzed. The methodology of this study has been extensively described below as phases.

Research problem

This study focuses on the problem whether there is a relationship between

orthography and the articulation time ratios of geminated and singleton consonants in Sinhala. Two research questions were posed in order to examine this research problem. 1) What are the articulation time ratios between the geminated and non-geminated consonants in Sinhala? and 2) What relationships exist between orthographic symbolization and those ratios?

Selection of the sixteen consonant sounds

According to Wasala and Gamage (2005) “spoken Sinhala contains 40 segmental phonemes; 14 vowels and 26 consonants, including a set of 4 pre-nasalized voiced stops peculiar to Sinhala.” (p.474). The consonant inventory of Sinhala is visible in the table below.

Table 4: Spoken Sinhala Consonant Inventory

		Labial	Dental	Alveolar	Retroflex	Palatal	Velar	Glottal
Stops	Voiceless	p	t		ʈ		k	
	Voiced	b	d		ɖ		g	
Affricates	Voiceless					c		
	Voiced					j		
Pre-nasalized voiced stops		b̃	d̃		ɖ̃		g̃	
Nasals		m		n		ɲ	ŋ	
Trill				r				
Lateral				l				
Spirants		f	s			sʰ		h
Semivowels		v				y		

(Wasala & Gamage 2021, p.474)

Out of the 26 consonants mentioned above, the 8 voiceless and voiced stops

(p ජ, b බ, t ජ, d ජ, ʈ ජ, ɖ ජ, k ක, g ග), the 2 voiceless and voiced affricates (c ජ, j ජ



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ඡ), labial and alveolar nasals (m ම, n න), the alveolar lateral (l ල), the dental spirant (s ස), and the labio and palatal semivowel (v ව, y ය) are the sounds that make true consonant geminates in Sinhala. Even though Pyatt studied pre-nasals as geminates, the present study has eliminated them despite the fact that they appear in minimal pairs.

The argument which is stated in this paper, is that they are not lengthening of the same consonant, as in /bb/ or /kk/. The table below includes triads of words with singleton, geminated and the pre-nasalized consonants, clearly illustrating how they produce minimal pairs with the singleton version.

Table 5: Minimal pairs occurred due to gemination and pre-nasalization in Sinhala

In IPA	In Sinhala letter	Meaning
vadə - vaddə - vad̥ə	වද - වද්ද - වද්	punishment – strike against (stem)-barren
hadə - haddə - had̥ə	හද - හද්ද - හද්	heart – very – moon
badə - baddə - bad̥ə	බද - බද්ද - බද්	grasp (stem) – lease – trunk/body

The glottal spirant /h/ is not lengthened in Sinhala, instead in such phonological environments /s/ is inserted and lengthened, for instance [kæhi > kæssə] cough plu. > sing., [væhi > væssə] rain plu. > sing. Geminated versions of the palatal nasal /ɲ/ (ඤ) are also used in the derived words from Portuguese such as /pipiɲna:/ (පිපිඤ්ඤා) and /maɲɲokka:/ (මඤ්ඤාක්කා). However, /ɲ/ was also eliminated due to the fact that it never appears in Sinhala minimal pairs. When the traditional speech sound range expanded in the 20th century, Sinhala needed the labio-dental spirant /f/ for the accurate pronunciation of many borrowed words from English and Arabic names such as [fæ:n ekə] the fan, [fæsisvādəyə] fascism, [fil̥tər ekə] the filter, Fatima, Faizer and Feröz.

Participants and data collection

Ten native Sinhala speakers, who were originally from six districts in Sri Lanka

– Colombo, Kandy, Ambilipitiya, Gampaha, Matara, and Nuwara Eliya – participated in the research. They were in an age range of 28-38 years and used a standard dialect of Sinhala. All ten were bilingual in English and Sinhala. Following the filling out of the demographic questionnaire (gender, age, native language, as second languages), participants were provided with a list of 32 simple sentences to read in front of a microphone. They were advised to read the sentences at a natural speed using their natural speech.

Data collection and analysis instruments

Sixteen sentence pairs were recorded of each participant as one file and later segmented into sixteen files. The ten recordings of each sentence pair were then copied and pasted into one file. Each of the 16 simple sentence pairs consisted of a target word, either with



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singleton or a geminated consonant – for example [me: atə] – [me: attə] (This is arm – This is branch). The main technical instrument used for data collection (recording) and data segmenting was Speech Analyzer version 3.1. The articulation timings were measured with Praat.exe.

Results and findings

The numerical data analysis was done using the pronunciation timings of the geminated and non-geminated consonants of the ten native speakers. The time measurements were taken in milliseconds. The pronunciation timings and ratio calculations are attached as an appendix. The table below presents answers to the first research question.

Table 6: Articulation time ratios between singleton and the geminated consonants in Sinhala

		Labial	Dental	Alveolar	Retroflex	Palatal	Velar	Glottal
Stops	Voiceless	p 1.7	t 1.8		ʈ 1.9		k 1.9	
	Voiced	b 1.8	d 1.9		ɖ 2.4		g 1.9	
Affricates	Voiceless					ʈʃ 1.7		
	Voiced					ɖʒ 1.7		
Pre-nasalized voiced stops								
Nasals		m 2.0		n 2.4				
Trill								
Lateral				l 2.4				
Spirants			s 1.6					
Semivowels		v 2.1				j 2.0		

The data reveals that the general ratio distribution of singleton to geminate consonants in Sinhala was 1:1.6 and 1:2.4. The sixteen sounds could be

divided into seven sections according to the length ratios between singleton and geminated consonants.

Table 7: Sequence of consonants arrayed in descending order according to length ratios

1.6	1.7	1.8	1.9	2	2.1	2.4
s	p, c, j	b, t	k, g, ʈ, d	m, y	v	ɖ, n, l

Only two consonants (/m/ and /y/) out of sixteen were doubled from their singleton counterparts. Ten geminates were lengthened less than doubling (s, p, ʈ, ɖ, b, t, k, g, ʈ, d) and four consonants (v, ɖ, n, l) were lengthened

more than two times. Except /d/, the seven voiced and voiceless stops in Sinhala are lengthened between 1.7 to 1.9 times compared to their singleton counterparts. Both voiced and voiceless affricates are lengthened by 1.7 times



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when they are geminated. The two nasals and the two semivowels reported doubling (/m/, /y/) and lengthen even more than doubling (/n/, /v/). The dental fricative /s/ is marked as the weakest geminable consonant in Sinhala. Supporting the fact that glides are not that rapid (Maddison 2005), the findings also illustrate that glides in Sinhala are doubled when they are geminated. Figure 1 and 2 illustrate the contrast between singleton and geminated /l/ sound and /d/ sounds that clearly visible in a spectrogram.

Figure 01: Contrast between the articulation timings of /l/ and /ll/ visible in spectrogram

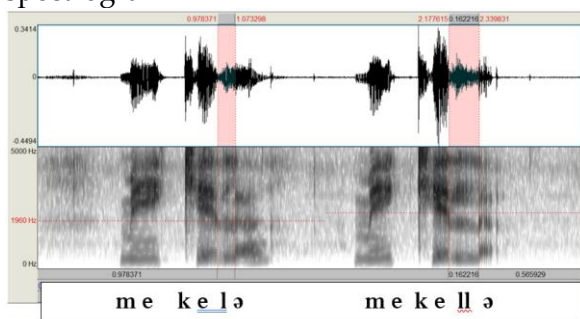
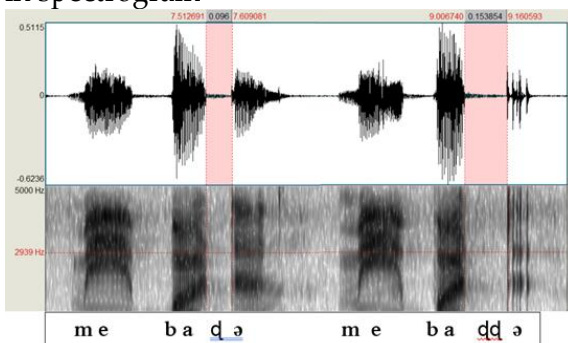


Figure 02: Contrast between the articulation timings of /d/ and /dd/ visible in spectrogram



CONCLUSION

In conclusion, the data shows that the ratios between the singleton

consonants and their geminated counterparts in the Sinhala language have different pronunciation time ratios, ranging between 1:1.6 – 1:2.4. Therefore, in Sinhala consonant gemination means consonant lengthening but the pronunciation time of the singleton does not exactly double. Sinhala orthography always doubles the particular consonant letter in a row to symbolize consonant gemination. These results show that the differences in articulation time ratios do not make any difference to orthographic symbolization. Sounds are always represented as double consonants in writing but lengthened according to different time ratios in actual speech.

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Appendix

Articulation timings of the five male (M) and the five female (F) participants

	M1	M2	M3	M4	M5	F1	F2	F3	F4	F5	Average
me: hakə	0.09448	0.1134	0.13019	0.1404	0.16984	0.126	0.12021	0.11217	0.14101	0.18415	
me: hake	0.18627	0.20309	0.27062	0.26542	0.27032	0.25523	0.23796	0.20855	0.25121	0.29511	
	1.97153	1.79097	2.07855	1.89044	1.59161	1.97153	1.79097	2.07855	1.89044	1.59161	1.86462
me: nagəṇə	0.07072	0.07754	0.10304	0.11583	0.08944	0.0968	0.11273	0.1238	0.09401	0.1094	
me: naggəṇə	0.13584	0.13057	0.18845	0.18574	0.20038	0.19728	0.16055	0.26128	0.18241	0.21316	
	1.9208	1.68385	1.82887	1.60366	2.24028	2.038	1.42425	2.11053	1.94044	1.94852	1.89235
me: kaṭə	0.09516	0.13291	0.13663	0.13439	0.12181	0.14661	0.15245	0.16703	0.12365	0.17722	
me: kaṭṭə	0.20497	0.20597	0.26107	0.27516	0.25323	0.25118	0.22074	0.33373	0.23584	0.29715	
	2.15401	1.54966	1.91078	2.04749	2.0789	1.71326	1.44796	1.998	1.90727	1.6767	1.74864
me: baḍə	0.06311	0.04668	0.08404	0.07483	0.07408	0.07273	0.10364	0.12202	0.08331	0.10478	
me: baḍḍə	0.15403	0.14833	0.20888	0.19697	0.19072	0.20749	0.18378	0.24437	0.18793	0.18961	
	2.44085	3.17789	2.48541	2.63234	2.57459	2.85289	1.77337	2.0027	2.25583	1.80955	2.13887
mage ko:pəyə	0.0934	0.13641	0.12707	0.11832	0.11879	0.15021	0.12406	0.10049	0.12526	0.14914	
mage ko:ppəyə	0.16679	0.16626	0.19381	0.23187	0.19814	0.19491	0.1903	0.21863	0.23927	0.23971	
	1.7858	1.21889	1.52521	1.95964	1.66804	1.2976	1.5339	2.17559	1.91019	1.60726	1.70491
me: kabə	0.08423	0.09879	0.09615	0.12414	0.11165	0.0979	0.11185	0.14048	0.11379	0.13637	
me: kabbə	0.18648	0.15941	0.19009	0.20996	0.21494	0.18747	0.1971	0.24504	0.20592	0.24273	



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	2.2138	1.61369	1.97709	1.69133	1.92516	1.9148	1.76228	1.74439	1.80969	1.77999	1.80223
kæ:mə kanə	0.06062	0.07861	0.06594	0.07396	0.08117	0.08703	0.08151	0.08151	0.07995	0.10041	
kæ:mə kannə	0.15022	0.16324	0.19048	0.19648	0.19227	0.20877	0.15506	0.24271	0.17661	0.20313	
	2.47803	2.07657	2.88891	2.65678	2.36885	2.39883	1.90237	2.97768	2.20886	2.02306	2.30216
me: bæmə	0.07393	0.08889	0.07275	0.13136	0.10511	0.08038	0.10079	0.1041	0.10866	0.10455	
me: bæmmə	0.144	0.19945	0.21637	0.22971	0.19053	0.1603	0.15455	0.22129	0.17145	0.21887	
	1.94783	2.2438	2.97416	1.74877	1.81277	1.9943	1.5334	2.12576	1.5778	2.09351	1.86496
me: æsə	0.11599	0.16627	0.13361	0.15875	0.14661	0.16258	0.19541	0.17162	0.13836	0.18107	
me: æssə	0.20701	0.22072	0.24084	0.24839	0.2176	0.26818	0.24233	0.33104	0.22832	0.27992	
	1.78476	1.32752	1.8026	1.56472	1.48417	1.64948	1.24012	1.92894	1.65015	1.54587	1.60291
me: atə	0.12397	0.15461	0.13897	0.15595	0.1582	0.17448	0.16038	0.16958	0.145	0.18528	
me: attə	0.22612	0.22613	0.26057	0.33605	0.25906	0.26628	0.24253	0.32458	0.31319	0.30194	
	1.82399	1.46254	1.87508	2.15495	1.63752	1.52611	1.51215	1.91398	2.16003	1.62971	1.7484
me: hadə	0.06643	0.11347	0.10846	0.12335	0.13021	0.09659	0.11738	0.14814	0.10682	0.11757	
me: haddə	0.17944	0.19225	0.21623	0.2339	0.22735	0.21282	0.15772	0.27933	0.2022	0.24636	
	2.70133	1.69434	1.99373	1.89618	1.74605	2.20326	1.34367	1.88567	1.89285	2.09535	1.88416
me: paŋə	0.09728	0.14002	0.14273	0.18272	0.17129	0.15245	0.16403	0.20025	0.1486	0.18629	
me: paŋŋə	0.23708	0.22309	0.24365	0.31146	0.22707	0.2595	0.20263	0.33961	0.2639	0.29945	
	2.43715	1.59325	1.70703	1.70458	1.32567	1.7022	1.2353	1.69591	1.77593	1.60746	1.60336
me: radʒu	0.08845	0.11372	0.09508	0.11476	0.13044	0.12028	0.14662	0.12261	0.11527	0.14383	
me: radʒɔʒu	0.16619	0.1719	0.20791	0.23319	0.18707	0.1541	0.18453	0.22856	0.20795	0.25818	
	1.87893	1.51161	2.18672	2.03195	1.43417	1.28118	1.25854	1.86408	1.80412	1.79506	1.6006
me: kajə	0.09299	0.0699	0.08396	0.08309	0.10599	0.09379	0.06539	0.12375	0.07429	0.11607	
me: kajjə	0.17095	0.13112	0.1778	0.18843	0.21064	0.19053	0.14991	0.20587	0.16832	0.1811	
	1.83843	1.87585	2.11774	2.26765	1.98743	2.03146	2.29244	1.66356	2.26579	1.56032	1.96271
me: kelə	0.06519	0.06931	0.08844	0.05608	0.09034	0.08624	0.09175	0.10877	0.08432	0.08186	
me: kellə	0.15822	0.13521	0.19246	0.21405	0.1854	0.19019	0.17686	0.23676	0.20852	0.20689	
	2.42709	1.95093	2.17624	3.81675	2.05232	2.20526	1.92765	2.17669	2.47305	2.52744	2.26202
me: divə	0.08446	0.0815	0.08032	0.10179	0.08679	0.84002	0.0814	0.0729	0.08181	0.08798	
me: diwwə	0.1092	0.18832	0.23376	0.23905	0.14623	0.18991	0.16774	0.24391	0.1995	0.21436	
	1.29291	2.31084	2.91055	2.34852	1.68494	0.22608	2.06065	3.34572	2.43852	2.43638	2.10147