THE PHONETIC REALIZATION OF SINGLETON-GEMINATE CONTRASTS IN THREE LANGUAGES OF INDONESIA

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ABSTRACT

This paper examines the timing properties of singleton-geminate contrasts in three Austronesian languages of Indonesia: Buginese, Madurese and Toba Batak. This study details the hitherto poorly described phonetic properties of the consonant systems of these languages, and investigates the role of prosodic organization in the phonetic implementation of duration. Results show that in each of the languages, singleton-to-geminate closure ratios tended to be smaller for voiceless than voiced sounds and greatest for voiced stop geminates. Strikingly, voicing was systematically observed throughout the closure portion of the voiced stop geminates (despite the aerodynamic difficulties of sustaining voicing in obstruents), hypothesized here to be the result of a voicing enhancement strategy. In all cases, singleton-geminate duration differences in stops were realized during the closure and not the following burst or VOT. All three languages also exhibit closed syllable shortening preceding geminates, suggesting a syllable-based timing strategy.

1. INTRODUCTION

In this study, we investigate the temporal properties of consonants in three Austronesian languages of Indonesia spoken in distinct regions of the archipelago: Buginese (southern Sulawesi), Madurese (Madura and eastern Java) and Toba Batak (northern Sumatra). Unlike most of their close neighbors, all three languages display a singleton-geminate contrast in word-medial position, as illustrated in (1):

(1) a. Buginese
*la**p**a* ('lava') vs. *la**pp**a* ('joint')

b. Madurese
*ta**p**a* ('to mediate') vs. *pa**pp**a* ('type of stem')

c. Toba Batak
*u**m**a* ('field') vs. *u**mm**a* ('spear')

While the contrasts represent independent innovations, their historical sources — total assimilation of various medial consonant clusters — are similar, as discussed, for example, by Stevens [17] for Madurese and Mills [10] for Buginese.

Cross-linguistic evidence shows that timing strategies employed in the realization of singleton-geminate contrasts are due in part to differences in prosodic organization [3]. In particular, durational differences between singletons and their geminate counterparts tend to be substantially smaller in languages which attempt to achieve even temporal spacing among syllables (as opposed to subsyllabic units such as moras). Cross-linguistic evidence also shows that segmental timing can be influenced significantly by aerodynamic constraints (e.g., the difficulty of maintaining prolonged obstruent voicing) [12]. This paper addresses both types of effects on consonant duration in these three languages, based on data from the full range of consonantal contrasts.

This paper is organized as follows: In section 2, we provide a brief phonological overview of the consonant systems of the three languages; in section 3, we discuss the general methodology used in the acoustic studies; in section 4, we present the results of the studies and discuss their implications for the prosodic structure and temporal organization of these languages. In section 5, we provide a brief conclusions.

2. PHONOLOGICAL OVERVIEW

This section provides an overview of the consonant inventories of each of the three languages. The consonant inventory of Buginese is shown in Table 1. Morpheme-internally, all consonants except [w] and [ʔ] also occur as geminates word-medially, while only voiceless obstruents and sonorants can occur as geminates at morpheme boundaries [14, 15]:

	lab.	alv.	pal.	velar	glot.
stops	p, b	t, d	c, j	k, g	ʔ
frics.		s			
nasals	m	n	ɲ	ŋ	
liquids		l, r			
glides	w		y		

Table 1. Consonant inventory of Buginese.

The consonant inventory of Madurese is presented in Table 2. All consonants except [ʔ] also occur as geminates word-medially, with no morphological restrictions [2, 18]:

	lab.	den.	retro.	pal.	velar	glot.
stops	p, b, p^h	t, d, t^h	ʈ, ɖ, $ʈ^h$	c, j, c^h	k, g, k^h	ʔ
frics.		s				
nasals	m	n		ɲ	ŋ	
liquids		l, r				
glides	w			y		

Table 2. Consonant inventory of Madurese

Note that Madurese (Table 2) is unique among the three languages in having a five-way place contrast as well as a three-way phonation contrast (voiceless, voiced and voiceless aspirated) in the stops.

Lastly, the consonant inventory of Toba Batak is presented in Table 3. All consonants except [ʔ] and [h] appear as geminates word-internally (though we were not able to identify examples of geminate [r] to include in the study). (In the Toba dialect of Batak, there are no glides.) For a discussion of the consonant sandhi at word boundaries (which results in the creation of geminates, among other patterns), see Hayes [4], and for the phonology more generally see Nababan [11].

	lab.	alv.	pal.	velar	glot.
stops	p, b	t, d	j	k, g	ʔ
frics.		s			h
nasals	m	n	ɲ	ŋ	
liquids		l, r			

Table 3. Consonant inventory of Toba Batak.

While vowel inventories are not discussed here (see references), it should be noted that vowel length is not phonologically contrastive in any of the three languages.

3. METHODOLOGY

The data reported here come from recordings of two native speakers of each Buginese and Madurese and one of Batak (analysis of a second speaker is underway). Lists of disyllabic words (the canonical root shape in the three languages) containing all of the relevant consonantal contrasts in word-medial position were assembled. The words were then elicited from the speakers in phrase-medial position by embedding them in a carrier phrase. Recordings were digitized at a sampling rate of 11,025 kHz, and measurements were performed using ESPS Waves+® speech analysis software. In most cases, the measurements reported here are based on three repetitions per word.

4. RESULTS

4.1. Closure duration.

Mean closure duration for word-medial singleton and geminate consonants and mean singleton-to-geminate closure ratios for Buginese (combined for two speakers) are shown in Table 4:

	singleton	geminate	ratio
vl. stops	102	169	1:1.7
vd. stops	68	116	1:1.7
frics. (vl.)	138	192	1:1.4
nasals	88	144	1:1.6
lateral liquid	84	151	1:1.8
rhotic	19	73	1:3.8
glide (y)	105	151	1:1.8

Table 4. Mean closure durations (ms) for word-medial singleton and geminate consonants and closure ratios for two Buginese speakers.

The results here are pooled across two speakers, but we call to attention the fact that their individual singleton-to-geminate ratios were not entirely uniform. This ratio was on average 1:1.9 for one speaker and 1:1.4 for the other. Nonetheless, except for /r/ which as a singleton is realized as a tap and as a geminate as a trill, all of the singleton-geminate ratios are within a relatively close range for both speakers. Both speakers also evidence a pattern in which the singleton-to-geminate ratio for voiced stops is greater than or equal to that of voiceless stops and voiced sounds in general have greater ratios than voiceless ones (vl. stops and fricatives).

Mean closure duration for word-medial singleton and geminate consonants and mean singleton-to-geminate closure ratios for Madurese (combined for two speakers) are shown in Table 5:

	singleton	geminate	ratio
vl. stops	107	165	1:1.5
vd. stops	85	145	1:1.7
asp. stops	112	159	1:1.4
frics. (vl.)	131	162	1:1.2
nasals	90	145	1:1.6
lateral liquid	85	153	1:1.8
rhotic	20	114	1:5.7
glides	106	160	1:1.5

Table 5. Mean closure durations (ms) for word-medial singleton and geminate consonants and closure ratios for two Madurese speakers.

The Madurese results are similar to those for Buginese (and here the results of the two speakers are quite consistent). Here too, with the except of /r/ which again is realized as a tap when a singleton and a trill as a geminate, the range of ratios is quite small. Ratios for voiced sounds again tend to be greater than voiceless ones (vl. stops, asp. stops and fricatives), with the voiced stops showing a greater ratio than voiceless ones.

Mean closure duration for word-medial singleton and geminate consonants and mean singleton-to-geminate closure ratios for Toba Batak are shown in Table 6:

	singleton	geminate	ratio
vl. stops	58	114	1:2.0
vd. stops	38	119	1:3.2
frics. (vl.)	76	132	1:1.7
nasals	56	111	1:2.0
lateral liquid	53	108	1:2.0

Table 6. Mean closure durations (ms) for word-medial singleton and geminate consonants and closure ratios for one Toba Batak speaker.

While the ratios in Toba Batak are greater than for Madurese or Buginese (though not that different from the Buginese speaker with the greater ratios), the overall patterns are similar, with voiced sounds having greater ratios than voiceless (vl. stops and fricatives) and the greater ratio for voiced stops. (Examination of additional speakers of Toba Batak is needed to determine whether these ratios are due to individual speaker variation or are characteristic of the language more generally.) Here the difference between the ratios for the voiced stops and the other classes of sounds is strikingly high, at 1:3.2. This high ratio is due in part to the relatively long closure duration for the geminate, which is most likely achieved with the help of an aerodynamic enhancement strategy. The very short duration of the intervocalic singleton also

contributes to this high ratio. Medially, singleton voiced stops are lenited, exhibiting not only a shorter duration than their initial counterparts (38 ms vs. 67 ms), but formant structure as well.

The overall mean singleton-to-geminate closure ratios are 1:1.65 for Buginese, 1:1.55 for Madurese (excluding the tap-trill contrast in each case) and 1:2.2 for Toba Batak. The values for Buginese and Madurese fall well within the range for singleton-to-geminate closure ratios in syllable-timed languages reported in Ham's cross-linguistic survey (ca. 1:1.25 to 1:1.85) [3], while those for Toba Batak are somewhat greater than expected. We will return to this issue below in section 4.3, where further evidence for the syllable-timed status of these languages is presented, based on the timing of vowel-stop sequences.

4.2. Closure duration and VOT in stops.
We turn next to a closer examination of the relationship between voice onset time (VOT) and closure duration in singleton and geminate stops in the three languages.

Beginning with voiceless stops in Buginese, we see in Table 7 that VOT does not contribute to the distinction of length in Buginese. The singleton-geminate contrast is realized in closure duration alone.

	singleton	geminate
voiceless	36	38

Table 7. Mean VOT (ms) for voiceless singleton and geminate stops for two Buginese speakers.

The same pattern was found for Madurese. As illustrated in Table 8, mean VOT values for singleton and geminate voiceless stops, and for singleton and geminate voiceless aspirated stops, are virtually identical. The small aspiration difference between the two phonation types is maintained, but not augmented in the geminate forms:

	singleton	geminate
voiceless	17	15
voiceless aspirated	38	36

Table 8. Mean VOT (ms) for voiceless and voiceless aspirated singleton and geminate stops for two Madurese speakers.

As was the case in Buginese and Madurese, the VOT of singleton voiceless stops is virtually identical to that of a geminate, as shown in Table 9:

	singleton	geminate
voiceless	13	10

Table 9. Mean VOT (ms) for voiceless singleton and geminate stops for one Toba Batak speaker.

In each of the three languages, then, the differences in duration observed between singletons and geminates is realized fully during the closure alone. VOT values, whether for voiceless unaspirated or aspirated cases, are stable across the two length categories.

Even more striking than the data for positive VOT, however, are the data for negative VOT. In each of the three languages, voiced geminates are approximately as long as their voiceless counterparts, and are consistently voiced throughout the closure. In Toba Batak, the voiced geminate stops are actually slightly longer (vd. 119 vs. vl. 114 ms), in Madurese slightly shorter (vd. 145 vs. vl. 165 ms) while in Buginese noticeably shorter (vd. 116 vs. vl. 169 ms). These results for Madurese and Toba Batak are unexpected, given the aerodynamic difficulties associated with maintaining prolonged obstruent voicing discussed, for example, by Ohala [12]. As Ohala points out, voiced geminate stops tend to become either devoiced or implosivized, since the equalization of sub- and supraglottal air pressure tends to occur fairly rapidly, explaining why the presence of an oral seal often inhibits prolonged voicing.

The fact that voicing is consistently maintained in phonemically voiced geminates in Buginese, Madurese and Toba Batak suggests that these languages may make use of (perhaps different) voicing enhancement strategies. A number of such strategies have been identified in the phonetic literature. These include compromising the oral seal by allowing egressive leakage of airflow through the velum [5, 6, 8, 13], and expanding the size of the oropharyngeal cavity behind the point of closure by fronting the constriction, advancing the tongue root, or lowering the larynx [7]. Further instrumental investigations are needed to determine if the languages studied here make use of one of these strategies, though there is some independent evidence for a larynx lowering strategy in Madurese [1].

4.3. Closed syllable shortening.
Finally, in all three languages, vowels preceding geminates are substantially shorter than those preceding singletons, exhibiting closed syllable shortening (also found for vowels before medial clusters in these languages).

	vowel	stop	total
singleton	139	85	224
geminate	113	145	258

Table 10. Mean durations (ms) of preceding vowel, stop closure, and vowel plus stop closure sequences for two Buginese speakers.

	vowel	stop	total
singleton	108	101	209
geminate	67	172	239

Table 11. Mean durations (ms) of preceding vowel, stop closure, and vowel plus stop closure sequences for two Madurese speakers.

	vowel	stop	total
singleton	109	48	157
geminate	68	117	185

Table 12. Mean durations (ms) of preceding vowel, stop closure, and vowel plus stop closure sequences for one Toba Batak speaker.

The result of closed syllable shortening in each case is that the duration of vowel-consonant sequences is held more or less constant, meaning that vowel onsets are approximately equally spaced in time [9]. In other words, these languages appear to be syllable-timed [3, 16].

In a cross-linguistic survey of languages with singleton-geminate contrasts, Ham [3] finds that there is a close correlations between the singleton-to-geminate ratios and the kind of timing strategy used. Languages which exhibit syllable-timed strategies characteristically have shorter ratios than those with a mora-timing strategy. Results for both Madurese and Buginese, which show syllable-timed strategies, are as predicted. The ratios for Toba Batak, also syllable-timed, are greater than expected. This suggests that Toba Batak does not take advantage of the possibility of using shorter ratios, made available by the independent cueing of syllable structure through closed syllable shortening. In addition, the lenition of singleton medial stops in Toba Batak also contributes to these greater ratios.

5. CONCLUSIONS

In summary, we have investigated the timing characteristics of the singleton-geminate contrasts in three languages spoken in Indonesia: Buginese, Madurese, and Toba Batak. We have found that for each speaker of the three languages, singleton-to-geminate closure ratios fall within a close range, tending to be greater for voiced than voiceless sounds. There is variation in overall singleton-to-geminate ratios which warrants study of additional speakers of each language to determine if this is individual variation or characteristic of specific languages. In addition, we found that geminate voiced stops have the largest ratios of all segment types and consistently exhibit voicing throughout their entire closures. These results are surprising, given the aerodynamic difficulty in maintaining stop voicing and we therefore hypothesize that speakers of these languages are using voicing enhancement strategies. The specific strategies employed remain to be determined in further instrumental investigations. We also found that in voiceless stops, the length distinction in all three languages is realized in the closure duration alone, as the VOTs of singletons and geminates were not substantially different. Finally, vowels before medial consonants exhibit closed syllable shortening; vowels preceding geminates are considerably shorter than those preceding singletons. These results, combined with the magnitude of the singleton-to-geminate closure ratios presented in section 4.1, suggest that the three languages investigated here employ a timing strategy organized around the syllable, as opposed to a subsyllabic unit such as the mora.

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