

POSITIONAL ASYMMETRY IN LENGTH AND VOICING CUES IN THE ALVEOLAR PLOSIVES OF IKEMA MIYAKO RYUKYUAN

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ABSTRACT

In Ikema (a Miyako Ryukyuan dialect), obstruents and nasals contrast in length and/or voicing in word-initial and medial positions. Yet, none of them has the four-way distinction in both positions. Our study focuses on asymmetric alveolar plosive contrasts: a triplet of /t tt d/ in the word-initial position and a quadruplet /t tt d dd/ in the medial position. The study investigates relevant temporal and non-temporal acoustic properties of these consonants. The classificatory importance of each acoustic property was also evaluated. The results suggest that many of the acoustic values of the initial triplet are more dispersed in the acoustic space than those of the medial quadruplet. The orders of importance of acoustic parameters showed their distinct roles depending on the positions. Duration-related cues are dominant in both positions; however, voice quality, intensity and f₀ have a more important role in the initial position.

Keywords: Initial geminate, laryngeal contrast, Ryukyuan, Ikema, alveolar plosive.

1. INTRODUCTION

Ikema is a dialect of Miyako Ryukyuan (a Japonic language) spoken by around 1300 elderly people in Ikema island, the Sarahama area of Irabu and the Nishihara area of Miyako islands of Japan [11, 21, 34]. The obstruent system of Ikema has a rich set of length and voicing contrasts in word-initial and medial positions [29] but with segmental gaps. Based on her fieldwork in the Nishihara area, [11] identifies the following phonemic consonants: /p b t d k g f v s z h ts m ŋ n r w j/ (symbols are adapted). Among them, the obstruents that appear as word-initial geminates include /tt tts kk ff ss vv zz/ (words starting with /kk/ are very rare) and geminate obstruents that appear in the medial position include /pp kk dd/ on top of the initial geminate set (occurrence of /pp/ or /kk/ is very low). Singleton /v/ does not occur anywhere; occurrence of singleton /p/ depends on idiolect. We focus on the asymmetric contrast of alveolar plosives, which remains the most complete set among the obstruents. A four-way distinction /t tt d dd/ is present

in the word-medial position ([bata] ‘stomach’, [tatta] ‘more’, [hada] ‘period’ [badda] ‘trench’) while the initial position limits the contrast to three types /t tt d/ ([ti:] ‘hand’, [tti:] ‘pipe’ [di:] ‘cane’) lacking /dd/.

In previous acoustic and articulatory studies, full voicing (with prevoicing) was observed in the voiced obstruents in both positions [33, 8]. Concerning the alveolar plosives, longer Voice Onset Time (VOT) is characteristic of initial voiceless singleton /t/ [33, 17]. Thus, in terms of VOT, the initial position hosts three types: a negative valued /d/, a short lagged /tt/ and a long lagged /t/. [17] reported more acoustic results (formants and spectral tilts of the following vowel) on initial obstruents /b t tt d k g ts ([te]) z ([dz]) f ff vv s ss z zz/ followed by /a/ in Ikema. Overall, consonant duration (VOT for stops and affricates; total duration for fricatives) is the most reliable acoustic correlate of voicing and length contrasts. As to the non-temporal properties, geminates and voiceless obstruents generally induced higher fundamental frequency (f₀) at the onset of the following vowel, with exception of /t/ with a long aspiration, which induced slightly higher f₀ than /tt/. In addition, geminates /tt ff ss zz/ were differentiated from singletons by the higher intensity and lower F1/H1-H2. Non-temporal aspects of medial obstruents of Ikema remained unreported.

In this paper, we examine the phonetic properties of alveolar plosives in initial and medial positions in Ikema to explain its asymmetric distribution in the synchronic state. We explore selected acoustic measures proven to be most efficient in the previous study of initial obstruents in Ikema [17]: duration of the consonants and f₀, F1, intensity, H1-H2c at the onset of the following vowel (see 3.2 for the detail).

2. THEORETICAL ASSUMPTIONS

Cross-linguistically, consonant and closure durations are known to be the most salient cues for length [9, 25, 10, 18] and voicing [27, 16] distinctions. However, there may be many other cues. Voicing is well-known to impact the microprosody of the following vowel [13, 27] to the extent of triggering tonal changes in some languages [12]. An increasing number of studies are confirming the impact of geminates on f₀ onsets [1, 10]. Other acoustic parameters are also

influenced by gemination: lower F1 [20, 2], higher intensity [1, 10] and arguably smaller H1-A1 [19]. In contrast, the VOT difference between geminates and singletons may be variable among languages [28, 3]. VOT differences, in turn, may influence f0 [22]. Some of the non-duration properties may be used as enhancing cues and their role may not be the same when the phonetic and phonological contexts differ [32].

Initial obstruent length is hard to perceive [31, 23] because there is no preceding sound that conveys various acoustic cues [20, 16]. Especially, plosives are the most handicapped consonant type in the initial position for length distinction because the length difference is mainly conveyed by the closure duration in intervocalic position. Without this duration, consonant length may be mostly contrasted on the laryngeal dimension. Cross-linguistic studies suggest that there are typically only three VOT contrasts [6, 14]. We examined the release duration of the plosives and four non-temporal values at the onset of the following vowel in the initial position to determine if they are used differently than in the medial position.

A functional assumption, the Dispersion theory presupposes that maximally distant acoustic dispersion assures the perceptibility of the contrastive elements [7]. In this regard, given the asymmetric numbers of alveolar plosives, their acoustic realisations may be different between the positions, despite the same distinctive feature combinations for three of the consonants: /t tt d/.

We shall measure, thus, the selected acoustic values in the two positions and the closure duration of the medial plosives and consider the positional differences. After reporting the acoustic measurements, we shall evaluate the classification power of each of the acoustic parameters.

3. METHODS

3.1. Recording

Ten Ikema speakers (three males born 1952-1959, avg. age 61.7; seven females born 1932-1952, avg. age 75.6) were recorded in 2018 at a participant's house or a local community centre.

A word list of singleton and geminate obstruents was created. This study uses only seven words involving alveolar plosives out of the whole corpus: [ta:] 'rice field', [tta] 'tongue', [dariru] 'being tired', [bata] 'stomach', [batta] 'grasshopper', [bada] 'trench' and [badda] 'side.' A Sony Linear PCM-M10 digital voice recorder with an integrated microphone was set on the table to record the audio sounds (44.1 kHz, encoded in 16 bit). Participants were introduced to the word list and instructed to produce

each word in citation form. The Ikema syntax allows for *pro*-drop and bare forms in the phrase-initial position, creating a natural language usage situation in citation forms. During the session, an equivalent of each target word was presented orally in standard Japanese, and participants produced each target word three times. Some participants provided additional repetitions that were included in the final analysis, while other items had to be discarded due to poor quality, such as uneven tempo or creaky voice.

3.2. Analyses

A total of 227 tokens were included in the analyses (word-initial: 104; word-medial: 123). The data were segmented and analysed in Praat [4]. The release interval of the plosives was segmented from the beginning of the release burst to the first glottal pulse of the following vowels. (Fig. 1). The closure duration of word-medial consonants was defined as the temporal interval from the offset of the preceding vowel to the release of the closure. f0, F1, intensity (cubic interpolation) and H1-H2c (corrected) at the onset of the following vowels [a] or [a:] were measured. The formants were extracted using LPC analysis over a sliding 25 ms window.

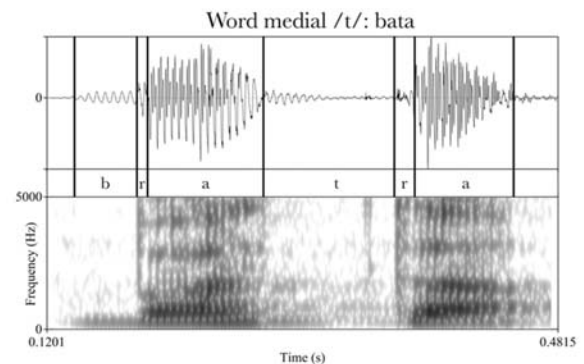


Figure 1: Spectrogram of /bata/ 'stomach.' r refers to the release interval, t is the measured closure duration in this example.

A series of linear mixed effects (LME) models was conducted in R [30] *lmerTest* packages [24]. The *emmeans* package [26] was used to perform pairwise comparisons. In all the LMER models, we performed pairwise comparisons, which included all the words (α value: $p = 0.05$) but run separately for each position. For all the LME models, Speaker was included as a random factor, Voicing (voiceless and voiced) and Length (singleton and geminate) as fixed factors. The following measurements were included as dependent variables: release duration of the plosives (and closure duration of the medial ones) (ms), f0 (Hz), F1 (Hz), intensity (dB), H1-H2c (dB). All the non-temporal acoustic measures were z-score

normalised. Classification of the target segments was performed using the *rpart* package [35] and `predict()` function in R [30]. Variable importance was calculated to further investigate the ranking and role of each acoustic measure in the classification of voicing and length contrasts [15].

4. RESULTS

The results of acoustic measurements are illustrated in Figs. 2-7 and the main results of the pairwise comparisons among the consonants are summarised for each measurement. The symbol ‘>’ indicates where α value appeared in the difference. ‘,’ indicates where no such difference appeared between the consonants.

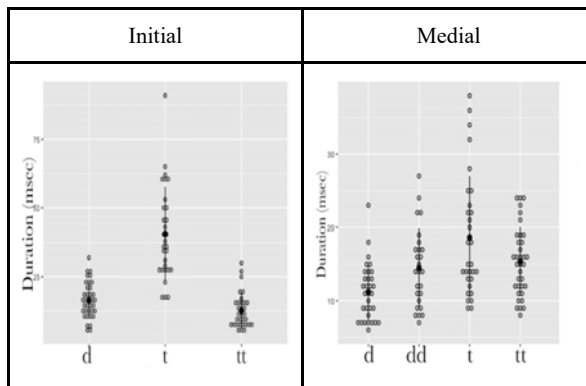


Figure 2: Release duration of the consonants.

The release duration of /t/ was longer than the others in both positions. That of /d/ in the medial position was shorter than the rest. (Initial: $t > tt, d$; Medial: $t > tt, dd > d$).

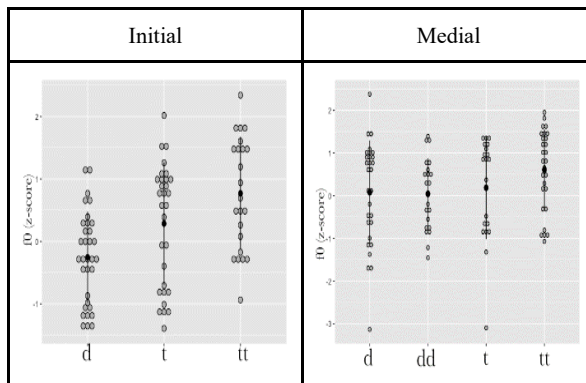


Figure 3: f_0 (z-score) measured at the onset of the vowel.

The geminate had higher f_0 than the singletons and the voiceless consonants induced higher f_0 than the voiced counterpart in the initial position ($tt > t > d$) while no difference was observed among any pairs in the medial position.

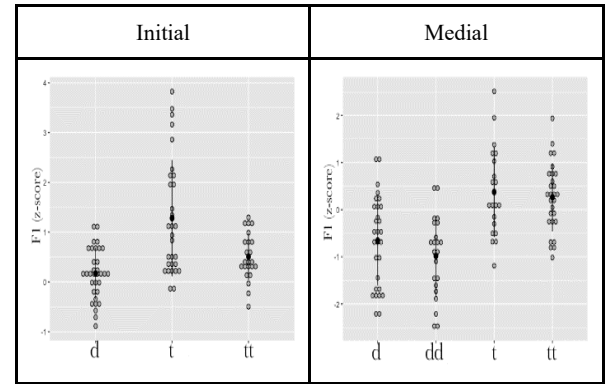


Figure 4: F1 (z-score) measured at the onset of the vowel.

/t/ had higher F1 than its geminate and voiced counterparts in the initial position ($t > tt, d$). No difference was found between the members of the voiceless pair in the medial position ($t, tt > d > dd$).

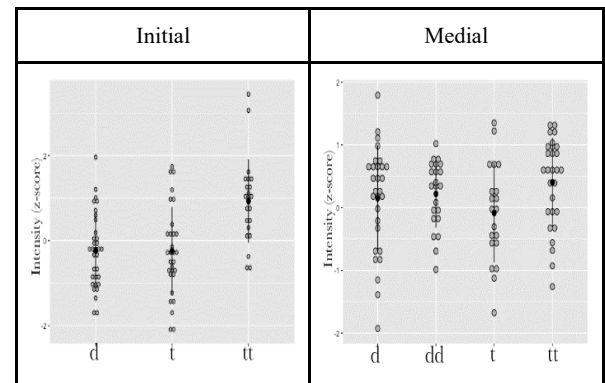


Figure 5: Intensity (z-score) measured at the vowel onset.

Voiceless geminate had higher intensity than its singleton counterpart in both positions ($tt > t$). The voiced pair in the medial position did not show any difference. (Initial: $tt > d, t$; Medial: $tt, dd, d > t$).

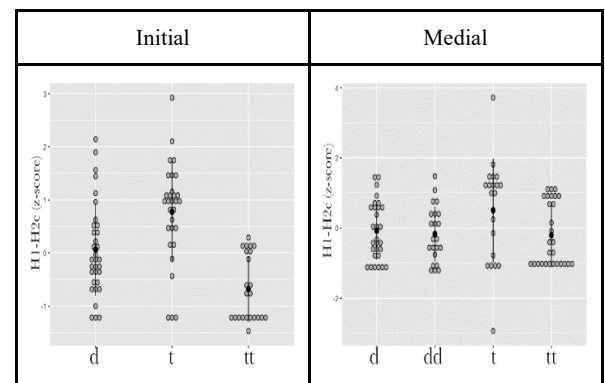


Figure 6: H1-H2c (corrected / z-score) measured at the vowel onset.

The initial triplet was separated by H1-H2c ($t > d > tt$) but it was not the case in the medial position.

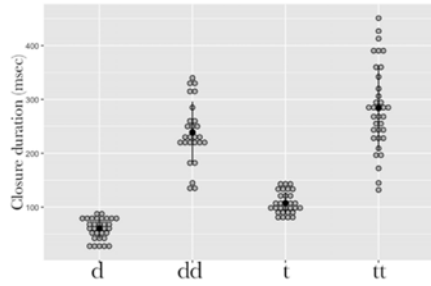


Figure 7: Closure duration of medial consonants.

The closure duration of the medial consonants was longer in geminates than in singletons and voiceless ones than in voiced ones. ($tt > dd > t > d$).

The different orders in the acoustic measurements imply different cue weights in each position. To assess the importance of each acoustic cue in each position, we conducted an additional test as outlined in section 3.2. Figs. 8-9 display the results using a unitless scale.

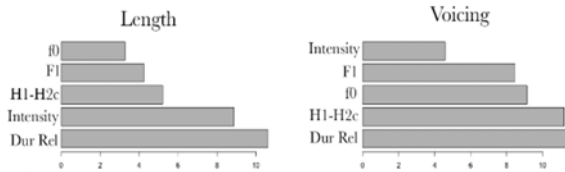


Figure 8: Importance of acoustic parameters for the initial plosives in Ikema.

In terms of length distinction among the initial triplet, intensity is the second most important cue after release duration (Dur Rel). Regarding voicing, voice quality (H1-H2c) along with release duration are the most significant cues.

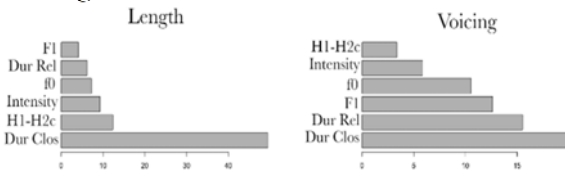


Figure 9: Importance of acoustic parameters for the medial plosives in Ikema.

The analyses for the medial quadruplet included closure duration (Dur Clos). For length distinction, closure duration is by far the most important cue. In terms of voicing, closure duration is also more significant than any other attributes of the consonant.

5. DISCUSSION

We investigated acoustic properties of the length and voicing contrasts in the asymmetrically distributed alveolar plosives of Ikema (/t tt d/ initially vs. /t tt dd/ medially). Dispersion theory predicts that the acoustic space would be used to optimise the

perception of the contrasts. Figs. 2-6 illustrate that acoustic values of each consonant category are mostly more dispersed in the initial position and more clustered in the medial position. A larger difference between the minimum and maximum values in certain measures (f_0 , Intensity, H1-H2c) between the two positions may be partly a by-product of the domain initial strengthening [5, 10], however, different variable importance between the positions cannot be explained by this effect alone.

The variable importance analysis revealed the predominance of the closure duration in the medial plosives, while release duration is the most important variable for the initial plosives. Non-temporal properties are more influential in the initial length contrast and are likely also more important in the initial voicing contrast than in the medial ones.

None of the obstruents has a four-way contrast in the initial position in Ikema. Since release duration has been confirmed as the more powerful variable than non-temporal properties in this position, our results are in line with [6] claiming up to three VOT contrasts. For instance, [6] noted that an apparent four-way laryngeal contrast in Pakistani languages (Jangli and Urdu) relies on other phonetic parameters rather than VOT. It is worth noting that in the triplet, /d/ had a mean voicing lead of 75.1 ms (sd : 52.3 ms), which could also be useful for its identification. However, it was excluded from the measurements to enable comparison with the medial voiced plosives where closure duration often overlaps with voicing lead in this language. This implies that VOT may play a more decisive role than release duration in the initial triplet. We hypothesise that without context preceding it (*i.e.*, word-initial position), no more than three contrasts can be hosted without introducing contrast in other laryngeal dimensions such as distinctive voice quality or tone on the following vowel. In the case of Ikema, non-temporal properties can be at best characterised as enhancing cues at the synchronic state.

Our study confirmed that the closure duration, the privileged attribute of the medial consonants, clearly separates the four categories (Fig. 7). Adjacent vowel durations are also known to give cues to consonant length and voicing [19, 16]. A future study invites us to study this aspect in Ikema.

6. ACKNOWLEDGEMENTS

We thank our participants and the staff of the NPO Kyuunu Hukarasha for allowing us to use their facilities. The study was supported by Labex EFL.

7. REFERENCES

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