

Acoustic Spectrographic Analysis of The Trill Consonant /r/ In the Melaka Dialect

Muhammad Firdaus bin Mohd Sah^{1*}, Sharifah Raihan Syed Jaafar²

¹Academy of Language Studies Universiti Teknologi MARA

²Centre for Research in Language and Linguistics, Faculty of Social Sciences and Humanities, National University of Malaysia

*Corresponding Author

DOI: <https://doi.org/10.47772/IJRISS.2026.102100154>

Received: 05 September 2026; Accepted: 23 September 2026; Published: 03 October 2026

ABSTRACT

This acoustic phonetic study examines the pronunciation of the trill consonant /r/ in the Melaka dialect. Fieldwork was conducted in Kampung Jalan Pulau, Melaka Tengah, where respondents pronounced 12 lexical items containing /r/ in word-initial, medial, and final positions. Respondents, comprising native Melaka dialect speakers aged 55 and older, were selected based on specific sociolinguistic criteria. The collected data were compared with Standard Malay pronunciations utilizing PRAAT software for spectral frequency analysis. Findings empirically demonstrate that variations in /r/ pronunciation occur across all word positions initial, medial, and final rather than being isolated strictly to word-final positions. Four primary phonological processes underlying these variations were identified: substitution, gliding, deletion, and coalescence. Furthermore, the study reveals that the word-final /r/ undergoes not only gliding but also a coalescence process influenced by the preceding vowel. In conclusion, this acoustic phonetic approach using PRAAT successfully uncovers comprehensive insights into the /r/ pronunciation variants within the structural phonology of the Melaka dialect.

Keywords: Spectrographic, PRAAT, consonant, dialect, Melaka

INTRODUCTION

The generation of speech sounds constitutes a highly intricate physiological and aerodynamic process involving the precise, synchronized coordination of active and passive articulators within the vocal tract. Within the broader domain of formal linguistics, phonetics systematically investigates these vocalic and consonantal realizations. Phonetic science is fundamentally stratified into three complementary sub-fields: articulatory phonetics, which examines the anatomical mechanics and physical production of speech sounds; auditory phonetics, which explores the neuro-perceptual reception and cognitive decoding of acoustic signals by the listener; and acoustic phonetics, which analyzes the physical properties of speech sound waves during transmission through the air (Ladefoged & Johnson, 2014; Clark et al., 2007).

According to Crystal (1990), acoustic phonetics utilizes specialized instrumental paradigms and laboratory equipment to empirically measure parameters such as airflow dynamics, subglottal pressure, acoustic waveforms, fundamental frequency (F0), and spectral energy distributions across speech segments. While traditional articulatory descriptions rely heavily on auditory impressionism which can be susceptible to perceptual bias instrumental acoustic phonetics provides quantifiable, objective data that captures subtle fine-grained phonetic variation (Johnson, 2012). In contemporary laboratory phonology, specialized software such as PRAAT (Boersma & Weenink, 2024) has become indispensable for conducting spectrographic analysis. PRAAT enables precise digital signal processing and spectral visualization, thereby providing empirical verification of complex phonological processes (Stevens, 1998).

Present investigation applies an instrumental acoustic phonetic framework to analyze positional realizations and

phonetic transformations of the trill consonant /r/ within the Melaka dialect. Geographically, the state of Melaka is situated along the southwestern coast of Peninsular Malaysia, positioned directly across the Strait of from the island of Sumatra. Encompassing an area of approximately 1,650 square kilometers, Melaka shares northern borders with Negeri Sembilan and eastern borders with Johor. The state comprises major urban and suburban administrative hubs including Melaka City, Jasin, Merlimau, Alor Gajah, Masjid Tanah, Asahan, and Ayer Keroh where local speech communities exhibit distinctive phonological traits that set them apart from Standard Malay and neighboring regional varieties (Asmah Haji Omar, 1985; Collins, 1989).

A prominent structural hallmark of Melaka is the dynamic phonetic behavior of the trill segment /r/. In impressionistic dialectological literature, it is widely acknowledged that word-final /r/ in Melaka undergoes systematic alternation when compared to the alveolar trill [r] or tap [ɾ] prescribed in Standard Malay (Zaharani Ahmad, 2006). However, existing accounts have overwhelmingly focused on word-final coda phenomena, often leaving word-initial and word-medial environments under-explored through experimental paradigms. Applying quantitative acoustic methodologies specifically wideband spectrographic analysis and spectral frequency quantification via PRAAT to examine /r/ across all three structural positions (word-initial, word-medial, and word-final) addresses a critical empirical gap in Malay dialectology. Providing spectrographic evidence for these environments yields new insight into positional conditioning, coarticulatory effects, and the broader structural topology of Melaka phonology.

Problem Statement

As highlighted by Shahidi et al. (2012), conventional scholarship on Malay linguistics has traditionally leaned heavily toward qualitative descriptions of structural phonology and morphology, frequently prioritizing the abstract application of theoretical frameworks over empirical, experimental validation. While structural and rule-based paradigms provide foundational insights into phonological inventories, they often lack the objective acoustic granularity required to detail subtle surface-level phonetic variations. Experimental phonetic approaches—specifically utilizing instrumental digital signal processing tools such as PRAAT for spectrographic, pitch, and duration analyses—offer an empirically rigorous method to quantify acoustic phenomena. Incorporating physical wave metrics such as formant frequency dynamics (F₁, F₂, F₃), spectral tilt, and duration profile measurements provides robust empirical evidence to confirm or refine long-standing phonological assertions (Kent & Read, 2002; Hayward, 2014).

In Malay dialectology, the behavior of the trill consonant /r/ in the Melaka dialect has received notable attention in foundational literature, most prominently in the seminal works of Asmah Haji Omar (1985) and Zaharani Ahmad (2006). Both scholars established that the trill consonant residing in the word-final coda position undergoes a process of gliding or weakening when compared to standard varieties. Despite these valuable baseline descriptions, several critical empirical questions remain unanswered:

1. **Vocalic Environment Conditioning:** Does trill gliding occur uniformly across all preceding vocalic contexts, or is the process constrained and conditioned by specific acoustic features (such as vowel height, backness, or roundedness) of the nucleus vowel preceding the coda /r/?
2. **Positional Distribution:** Is trill alternation strictly confined to the word-final coda environment, or do parallel structural modifications such as spirantization, tapping, or deletion—manifest when the trill occupies word-initial onset or word-medial intervocalic positions?

Addressing these questions reveals a clear gap in the existing literature regarding the complete positional distribution and phonetic variation of /r/ in Melaka. Furthermore, previous descriptions of Melaka trill realization have remained largely impressionistic or restricted to theoretical modeling, lacking verification via acoustic instrumentation. Relying solely on auditory transcription risks overlooking fine-grained acoustic details, such as subtle formant transitions or low-intensity fricative noise bands, which are crucial for distinguishing between complete deletion, gliding, and spirantization (Scobbie, 2005; Wright, 2004).

Therefore, this study employs acoustic spectrographic analysis using PRAAT to systematically re-examine the realization of the trill consonant /r/ across all word positions (initial, medial, and final) in Melaka. By providing

empirical, spectrographic proof, this research aims to update existing dialectological records, resolve theoretical ambiguities, and establish an acoustically grounded account of trill variations in regional Malay phonology.

LITERATURE REVIEW

The study of trill consonants (/r/) across the Malay language family occupies a central position in Austronesian dialectology and phonological theory. Historically, early descriptive dialectologists most notably Asmah Haji Omar (1985), Zaharani Ahmad (2006), and more recently Mansurni Abadi (2021) documented the systematic modification of word-final coda rhotics in the Melaka dialect. Asmah (1985) and Mansurni Abadi (2021) highlighted an intriguing comparative divergence between Melaka dialect and its geographical neighbor, Johor Malay. While both varieties exhibit strong typological affinities, they diverge sharply in their treatment of the open front vowel followed by a word-final trill sequence (/ar/). In Johor Malay, the sequence /ar/ undergoes complete vowel-consonant coalescence and rounding, merging into a mid-back monophthong [o] (e.g., /bakar/ → [bako]). Conversely, Melaka dialect triggers a process of diphthongization or off-gliding, transforming the coda trill into a labial-velar glide [w] (e.g., /bakar/ → [bakaw]).

This stark contrast between two closely related Southern Peninsular dialects demonstrates that the realization of coda /r/ is profoundly conditioned by the feature specifications of the preceding vowel nucleus (Nor Hashimah Jalaluddin, 2007). However, because early classical descriptions relied primarily on auditory impressionism and rule-based theoretical formalisms, the exact acoustic mechanisms underlying this vocalic conditioning remain to be empirically quantified. Advances in modern acoustic instrumentation specifically wideband spectrographic analysis and formant tracking via PRAAT (Boersma & Weenink, 2024) allow researchers to go beyond binary rule descriptions and empirically test whether word-final /r/ in Melaka dialect undergoes multiple distinct phonological processes (such as gliding, coalescence, or complete deletion) depending on specific acoustic environments.

Cross-dialectal evidence further underscores the inherent phonetic instability and structural vulnerability of trill segments in syllable-final coda positions across Peninsular Malaysia. In an empirical investigation of the Penang subdialect in Balik Pulau, Ong et al. (2016) demonstrated that underlying coda /r/ is consistently replaced by a voiced velar fricative [ɣ]. In Terengganu Malay, Nur Adibah Hasan and Sharifah Raihan Syed Jaafar (2017) observed a structural reorganization of syllable templates, where canonical closed CVC syllables reduce to open CV structures due to the complete erasure or coalescence of coda rhotics. In this dialect, the sequence /ar/ or /ay/ merges into an open-mid back rounded vowel [ɔ] (e.g., /tukar/ → [tu.kɔ], /besar/ → [bə.sɔ], and /dengar/ → [də.ŋɔ]).

A parallel phenomenon is observed in Northern Peninsular Malay. In their analysis of the Perlis dialect, Fazal Mohamed Mohamed Sultan and Noriati Muhamad (2017) noted that word-final rhotics undergo glottalization, converting underlying /r/ into a glottal stop [ʔ] alongside vowel lowering and rounding (e.g., /tidur/ → [ti.dɔʔ]). Globally, similar trill lenition, glottalization, and spirantization patterns are well-documented in Germanic and Romance languages, where syllable codas serve as prime environments for phonetic weakening (Lavoie, 2001; Lindau, 1985).

Taken together, these empirical findings across regional varieties demonstrate substantial phonetic diversity in the surface realization of the trill consonant /r/. This variation reinforces the premise that trill realization in Melaka dialect is unlikely to be uniform or restricted to a single process of gliding. By employing a rigorous acoustic phonetic framework using PRAAT, the present study provides the necessary instrumental spectrographic evidence to map the full acoustic spectrum of /r/ realization variants in Melaka dialect, thereby enriching contemporary Malay dialectology and experimental phonology.

METHODOLOGY

Research Design and Fieldwork Site

As observed by Sallinen and Braidwood (2009), qualitative phonetic and linguistic research prioritizes in-depth investigation of a specific structural concept or phenomenon over the statistical aggregation of broad sample

variables typical of quantitative paradigms. Collecting naturalistic and ecologically valid acoustic data necessitates direct field-based recording rather than artificial lab-bound simulations (Ladefoged & Johnson, 2014). Consequently, this investigation employed an acoustic phonetic fieldwork methodology.

Fieldwork was conducted in Jalan 10, Tangga Batu (76300 Sungai Udang, Melaka), an established dialectal pocket within the Melaka Tengah district. To preserve the acoustic integrity of natural speech production, primary raw audio data were gathered through direct, face-to-face structured interviews. The recorded tokens were subsequently digitized, archived, and processed using digital signal processing software to evaluate acoustic waveforms and spectral energy configurations.

Instrument and Word List Design

Data collection utilized a standardized citation word list elicitation task. Target lexical items were carefully curated to test the structural distribution of the underlying trill consonant /r/ across three canonical positional environments: word-initial onset, word-medial intervocalic, and word-final coda positions. A total of 12 target lexical items were selected, balanced across adjacent vocalic environments:

1. Word-Initial Onset Position: /rambut/ ('hair'), /raya/ ('celebration'), /rantai/ ('chain'), /roti/ ('bread')
2. Word-Medial Intervocalic Position: /keramat/ ('sacred'), /perabot/ ('furniture'), /teratai/ ('lotus'), /perut/ ('stomach')
3. Word-Final Coda Position: /ular/ ('snake'), /telur/ ('egg'), /bakar/ ('burn'), /tabur/ ('scatter')

During elicitation sessions, participants were prompted to utter each target word within a carrier phrase as well as in isolation using their native dialectal register.

Participant Selection Criteria

Experimental phonetic investigations require strict control over physiological and sociolinguistic variables to minimize acoustic noise and non-dialectal interference (Thomas, 2011). Participant selection from the local population in Tangga Batu adhered to five non-negotiable inclusion criteria:

Intact Vocal Tract Physiology: Absence of speech impairments, hearing defects, or anatomical anomalies affecting articulation; Age Threshold: Age ≥ 55 years, ensuring retention of conservative, unmerged dialectal features (Labov, 2001); Dialectal Nativeness: Lifetime native residency in the Melaka dialect zone; Educational Background: Minimal formal higher education to prevent structural over-generalization or standardization toward Standard Malay; Occupational Profile: Non-office-based or manual/traditional occupations, minimizing exposure to formal institutionalized registers.

To provide a robust acoustic contrast and isolate authentic dialectal realization, three participants were selected for recorded trials: two native Melaka dialect speakers who fully satisfied all sociolinguistic criteria, and one control speaker representing Standard Malay. The inclusion of a control baseline permitted precise, comparative spectrographic overlay and spectral frequency contrasting across all three positional contexts. Given the small sample size, this research is explicitly framed as a preliminary exploratory pilot study, which serves as a core limitation regarding the generalizability of the findings. However, to provide a robust acoustic contrast and isolate authentic dialectal realization for this initial exploration, three participants were selected for recorded trials: two native Melaka dialect speakers who fully satisfied all sociolinguistic criteria, and one control speaker representing Standard Malay. The inclusion of a control baseline permitted precise, comparative spectrographic overlay and spectral frequency contrasting across all three positional contexts.

Acoustic Signal Processing

Acoustic analyses were executed using PRAAT software (Version 6.0.36) developed by Paul Boersma and David Weenink at the Department of Phonetics, University of Amsterdam (Boersma & Weenink, 2024). PRAAT facilitates advanced digital signal processing, enabling precise mono/stereo signal visualization, pitch tracing,

formant analysis, and wideband spectrographic rendering. As noted by Agnes and Michael (2004), wideband spectrographic analysis provides an ideal diagnostic platform for phonetic research; distinct spectral energy bands and formant trajectories directly reflect underlying articulatory mechanics, tongue height, and place of constriction.

FINDINGS AND DISCUSSION

Upon uploading the raw data into the PRAAT software, several phonetic variations in the pronunciation of the trill consonant /r/ within the Melaka Dialect were observed. The spectrogram analysis reveals a distinct phonological process occurring in the word-initial position of the trill consonant /r/. The spectrographic readings for the word-initial/r/ are presented below:

/rambut/:

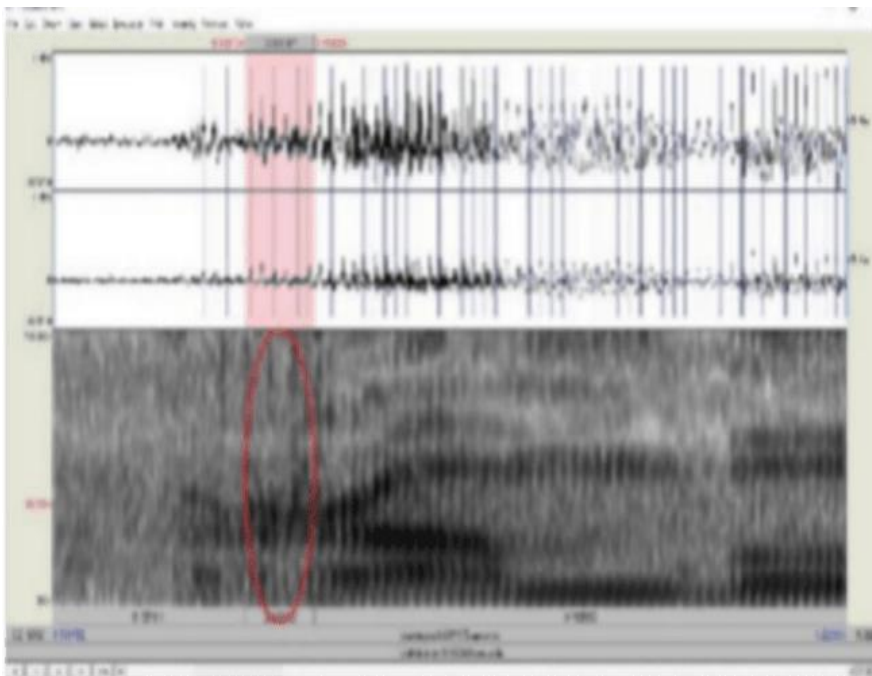


Figure 1 spectrogram reading of a standard Malay speaker for lexical /rambut/.

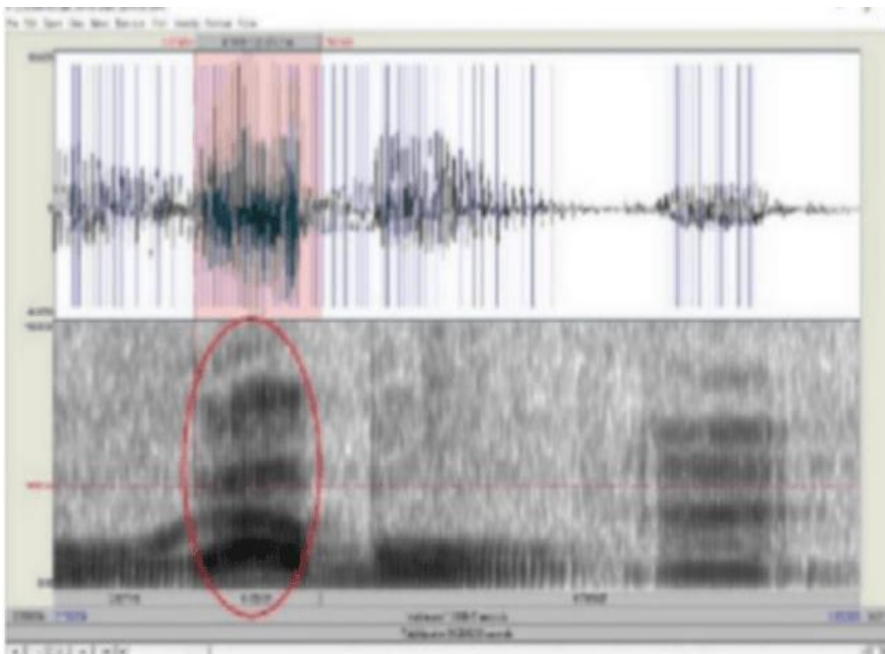


Figure 2 Spectrogram reading of the first responder of the Melaka Dialect for the lexical /rambut/

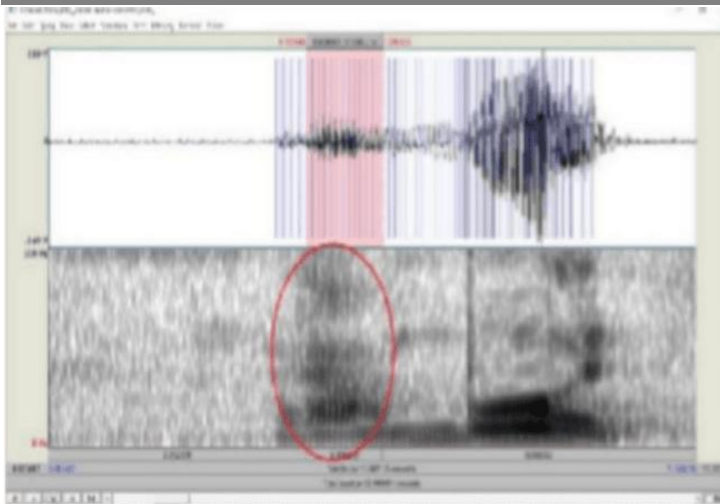


Figure 3 Spectrogram reading of the second responder of the Melaka Dialect for the lexical/rambut/

The three figures above present the spectrographic readings for the lexical item /rambut/. A comparative acoustic analysis reveals marked variations in the spectrographic patterns across the three speakers, with the red highlighted regions denoting the acoustic realization of the trill consonant /r/. Based on the spectrographic evidence, a distinct phonetic divergence is observable between the standard Malay speaker and the native speakers of the Melaka Dialect.

In Figure 1 (representing the standard Malay speaker), the acoustic signal demonstrates a stable and well-defined trilling pattern, characterized by regular, periodic energy pulses and distinct silent intervals typical of a fully articulated alveolar trill [r]. Conversely, the spectrograms in Figures 2 and 3 (representing the Melaka dialect speakers) exhibit higher energy concentration, manifested through darker, compressed formant bands and a significantly shorter closure duration. This spectral pattern implies that word-initial /r/ in the Melaka Dialect undergoes articulatory constriction and phonetic lenition rather than full multi-tap trilling. Consequently, native speakers demonstrate a clear phonetic preference for an alveolar tap [ɾ] over the standard trill [r].

This phonetic shift is further corroborated by the quantitative spectral frequency metrics. The mean spectral peak recorded in Figure 1 reaches 1733.98 Hz, whereas Figures 2 and 3 register substantially lower frequency values at 1092.13 Hz and 914.49 Hz, respectively. The pronounced drop in spectral energy among the dialect speakers provides robust acoustic proof of a modified manner of articulation specifically, a transition from a full trill to a brief tap confirming that the realization of the word-initial trill consonant /r/ undergoes systematic phonological conditioning in the Melaka Dialect.

/raya/:

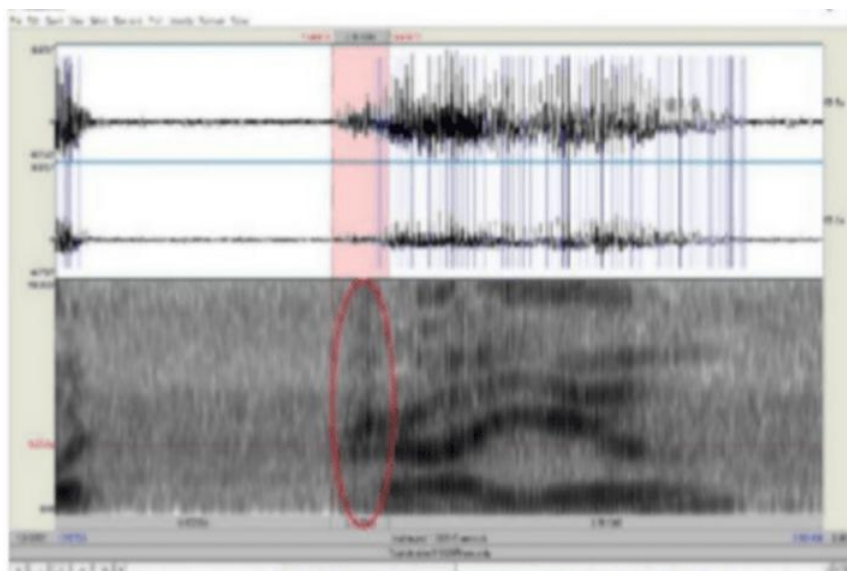


Figure 4 spectrogram reading of a standard Malay speaker for lexical /raya/.

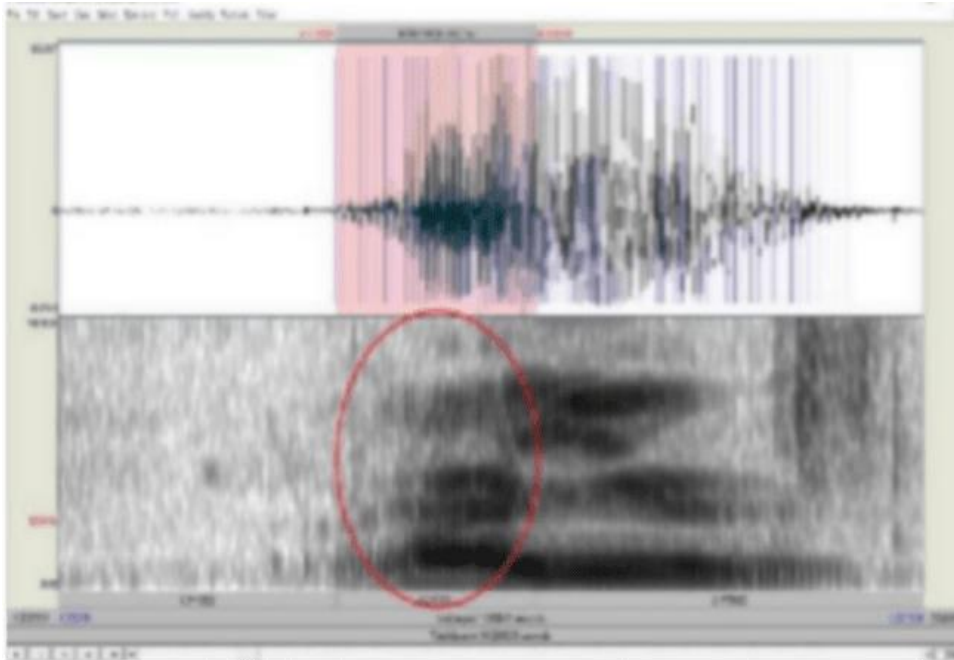


Figure 5 Spectrogram reading of the first responder of the Melaka Dialect for the lexical /raya/

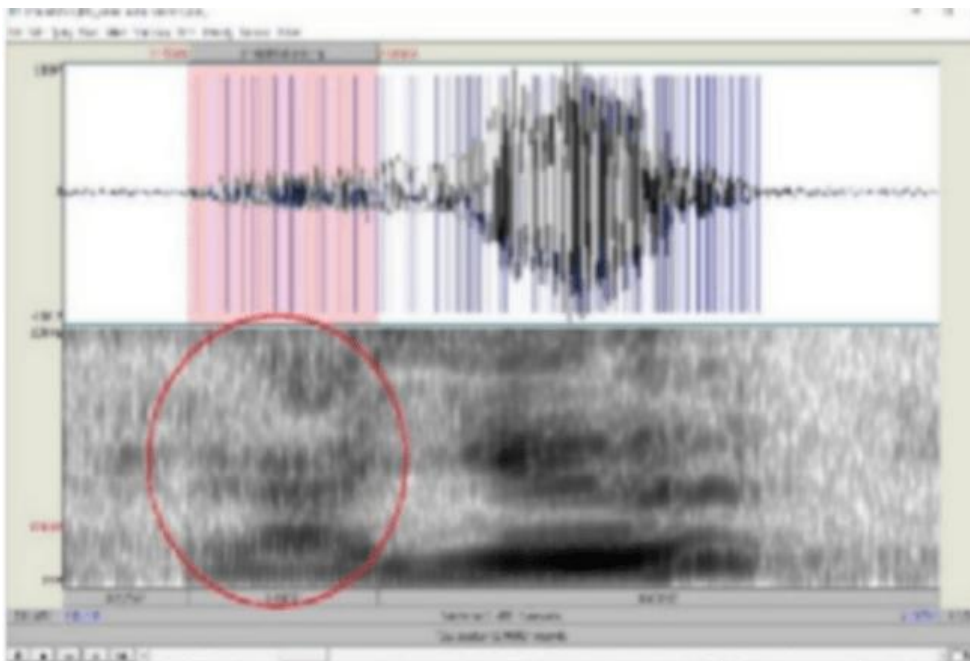


Figure 6 Spectrogram reading of the second responder of the Melaka Dialect for the lexical /raya/

A parallel acoustic trend is consistently observed in the spectrographic analysis for the lexical item /raya/. A comparative evaluation of the spectrographic signatures for the word-initial trill consonant /r/ reinforces the phonetic discrepancy between the standard Malay speaker and the native Melaka Dialect speakers. As illustrated in Figure 4, the acoustic signal for the standard Malay speaker mirrors the structural properties of Figure 1, displaying a highly stable, periodic trill ing pattern with clear burst-silence cycles that typify a canonical alveolar trill [r]. Conversely, the acoustic profiles in Figures 5 and 6 display a marked reduction in trill duration, accompanied by a higher concentration of energy across narrower formant bands. This acoustic behavior reflects a notable degree of articulatory compression and constriction, closely aligning with the tap-like properties previously identified in Figures 2 and 3.

This observed phonetic variation is quantitatively corroborated by the spectral frequency metrics. The peak spectral frequency for the standard Malay speaker in Figure 4 is registered at 1129.44 Hz. In stark contrast, the native Melaka Dialect speakers in Figures 5 and 6 exhibit a steep decline in spectral energy, recording

substantially lower values at 545.49 Hz and 551.76 Hz, respectively. This sharp drop in acoustic frequency—exceeding a 500 Hz reduction provides strong empirical evidence of a modified place and manner of articulation. Rather than executing a full alveolar trill requiring multiple lingual contacts, speakers of the Melaka Dialect exhibit an abbreviated constriction characteristic of the alveolar tap [ɾ]. Consequently, these findings confirm that the realization of the word-initial trill in /raya/ is governed by a systematic, dialect-specific phonological rule rather than random phonetic variation.

/rantai/:

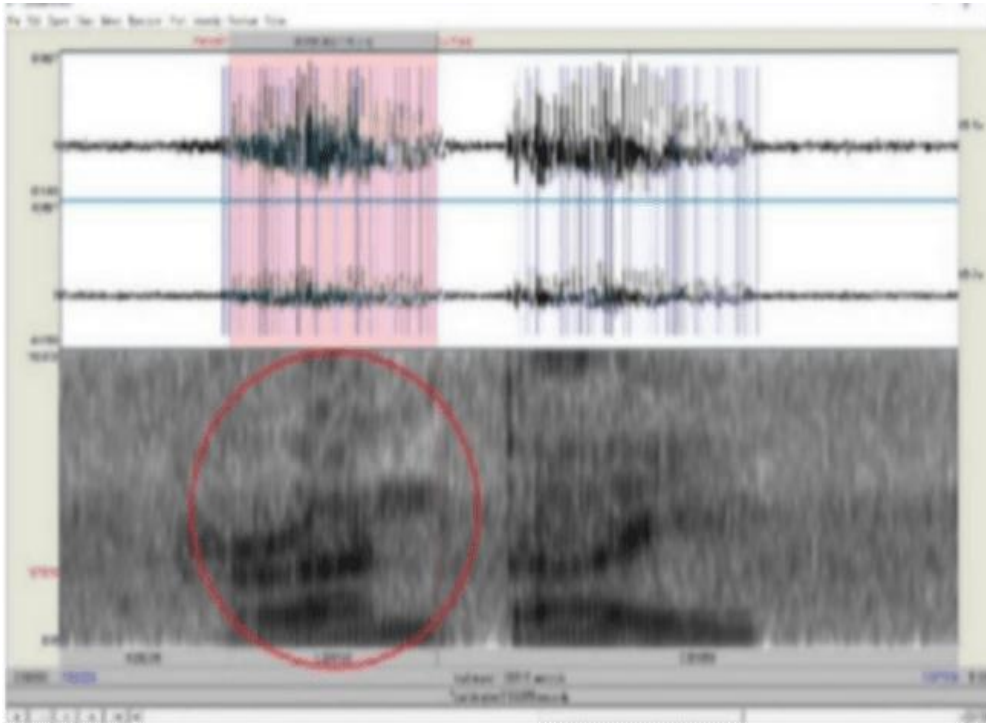


Figure 7 spectrogram reading of a standard Malay speaker for lexical /rantai/.

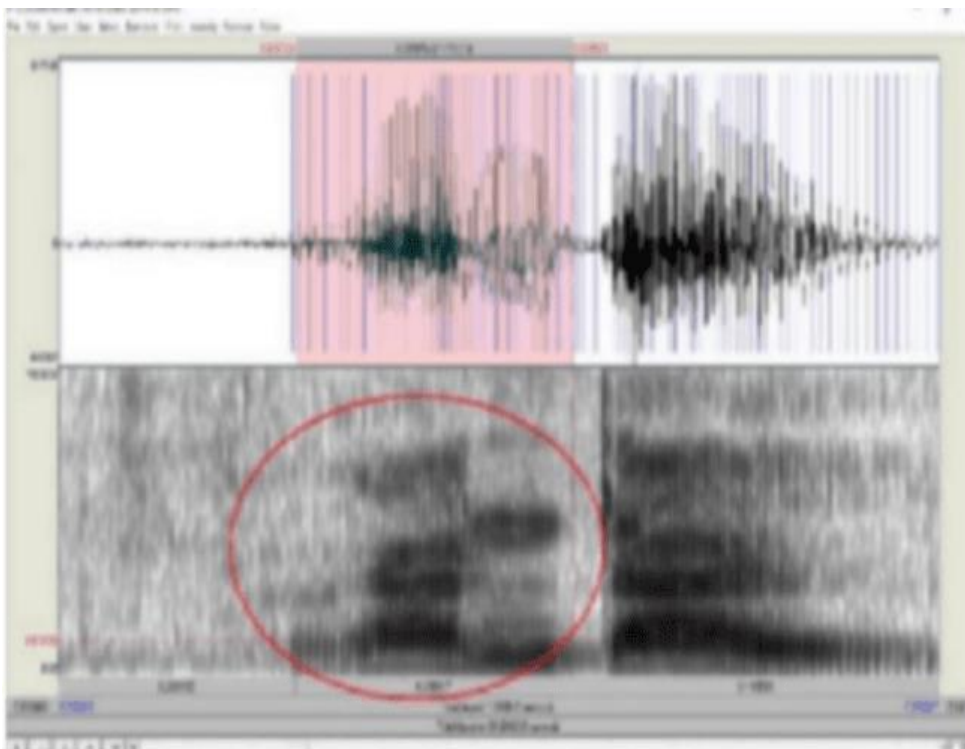


Figure 8 Spectrogram reading of the first responder of the Melaka Dialect for the lexical /rantai/

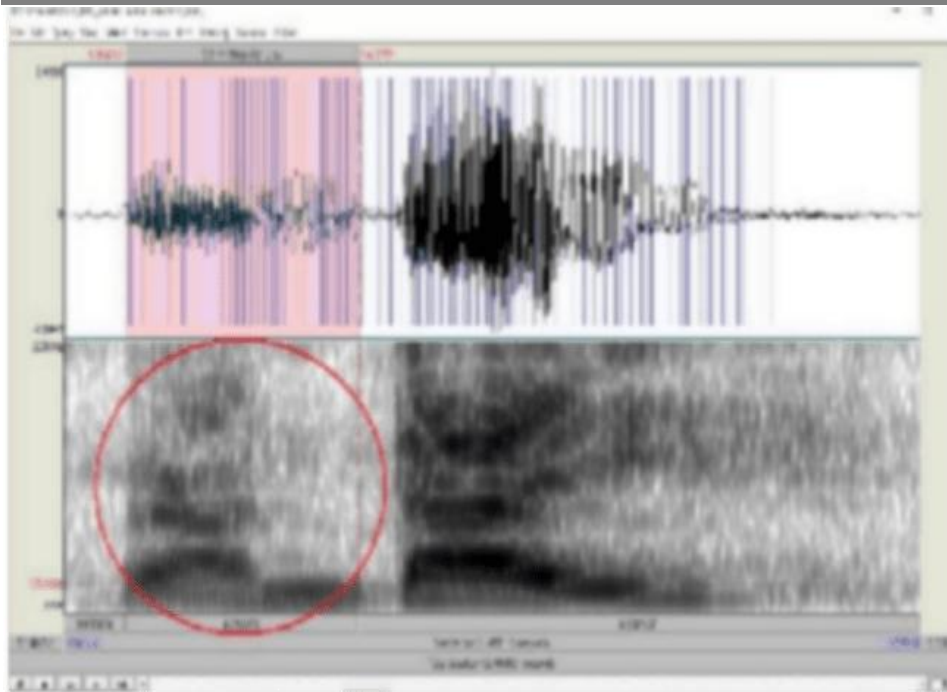


Figure 9 Spectrogram reading of the second responder of the Melaka Dialect for the lexical /rantai/

A congruent phonological process is similarly manifested in the pronunciation of the lexical item /rantai/. The spectrographic profiles generated by both dialect speakers exhibit noticeable acoustic divergences when compared against the baseline established by the standard Malay speaker. Quantitatively, the peak spectral frequency for the standard Malay speaker is recorded at 1021.97 Hz. In contrast, the spectrographic data depicted in Figures 8 and 9 display striking variation: Figure 8 registers a markedly lower frequency at 511.18 Hz, whereas Figure 9 records a substantially higher frequency at 1344.39 Hz.

This significant dispersion in spectral frequency values highlights a clear acoustic departure from standard Malay pronunciation. The lower frequency in Figure 8 aligns with the acoustic reduction and tap-like constriction [ɾ] observed in previous lexical items, whereas the elevated spectral peak in Figure 9 suggests localized acoustic emphasis or variations in formant transition during articulatory release. Despite this intra-dialectal variation in frequency distribution, both readings fundamentally diverge from the steady, periodic spectral signature of the standard trill [r]. This empirical evidence further confirms that word-initial /ɾ/ in /rantai/ undergoes dynamic phonological restructuring within the Melaka Dialect, reinforcing the systemic nature of trill variation across the dialect's lexicon.

/roti/:

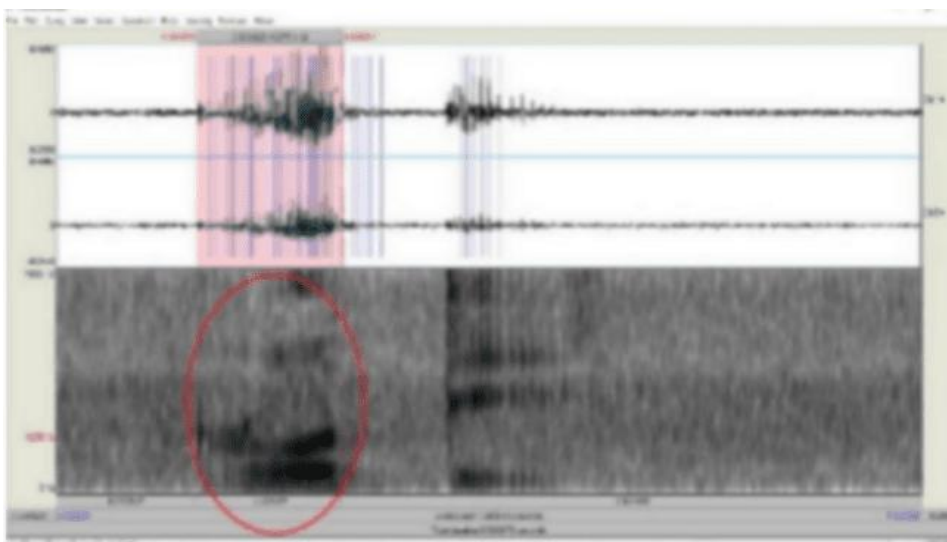


Figure 10 spectrogram reading of a standard Malay speaker for lexical /roti/.

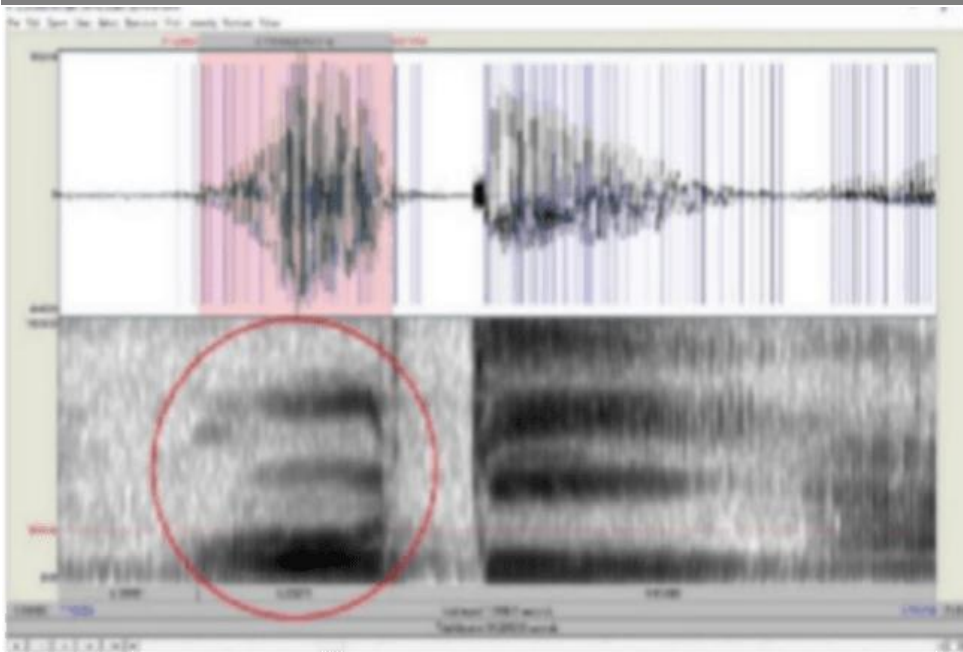


Figure 11 Spectrogram reading of the first responder of the Melaka Dialect for the lexical /roti/

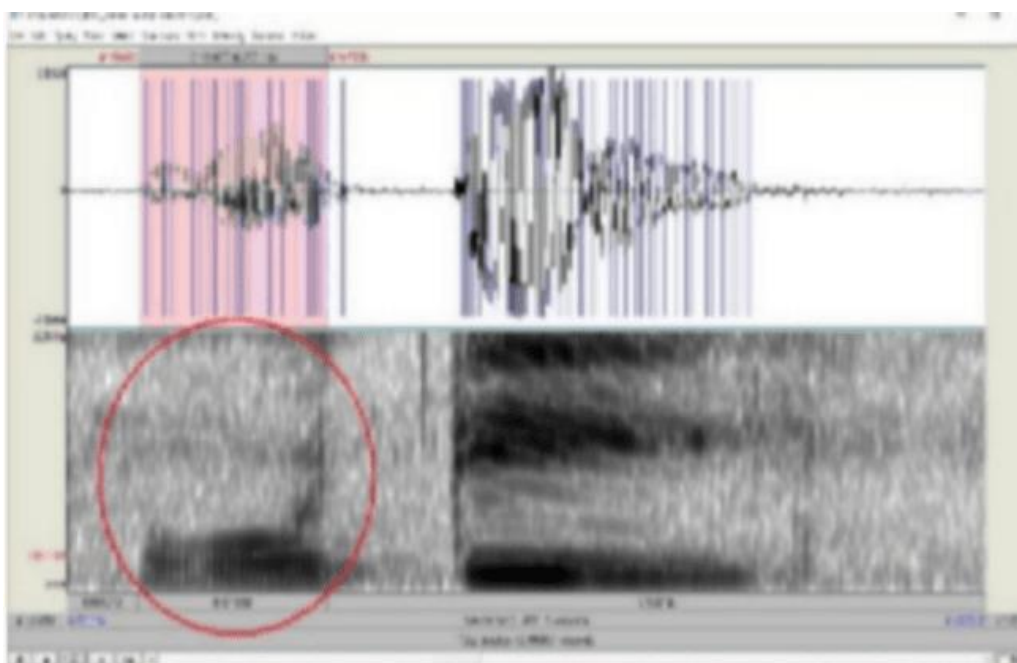


Figure 12 Spectrogram reading of the second responder of the Melaka Dialect for the lexical /roti/

Conversely, the acoustic properties of the lexical item /roti/ for the standard Malay speaker exhibit a clear, periodic spectrographic signature, signifying a fully articulated trill ing mechanism during production. However, the spectrographic profiles for both native Melaka Dialect speakers reveal a distinct articulatory constriction during the realization of the trill consonant. As highlighted within the red bounded regions in Figures 11 and 12, the spectrograms display a high concentration of acoustic energy (increased formant darkness and density) compared to the standard Malay baseline. For both dialect speakers, this spectral density persists continuously from the onset of the trill consonant through to the transition into the following vowel /o/.

This acoustic shift indicates a categorical modification in the manner of articulation, where the standard alveolar trill /r/ shifts to a voiced velar fricative [ɣ]. This observation aligns with Ong Su Teck et al. (2016), who noted that the voiced velar fricative [ɣ] typically occurs in word-initial and word-medial positions, but is systematically absent in word-final position. These spectrographic findings empirically demonstrate that the Melaka Dialect similarly employs the voiced velar fricative [ɣ] as a phonological substitute for the standard trill /r/.

The temporal and spectral frequency metrics further substantiate this acoustic divergence. The peak spectral frequency for the standard Malay speaker in Figure 10 is registered at 1129.44 Hz. In stark contrast, the native dialect speakers in Figures 11 and 12 record substantially lower frequency values, at 547.49 Hz and 538.33 Hz, respectively. As established in the preceding analysis, the word-initial trill consonant undergoes a systematic phonological operation specifically, the process of phonological substitution. In line with Lahey (1988), phonological substitution entails a process wherein one speech segment is replaced by another segment within a specific phonetic environment. Based on the spectrographic analysis, the standard word-initial trill /r/ is categorically substituted with the voiced velar fricative [ɣ].

Crucially, the spectrographic evidence unveils a contextual conditioning factor governing word-initial trill realization, wherein the adjacent vowel quality directly dictates the phonetic output. Following Nor Hashimah Jalaluddin (2007), both /a/ and /o/ are classified as back vowels, but differ in tongue height: /a/ is a low back vowel, whereas /o/ is a mid-high back vowel. The empirical data reveals that when /r/ is adjacent to the low back vowel /a/, the spectrograms lack the dense, continuous frication bands observed when /r/ precedes the mid-high back vowel /o/.

Synthesizing these findings, when the word-initial trill /r/ precedes the low back vowel /a/ (as in /rambut/, /raya/, and /rantai/), it undergoes lenition to an alveolar tap [ɾ], yielding [rambut], [raja], and [rantai]. Conversely, when adjacent to the mid-high back vowel /o/, the trill undergoes dorsal substitution to a voiced velar fricative, resulting in [ɣoti]. This articulatory asymmetry confirms that vowel environment plays a pivotal role in conditioning allophonic variation in the Melaka Dialect.

Next, the discussion shifts to the spectrographic analysis of the trill consonant /r/ in the word-medial position. Based on the spectrographic data, the phonetic realization of the medial trill closely parallels the acoustic patterns observed in the word-initial position. Specifically, the acoustic evidence indicates that the word-medial /r/ similarly undergoes articulatory compression and emphasis rather than a standard, full trill. The spectrographic readings for the word-medial trill consonant /r/ are presented below:

/keramat/:

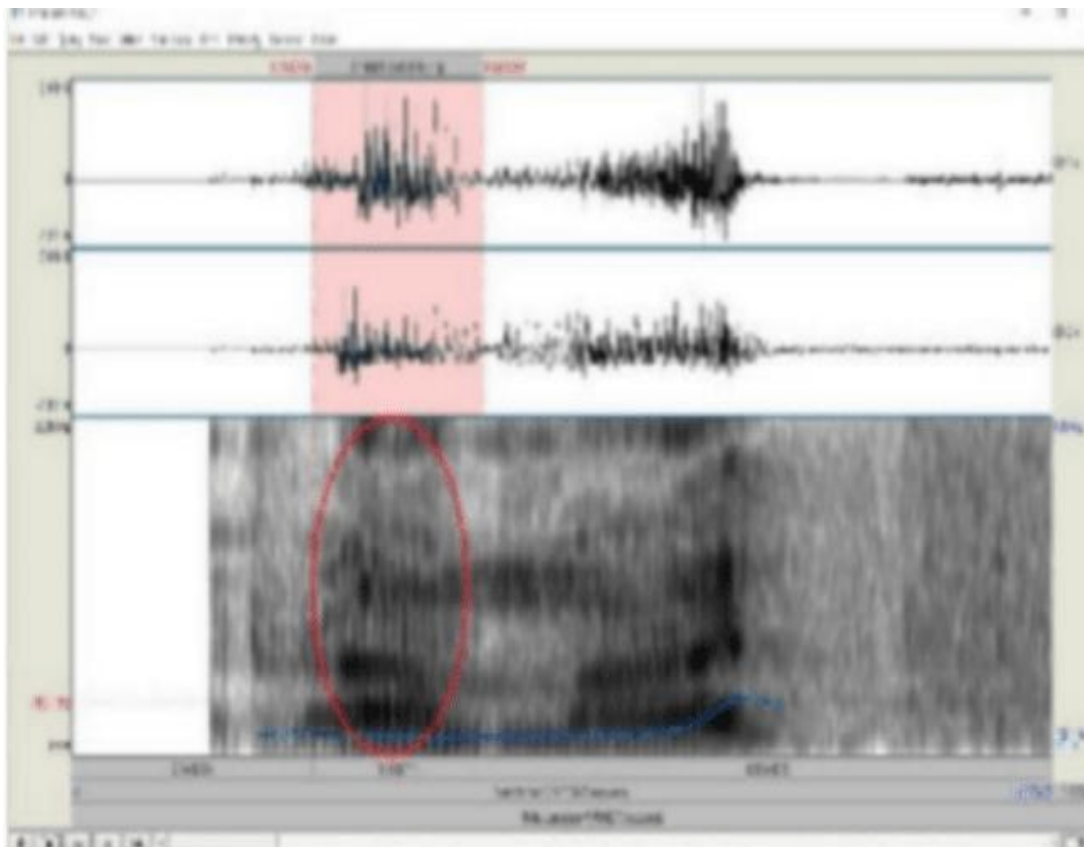


Figure 13 spectrogram reading of a standard Malay speaker for lexical /keramat/.

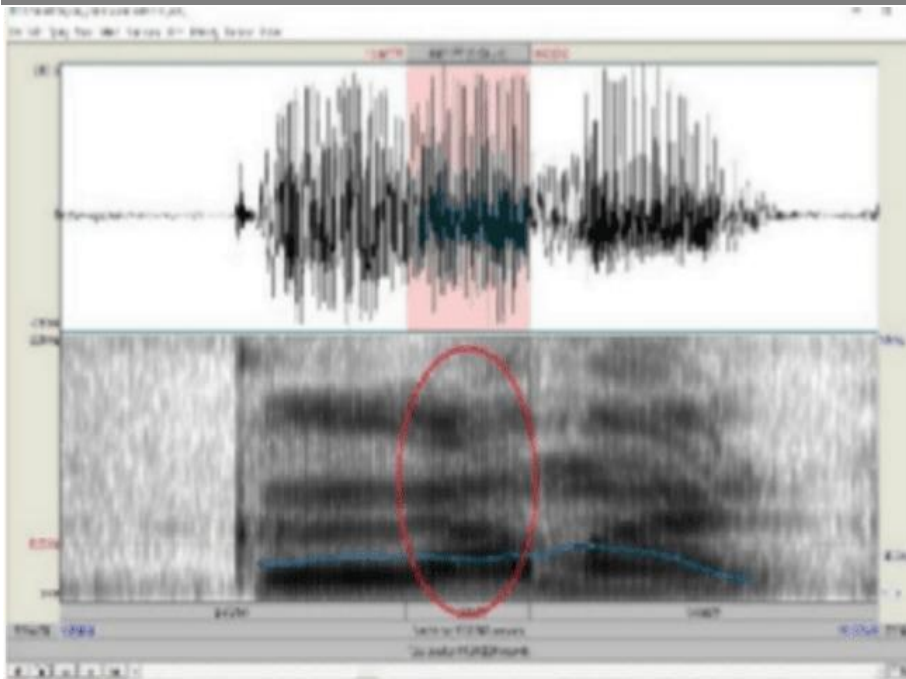


Figure 14 Spectrogram reading of the first responder of the Melaka Dialect for the lexical /keramat/

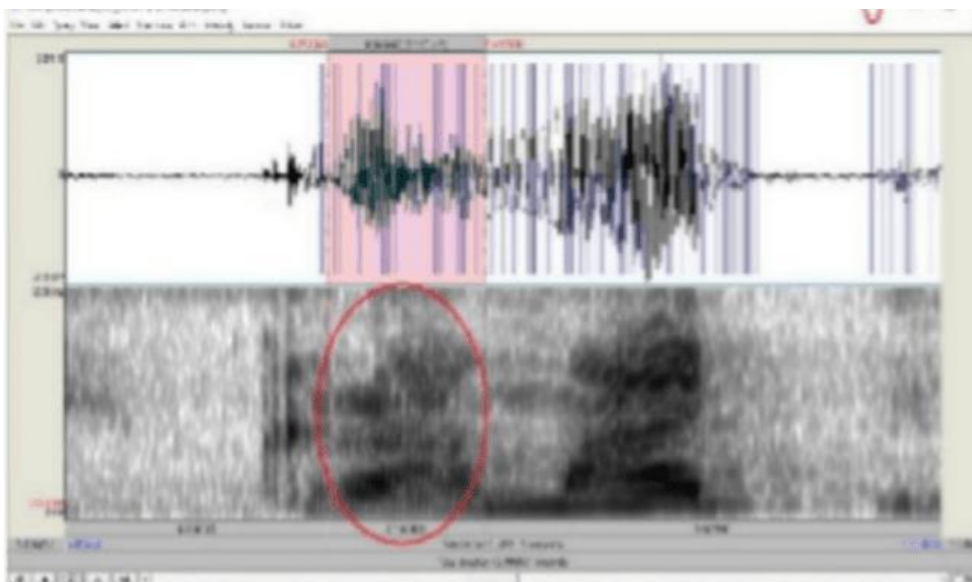


Figure 15 Spectrogram reading of the second responder of the Melaka Dialect for the lexical /keramat/

An examination of the spectrographic profiles reveals distinct spectral patterns and energy densities across the respondents. The spectrograms in Figure 14 (Respondent 1) and Figure 15 (Respondent 2) exhibit compressed formant bands, pointing to articulatory emphasis during the realization of the word-medial trill /r/. This acoustic behavior mirrors the spectrographic signatures previously observed in Figures 2 and 3 for the lexical item /rambut/. Consequently, the phonetic realization of the trill consonant in the lexical item /keramat/ shifts to an alveolar tap [ɾ], yielding the phonetic output [kəramat].

The quantitative spectral frequency metrics further reflect inter-speaker variation in the production of the medial trill consonant. The baseline PRAAT spectral analysis for the standard Malay speaker (Figure 13) registers a peak frequency of 847.32 Hz. In comparison, Respondent 1 (Figure 14) displays a higher spectral frequency of 1089.14 Hz, whereas Respondent 2 (Figure 15) records a lower frequency at 833.89 Hz. Thus, Respondent 1 registers an elevated frequency relative to the standard baseline, while Respondent 2 demonstrates a reduction in spectral energy compared to both the standard speaker and Respondent 1. This dispersion in spectral values across the dialect speakers underscores acoustic variation in the execution of the trill segment. In line with the phonological framework discussed in preceding sections, the word-medial trill in this lexical environment

undergoes phonological substitution, transitioning from a standard trill to an alveolar tap [ɾ]

/perabot/:

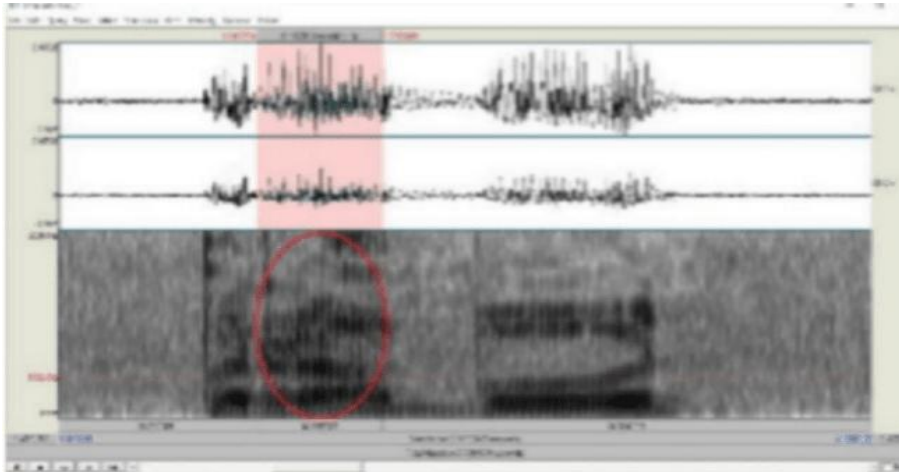


Figure 16 spectrogram reading of a standard Malay speaker for lexical /perabot/.

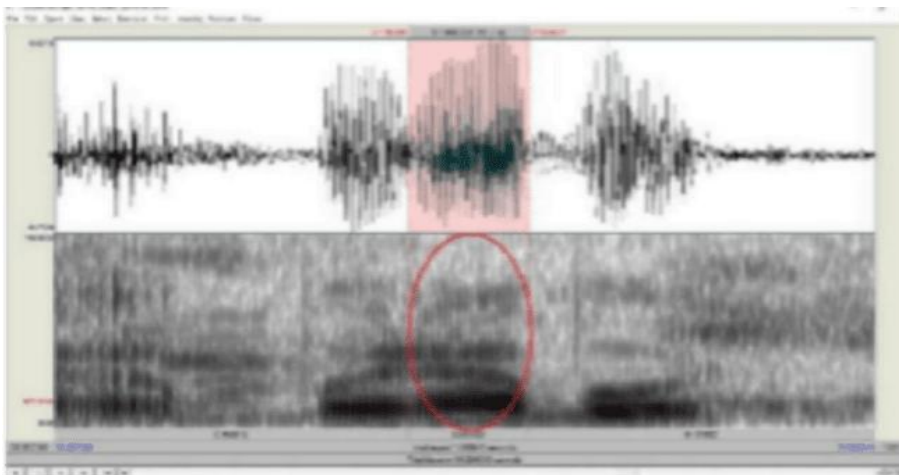


Figure 17 Spectrogram reading of the first responder of the Melaka Dialect for the lexical /perabot/

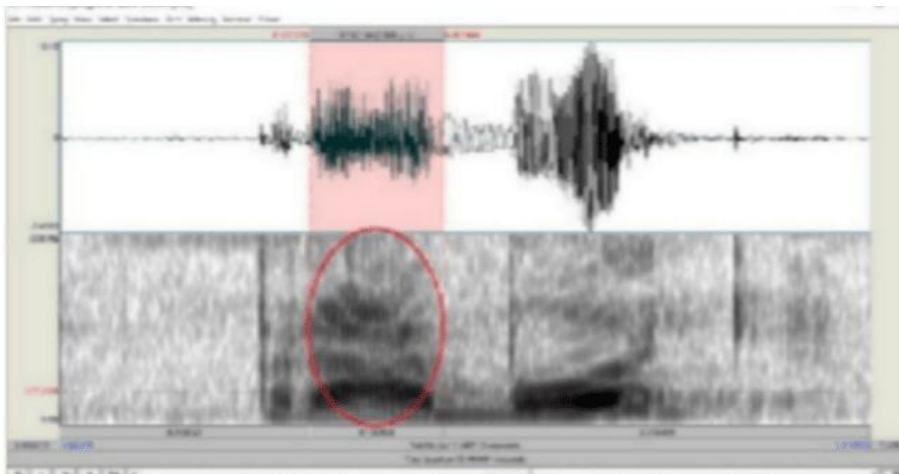


Figure 18 Spectrogram reading of the second responder of the Melaka Dialect for the lexical /perabot/

Based on the spectrographic readings above, the spectral profiles in Figures 17 and 18 display increased energy concentration and formant band density compared to the standard Malay baseline in Figure 16. The phonetic realization of the trill consonant /r/ in this word-medial position demonstrates a production mechanism similar

to that observed in the word-initial position. As established in the preceding analysis, the adjacent vocalic environment significantly conditions the phonetic output of the trill segment. Specifically, when the trill consonant is adjacent to the low back vowel /a/ in the Melaka Dialect, it is systematically realized as an alveolar tap [ɾ].

This acoustic differentiation is further substantiated by the quantitative spectral frequency metrics. The peak spectral frequency for the standard Malay speaker is recorded at 1539.95 Hz. In contrast, Respondent 1 registers a substantially higher frequency at 1922.06 Hz, whereas Respondent 2 displays a lower frequency reading at 712.98 Hz. The observed variation in spectral frequencies across the three speakers stems from distinct articulatory strategies in executing the trill segment. This divergence occurs because the dialect speakers apply articulatory constriction and emphasis to the consonant, rather than executing the multiple lingual strikes required for a standard alveolar trill [r].

/teratai/:

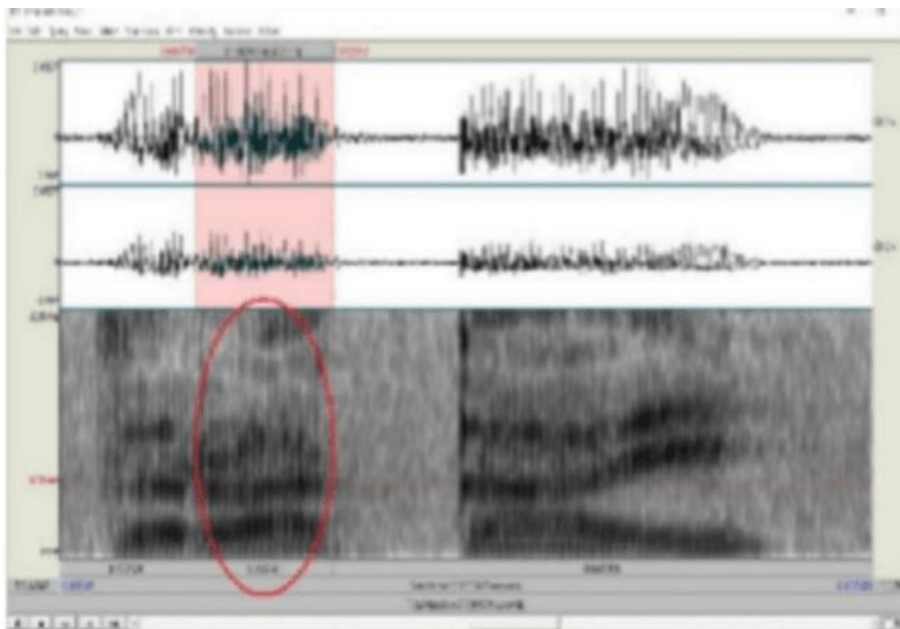


Figure 19 spectrogram reading of a standard Malay speaker for lexical /teratai/.

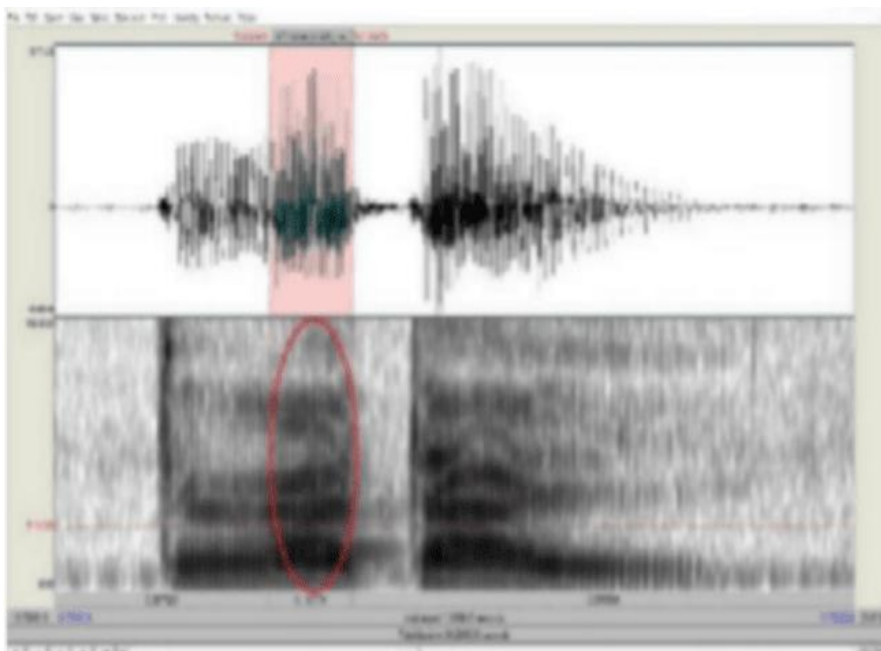


Figure 20 Spectrogram reading of the first responder of the Melaka Dialect for the lexical /teratai/

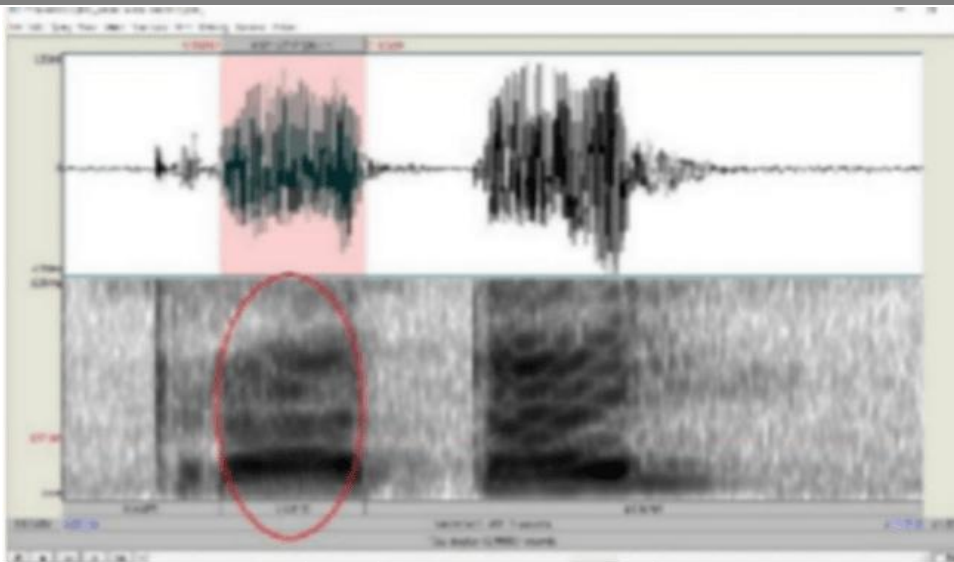


Figure 21 Spectrogram reading of the second responder of the Melaka Dialect for the lexical /teratai/

A parallel acoustic process is similarly observed in the spectrographic readings for both Respondent 1 (Figure 20) and Respondent 2 (Figure 21). Articulatory emphasis during the production of the trill consonant /r/ is clearly evident in the spectrographic signatures, as highlighted within the marked regions. When contrasted with the standard Malay speaker's spectrogram, the baseline profile demonstrates distinct, periodic formant pulses that characterize full alveolar trilling. Conversely, a close examination of the spectrographic profiles for Respondent 1 and Respondent 2 reveals narrower, more compressed formant bands.

This acoustic divergence is quantitatively reflected in the spectral frequency data. The baseline peak spectral frequency for the standard Malay speaker is recorded at 847.320 Hz. In comparison, Respondent 1 registers a spectral frequency of 1304.086Hz, whereas Respondent 2 displays a substantially reduced frequency of 712.977 Hz. These metrics underscore significant inter-speaker spectral variation, confirming that the dialect speakers apply varying degrees of articulatory constriction rather than executing the canonical trill [r] of Standard Malay.

/perut/:

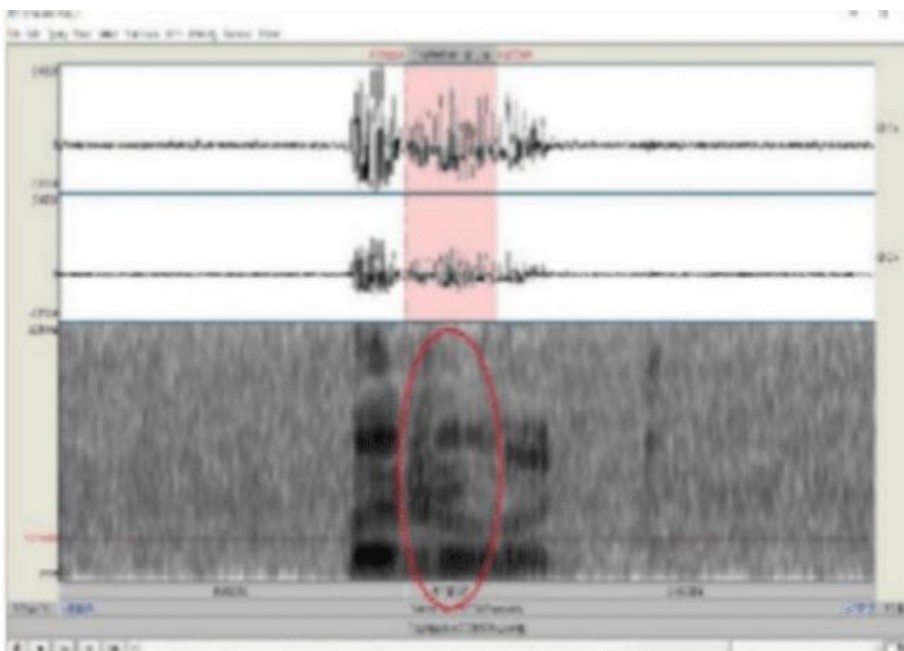


Figure 22 spectrogram reading of a standard Malay speaker for lexical /perut/.

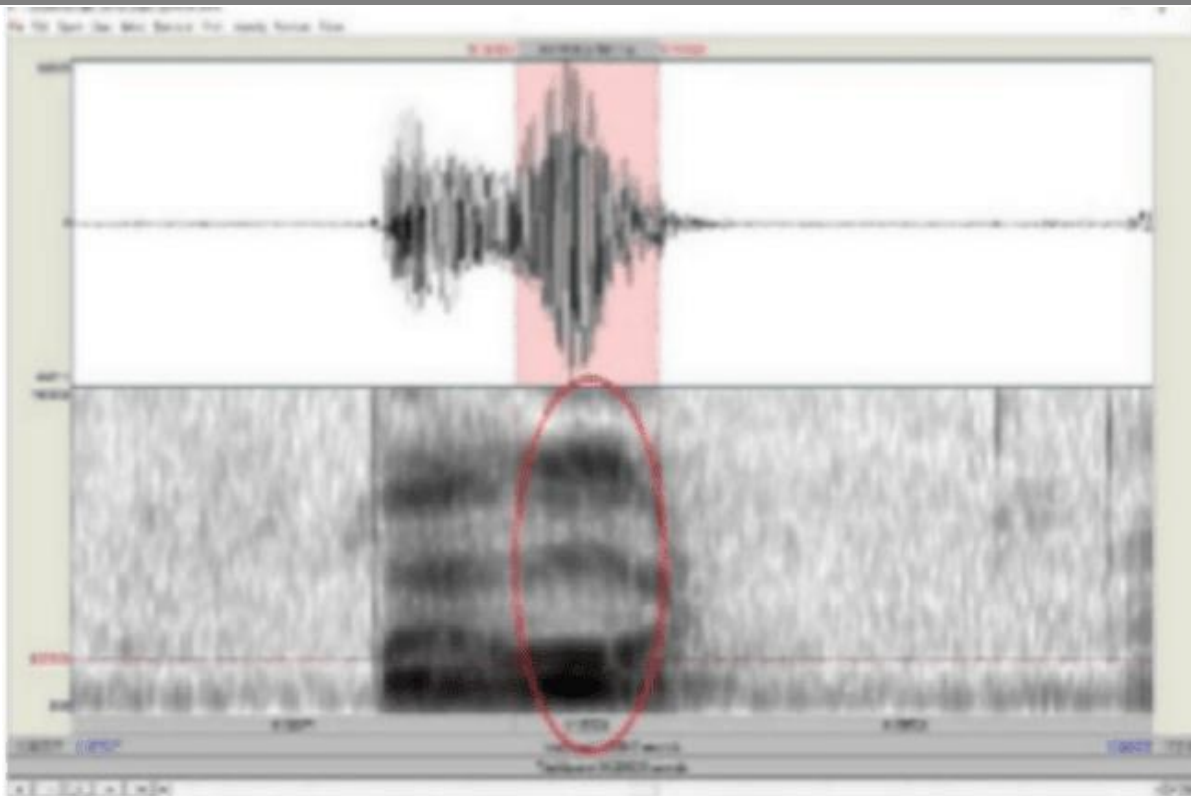


Figure 23 Spectrogram reading of the first responder of the Melaka Dialect for the lexical /perut/

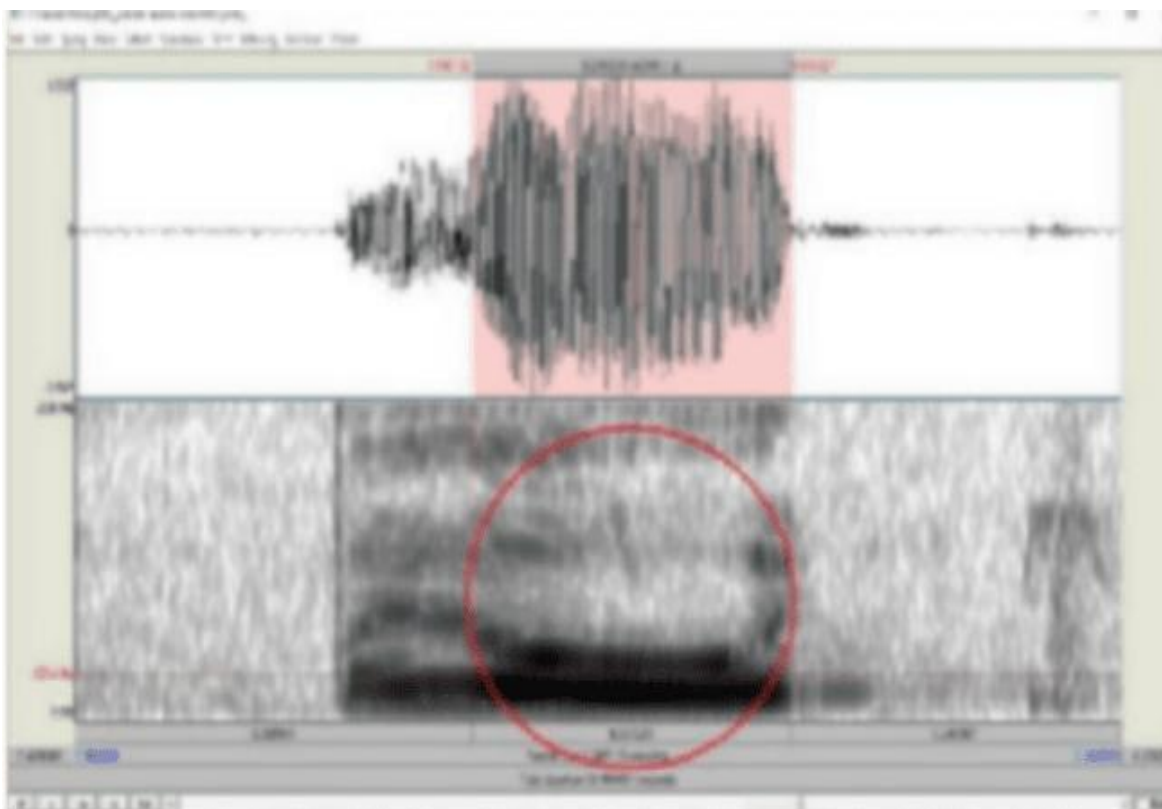


Figure 24 Spectrogram reading of the second responder of the Melaka Dialect for the lexical /perut/

The spectrographic readings for both Respondent 1 (Figure 23) and Respondent 2 (Figure 24) exhibit pronounced acoustic density during the production of the trill consonant /r/. In both spectrograms, there is a near-complete absence of trill periodicity in the realization of the trill segment. This acoustic phenomenon mirrors the pattern previously observed in the word-initial position when adjacent to the mid-high back vowel /o/ in Figures 11 and

12. These spectrographic signatures reinforce the premise that adjacent vowel quality fundamentally conditions the phonetic realization of the trill consonant in the Melaka Dialect. Quantitatively, the baseline peak spectral frequency for the standard Malay speaker is recorded at 644.31 Hz, whereas Respondent 1 registers a higher frequency at 780.15 Hz and Respondent 2 displays a frequency reading of 672.67 Hz.

A contextual comparison reveals fine phonetic nuances in the production of the lexical item /perut/ across speakers. Upon closer inspection, the formant band density in Figures 23 and 24 closely parallels the spectrographic signatures of /roti/ seen in Figures 11 and 12. However, the key contextual distinction lies in the vocalic environment following the trill segment. The spectrographic reading in Figure 23 displays a noticeably darker energy band compared to the standard Malay baseline in Figure 22. Akin to the lexical item /roti/, when the trill consonant /r/ is adjacent to the high back vowel /u/, it undergoes articulatory modification resulting in a voiced velar fricative realization [ɣ].

Following Nor Hashimah Jalaluddin (2007), /u/ is classified as a high back vowel. A parallel acoustic phenomenon operates when the trill segment precedes the mid-high back vowel /o/ (as shown by the dense spectral energy in Figures 11 and 12). Taken together, these spectrographic profiles provide strong acoustic evidence that back vowels (/o/ and /u/) systematically induce dorsal substitution, driving the transition from a standard alveolar trill /r/ to a voiced velar fricative [ɣ] in the Melaka Dialect.

The subsequent discussion evaluates the spectrographic profiles of the trill consonant /r/ in the word-final position. Based on the spectrographic evidence, the phonetic realization of the word-final trill reveals the co-occurrence of multiple phonological processes during lexical production. The spectrographic readings for the word-final trill consonant /r/ are presented below:

/ular/:

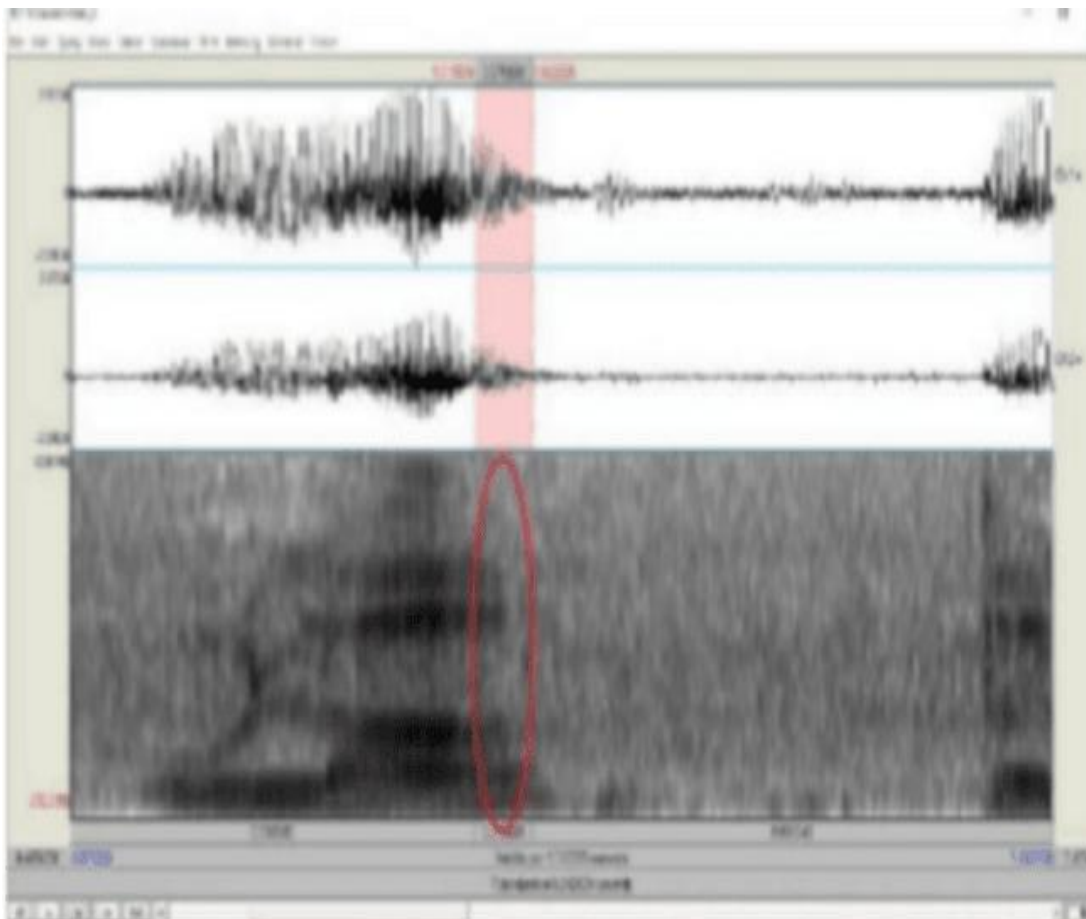


Figure 25 spectrogram reading of a standard Malay speaker for lexical /ular/.

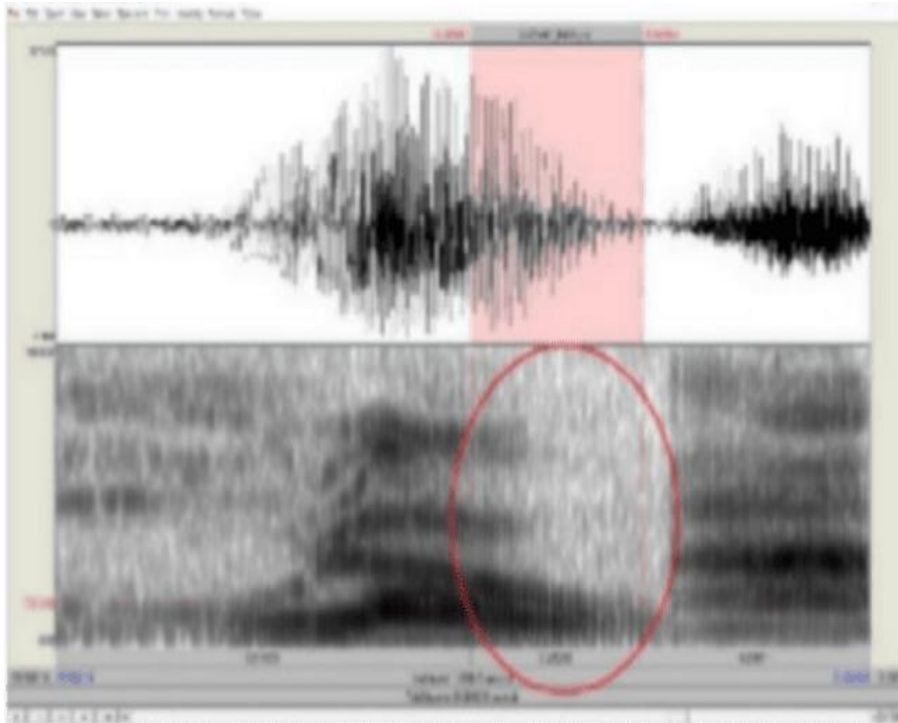


Figure 26 Spectrogram reading of the first responder of the Melaka Dialect for the lexical /ular/

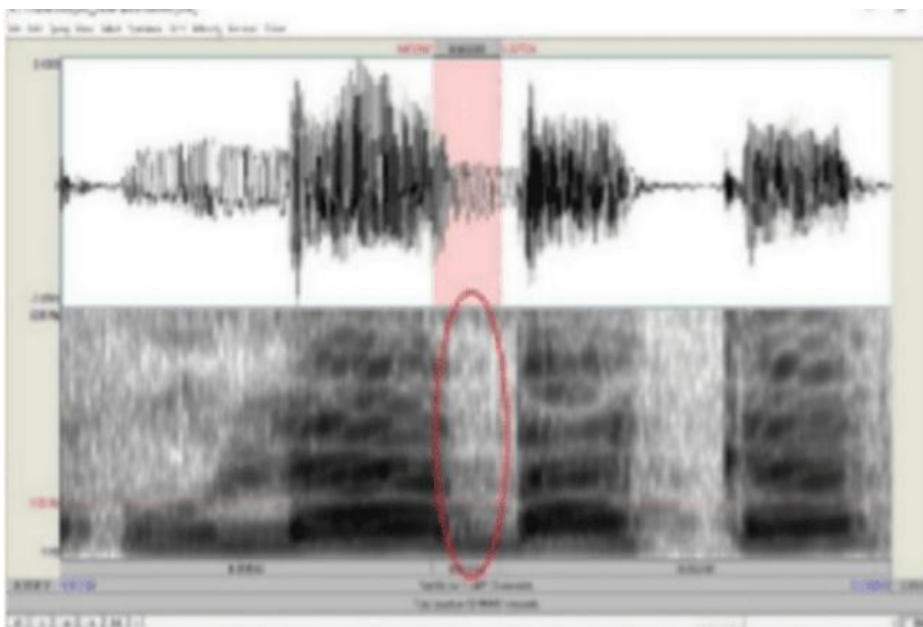


Figure 27 Spectrogram reading of the second responder of the Melaka Dialect for the lexical /ular/

The spectrographic readings in Figure 26 (Respondent 1) and Figure 27 (Respondent 2), representing native Melaka dialect speakers, demonstrate a marked acoustic departure from the standard Malay baseline in Figure 25. An examination of the spectrographic signatures in Figures 26 and 27 reveals a significant reduction in trill periodicity when the word-final trill /r/ is adjacent to the low back vowel /a/. This acoustic behavior is visually evidenced within the highlighted regions, where compressed and closely spaced formant bands contrast sharply with the well-defined trill pulses seen in Figure 25. The spectrographic evidence indicates that the word-final trill /r/ undergoes a phonological shift, being categorically realized as the labial-velar glide [w].

This dialectal variation aligns with Zaharani Ahmad (2006), who posits that dialects diverge from standard forms through the addition of specific grammatical rules, reflecting evolutionary language shifts over time. Specifically, the Melaka dialect incorporates a rule addition that converts the coda trill into a glide, formalizable as an /r/-gliding rule:

/r/ → [w] / #. Furthermore, Noor Azureen and Tajul Aripin (2014) elaborate that glide formation entails feature spreading a process wherein a segment assimilates distinctive features from an adjacent segment, resulting in a novel phonetic segment that either shares feature specifications or transitions into a distinct phoneme.

This phonetic alteration is quantitatively corroborated by the spectral frequency metrics. The baseline spectral frequency for the standard Malay speaker is recorded at 202.47 Hz. In contrast, Respondent 1 and Respondent 2 display elevated spectral readings, registering at 277.39 Hz and 373.34 Hz, respectively. The discrepancy in spectral frequency values confirms a fundamental shift in the manner and place of articulation, substantiating the presence of a coda glide substitution in the Melaka dialect.

/telur/:

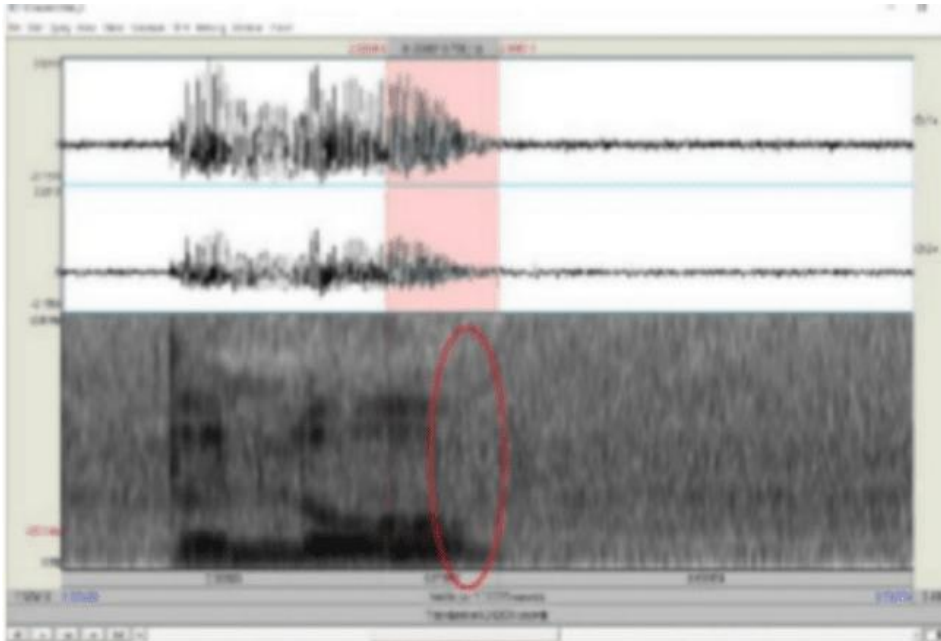


Figure 28 spectrogram reading of a standard Malay speaker for lexical /telur/.

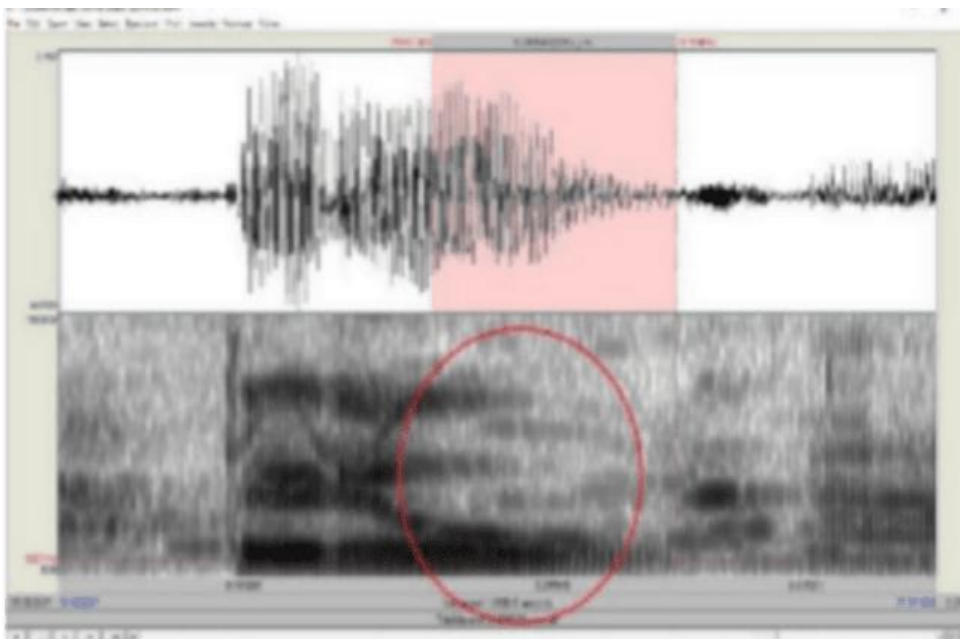


Figure 29 Spectrogram reading of the first responder of the Melaka Dialect for the lexical /telur/

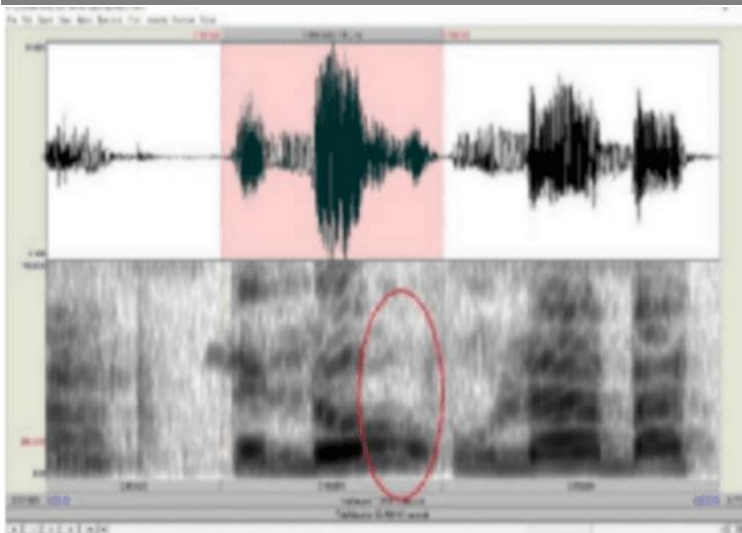


Figure 30 Spectrogram reading of the second responder of the Melaka Dialect for the lexical /telur/

In contrast to the preceding spectrographic patterns, the acoustic readings for the lexical item /telur/ demonstrate a distinct phonological mechanism. The spectrographic signatures in Figure 29 (Respondent 1) and Figure 30 (Respondent 2) diverge significantly from the spectral structures observed in prior lexical analyses. Specifically, the spectrographic data for both dialect speakers exhibit a complete absence of trill periodicity or glide formation during the articulation of the coda segment. This acoustic signature indicates that when the trill consonant /r/ follows the high back vowel /u/ in the word-final coda position, the sequence undergoes phonological deletion or coalescence. As noted by Shahidi et al. (2016), the process of coalescence serves as a repair strategy to avoid illicit segmental sequences whether vocalic or consonantal analogous to segment insertion. They further assert that through coalescence, adjacent or sequential segments are merged and replaced by a single, distinct segmental realization.

This phonological shift is quantitatively corroborated by the spectral frequency metrics. The baseline peak spectral frequency for the standard Malay speaker is recorded at 229.34 Hz. In contrast, Respondent 1 registers a frequency of 661.17 Hz, while Respondent 2 displays a closely aligned reading of 551.52 Hz. The minor spectral frequency variance between Respondent 1 and Respondent 2 highlights acoustic consistency in their production strategies. As established, both native dialect speakers undergo a process of vocalic-consonantal coalescence, wherein the high back vowel /u/ and the coda trill /r/ merge into a single open-mid back rounded vowel [ɔ]. Consequently, the lexical target /telur/ undergoes categorical phonological restructuring to yield [telo], replacing the expected canonical sequence of the high back vowel and word-final rhotic.

/bakar/:

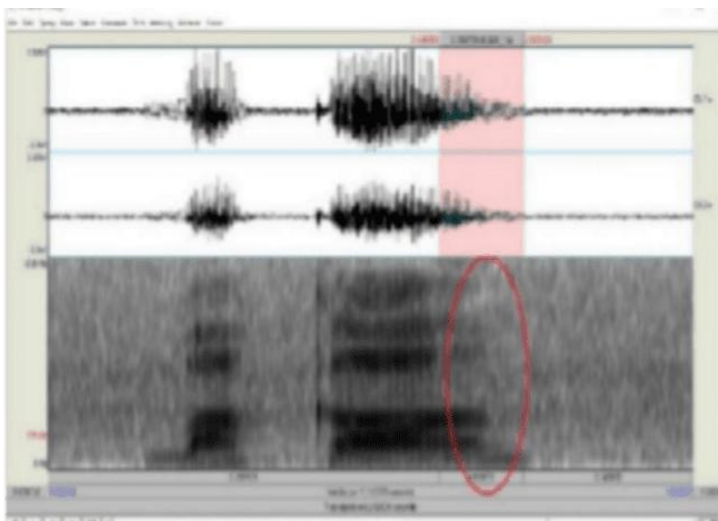


Figure 31 spectrogram reading of a standard Malay speaker for lexical /bakar/.

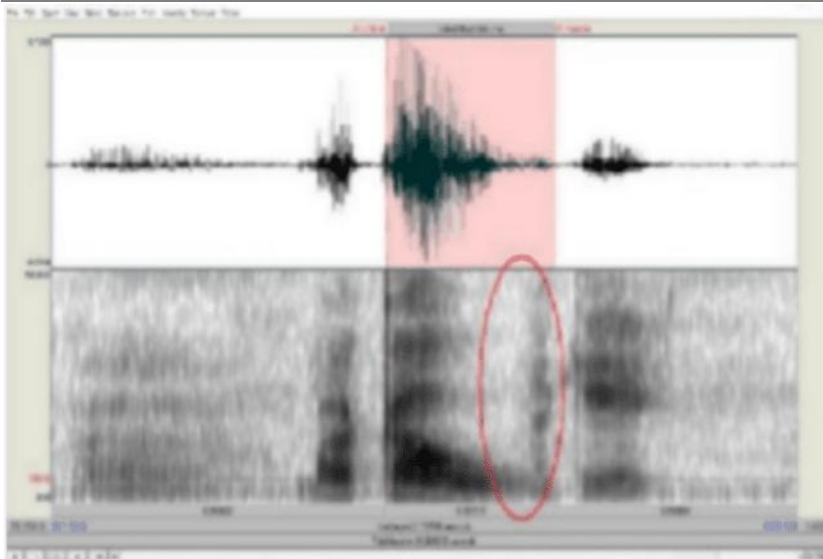


Figure 32 Spectrogram reading of the first responder of the Melaka Dialect for the lexical /bakar/

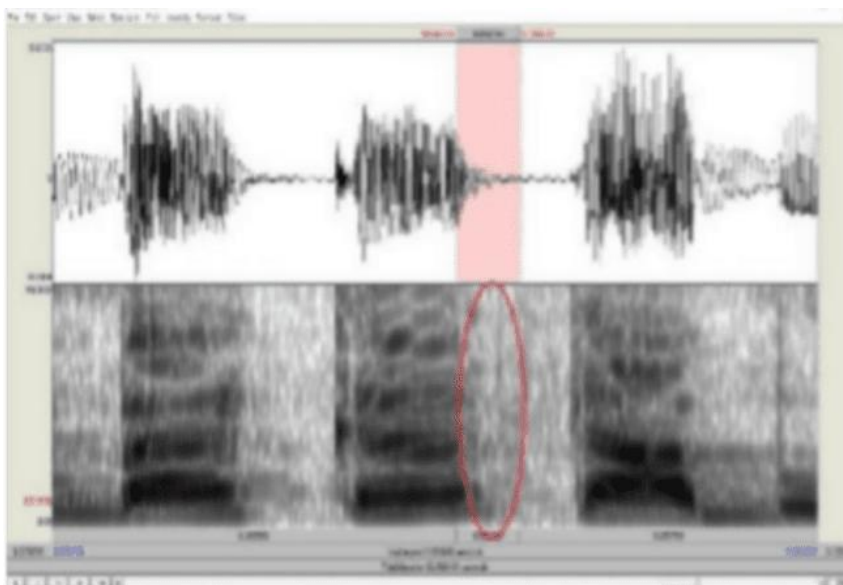


Figure 33 Spectrogram reading of the second responder of the Melaka Dialect for the lexical /bakar/

For the lexical item /bakar/, the spectrographic profiles closely parallel the acoustic patterns previously observed in /ular/. The spectrographic signatures for both Respondent 1 (Figure 32) and Respondent 2 (Figure 33) unequivocally demonstrate the occurrence of coda gliding in the word-final position. Notably, the spectrograms exhibit formant trajectories and energy distributions highly comparable to those identified in Figure 26, characterized by distinct spectral signatures corresponding to the labial-velar glide [w] at the offset of lexical production. This empirical evidence further substantiates the structural constraint governing trill realization in the Melaka Dialect: coda gliding is strictly conditioned by the low back vowel /a/, occurring exclusively when the coda trill /r/ is adjacent to /a/.

Quantitatively, the baseline peak spectral frequency for the standard Malay speaker is recorded at 417.42 Hz. In comparison, Respondent 1 registers a slightly lower frequency at 387.04 Hz, whereas Respondent 2 displays an elevated frequency reading of 688.58 Hz. Despite this inter-speaker frequency dispersion, the spectrographic data consistently reveals the realization of an off-glide [w]. From an acoustic standpoint, the transition from the low back vowel /a/ to the labial-velar glide [w] involves a dynamic lowering of the second formant (F2), reflecting lip rounding and velar constriction as the tongue moves away from the low vowel space. This confirms that the phonological sequence /a/ + /r/# systematically triggers /r/-gliding, yielding the phonetic output [bakaw].

When contrasted with the coalescence observed in /telur/ (/u/ + /r/# → [ɔ]), these findings demonstrate a clear

vocalic conditioning asymmetry in the Melaka Dialect: while high back vowels (/u/) trigger vocalic-consonantal coalescence, the low back vowel (/a/) preserves the vocalic nucleus while converting the coda trill into an off-glide.

/tabur/:

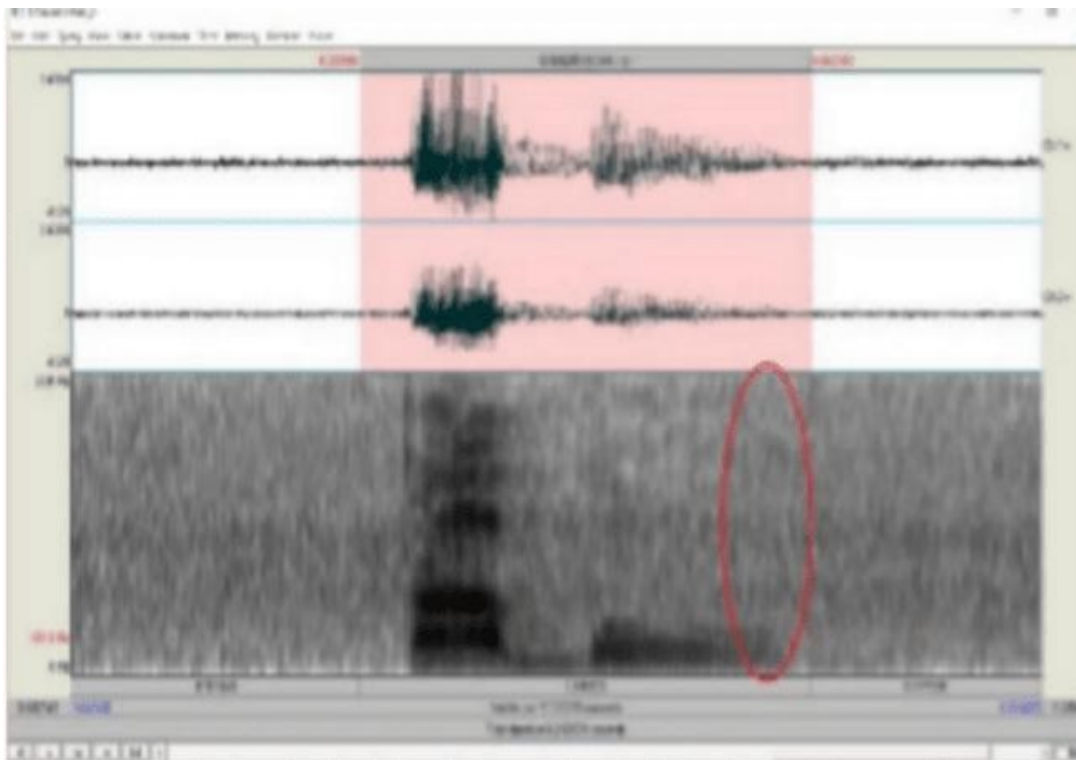


Figure 34 spectrogram reading of a standard Malay speaker for lexical /tabur/.

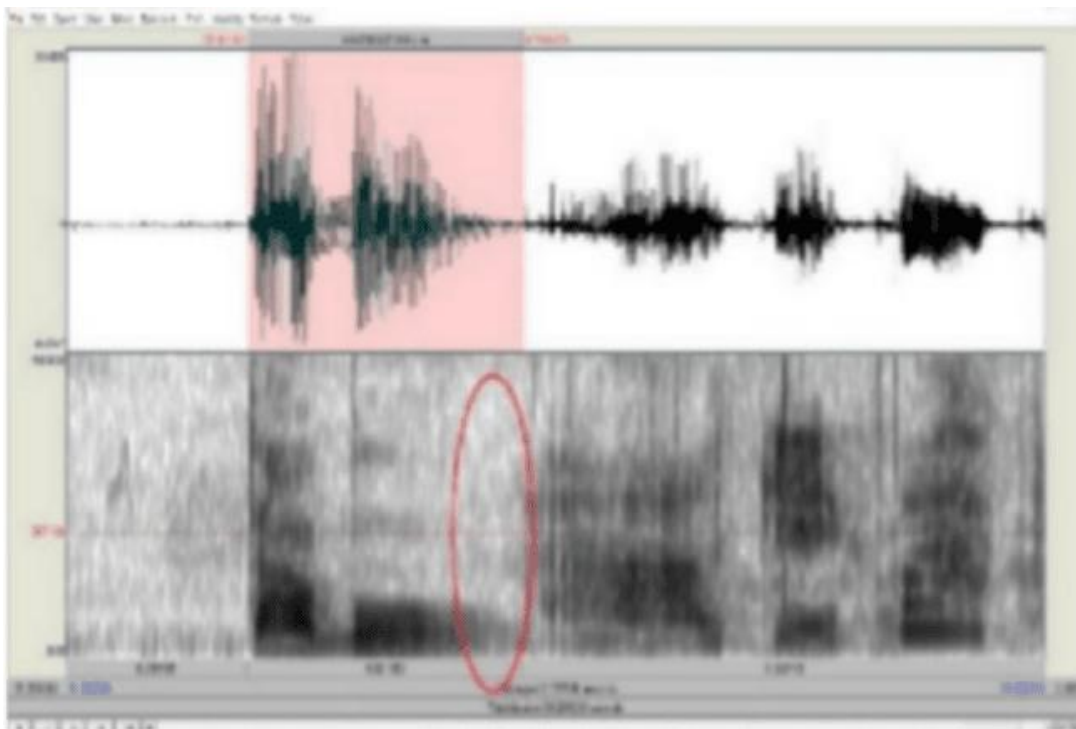


Figure 35 Spectrogram reading of the first responder of the Melaka Dialect for the lexical /tabur/

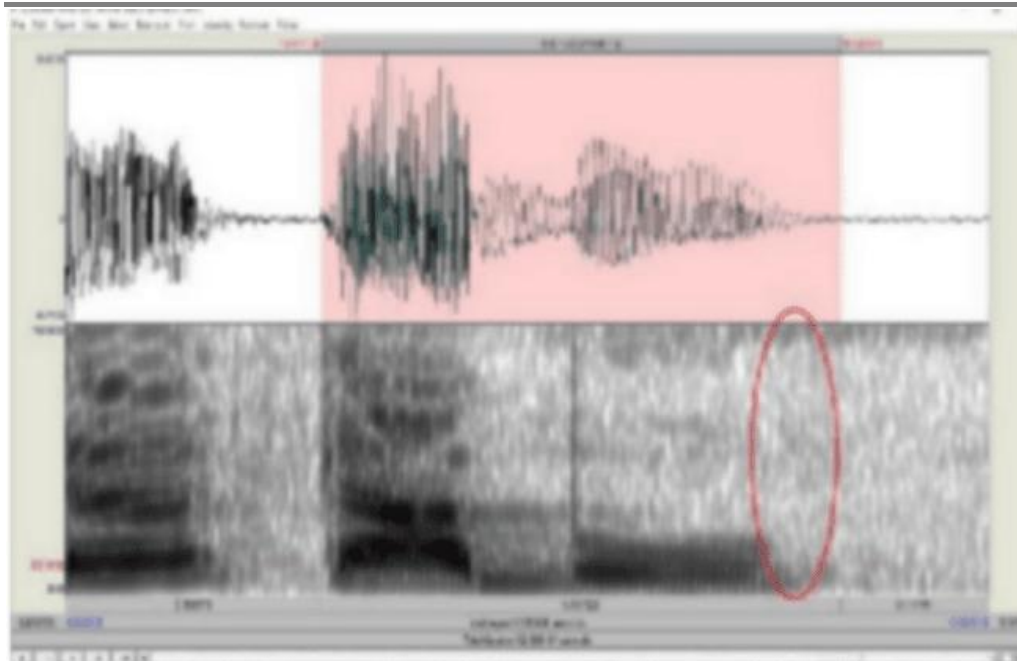


Figure 36 Spectrogram reading of the second responder of the Melaka dialect for the lexical /tabur/

The spectrographic readings for the lexical item /tabur/ closely parallel the acoustic behavior observed in /telur/. The spectrographic signatures in Figure 35 (Respondent 1) and Figure 36 (Respondent 2) demonstrate a complete absence of trill periodicity during the production of the word-final trill segment. Consistent with the phonological pattern identified in /telur/, when the high back vowel /u/ precedes the trill consonant /r/ in the coda position, the sequence undergoes a process of vocalic-consonantal coalescence. Specifically, the combination of the high back vowel /u/ and the coda trill /r/ merges into the mid-open back rounded vowel [ɔ]. Consequently, the lexical realization of /tabur/ shifts categorically to [tabɔ] in the speech of both dialect respondents. This spectrographic evidence confirms that the primary phonological operation governing this environment is segmental coalescence, wherein the word-final trill /r/ is elided simultaneously with the quality modification of the preceding high back vowel /u/.

The baseline peak spectral frequency for the standard Malay speaker is recorded at 323.38 Hz. In comparison, Respondent 1 registers a slightly higher frequency at 345.92 Hz, whereas Respondent 2 displays a frequency reading of 236.27 Hz. The spectral frequency metrics for both dialect speakers exhibit notable divergence from the standard Malay baseline. Mirroring the phonological restructuring observed in /telur/, the word-final trill coda is deleted and replaced by the monophthongal vowel [ɔ]. Furthermore, the relative proximity in spectral frequency values between Respondent 1 and Respondent 2 reinforces the empirical validity of this acoustic shift, confirming that the production of /tabur/ in the Melaka dialect is governed by a systematic, environment-conditioned phonological rule rather than idiosyncratic variation.

To provide a comprehensive synthesis of the experimental acoustic phonetic data, Table 1 summarizes the peak spectral frequency metrics (in Hertz) alongside the corresponding surface phonological realizations across all 12 target lexical items and positional environments (word-initial, word-medial, and word-final) for the three speakers.

Table 1 Summary of Peak Spectral Frequencies and Phonological Realizations

Lexical Item	Speaker	Peak Spectral Freq (Hz)	Phonological Output / Realization
/rambut/	Standard	1733.98	Alveolar trill [r]
	Resp. 1	1092.13	Alveolar tap [ɾ]
	Resp. 2	914.49	Alveolar tap [ɾ]

/raya/	Standard	1129.44	Alveolar trill [r]
	Resp. 1	545.49	Alveolar tap [ɾ]
	Resp. 2	551.76	Alveolar tap [ɾ]
/rantai/	Standard	1021.97	Alveolar trill [r]
	Resp. 1	511.18	Alveolar tap [ɾ]
	Resp. 2	1344.39	Acoustic variant / tap [ɾ]
/roti/	Standard	1129.44	Alveolar trill [r]
	Resp. 1	547.49	Voiced velar fricative [ɣ]
	Resp. 2	538.33	Voiced velar fricative [ɣ]
/keramat/	Standard	847.32	Alveolar trill [r]
	Resp. 1	1089.14	Alveolar tap [ɾ]
	Resp. 2	833.89	Alveolar tap [ɾ]
/perabot/	Standard	1539.95	Alveolar trill [r]
	Resp. 1	1922.06	Alveolar tap [ɾ]
	Resp. 2	712.98	Alveolar tap [ɾ]
/teratai/	Standard	847.320	Alveolar trill [r]
	Resp. 1	1304.086	Alveolar tap [ɾ]
	Resp. 2	712.977	Alveolar tap [ɾ]
/perut/	Standard	644.31	Alveolar trill [r]
	Resp. 1	780.15	Voiced velar fricative [ɣ]
	Resp. 2	672.67	Voiced velar fricative [ɣ]
/ular/	Standard	202.47	Alveolar trill [r]
	Resp. 1	277.39	Coda glide [w]
	Resp. 2	373.34	Coda glide [w]
/telur/	Standard	229.34	Alveolar trill [r]
	Resp. 1	661.17	Coalescence to [ɔ]
	Resp. 2	551.52	Coalescence to [ɔ]
/bakar/	Standard	417.42	Alveolar trill [r]
	Resp. 1	387.04	Coda glide [w]
	Resp. 2	688.58	Coda glide [w]
/tabur/	Standard	323.38	Alveolar trill [r]
	Resp. 1	345.92	Coalescence to [ɔ]
	Resp. 2	236.27	Coalescence to [ɔ]

As summarized in Table 1, a clear pattern of positional and vocalic conditioning emerges across the dataset. Word-initial and word-medial rhotics adjacent to low back vowels systematically shift from the standard alveolar trill [r] to an alveolar tap [ɾ], whereas adjacent mid-high and high back vowels condition dorsal substitution to a voiced velar fricative [ɣ]. In word-final coda positions, conditioning by the low back vowel /a/ results in coda gliding [w], while the high back vowel /u/ systematically triggers vocalic-consonantal coalescence to [ɔ]. These

quantitative frequency metrics provide empirical acoustic evidence that phonetic variation of /r/ in the Melaka dialect is governed by systematic, environment-conditioned phonological rules

CONCLUSION

Overall, the spectrographic analysis provides robust empirical evidence that the realization of the trill consonant /r/ across all evaluated lexical items in the Melaka dialect systematically diverges from Standard Malay. The spectrographic profiles reveal four primary phonological processes governing the pronunciation of these lexical items, namely substitution, gliding, deletion, and coalescence. These acoustic transformations are quantitatively corroborated by peak spectral frequency data extracted via PRAAT acoustic analysis software.

The empirical findings categorize these lexical items under three main phonological mechanisms. Phonological substitution occurs in the lexical items /rambut/, /raya/, /rantai/, /roti/, /keramat/, /perabot/, /teratai/, /perut/, as well as in/ular/ and /bakar/ for Respondent 1. Depending on word position and vocalic environment, the standard alveolar trill/r/ is systematically substituted with either an alveolar tap [ɾ] or a voiced velar fricative [ɣ]. Furthermore, deletion and glide formation operate in word-final coda positions; specifically, for Respondent 2, the word-final trill in/bakar/ and /ular/ undergoes a deletion of trill periodicity to form a labial-velar off-glide [w] conditioned by the preceding low back vowel /a/. Meanwhile, segmental coalescence operates systematically in /telur/ and /tabur/, where the high back vowel /u/ and the adjacent coda trill /r/ merge into a single open-mid back rounded monophthong [ɔ].

Consequently, this acoustic phonetic approach provides a rigorous, data-driven framework that deepens the understanding of dialectal phonological phenomena through objective PRAAT metrics. Beyond contributing to Malay dialectology, this study serves as a valuable methodological reference for researchers seeking to conduct similar investigations in acoustic phonetics and dialectal variation. Furthermore, applying this spectrographic framework to non-dialectal data in future research offers promising avenues to generate novel insights into language structure and speech variation.

REFERENCES

1. Agnes, B. G., & Michael, G. (2004). The creaky voice phonation and the organisation of Chinese discourse. Institute of Linguistics, Phonetic Laboratory, Chinese Academy of Social Sciences.
2. Asmah Haji Omar. (1985). Susunsalur bahasa Melayu. Dewan Bahasa dan Pustaka.
3. Boersma, P., & Weenink, D. (2024). Praat: doing phonetics by computer (Version 6.4.07) [Computer software]. <http://www.praat.org/>
4. Clark, J., Yallop, C., & Fletcher, J. (2007). An introduction to phonetics and phonology (3rd ed.). Blackwell Publishing.
5. Collins, J. T. (1989). Malay dialect research in Malaysia: The past and the future. *Bijdragen tot de Taal-, Land- en Volkenkunde*, 145(2/3), 235–264.
6. Crystal, D. (1990). A dictionary of linguistics and phonetics (3rd ed.). Basil Blackwell Ltd.
7. Fazal Mohamed Mohamed Sultan, & Noriati Muhamad. (2017). Dialek Perlis: Satu analisis sintaksis dan fonologi. *Jurnal Bahasa*, 17(1), 45–68.
8. Hayward, K. (2014). Experimental phonetics: An introduction. Routledge.
9. Johnson, K. (2012). Acoustic and auditory phonetics (3rd ed.). Wiley-Blackwell.
10. Kent, R. D., & Read, C. (2002). The acoustic analysis of speech (2nd ed.). Singular Publishing Group.
11. Labov, W. (2001). Principles of linguistic change, Volume 2: Social factors. Blackwell Publishers.
12. Ladefoged, P. (2003). Phonetic data analysis: An introduction to fieldwork and instrumental techniques. Blackwell Publishing.
13. Ladefoged, P., & Johnson, K. (2014). A course in phonetics (7th ed.). Cengage Learning.
14. Lavoie, L. M. (2001). Consonant weakening at the interface: Phonetics and phonology. Oxford University Press.
15. Lindau, M. (1985). The story of /r/. In V. A. Fromkin (Ed.), *Phonetic linguistics: Essays in honor of Peter Ladefoged* (pp.157–168). Academic Press.
16. Maddieson, I. (1984). Patterns of sounds. Cambridge University Press.
17. Mansurni Abadi. (2021). Analisis dialektologi sinkronik terhadap dialek Negeri Melaka, Malaysia: Studi

- kasus di kampung-kampung, Distrik Alor Gajah, Melaka, Malaysia. *Lampung Journal of Muhammadiyah Student Association*, 2(1), 25–36.
16. Milroy, L., & Gordon, M. (2003). *Sociolinguistics: Method and interpretation*. Blackwell Publishing.
 17. Nor Hashimah Jalaluddin. (2007). *Asas fonetik*. Dawama Sdn. Bhd.
 18. Nur Adibah Hasan, & Sharifah Raihan Syed Jaafar. (2017). Struktur suku kata terbitan dialek Terengganu. *Akademika*, 87(2), 167–175.
 19. Ohala, J. J. (1990). The phonetics and phonology of aspects of assimilation. In J. Kingston & M. E. Beckman (Eds.), *Papers in laboratory phonology I: Between the grammar and physics of speech* (pp. 258–275). Cambridge University Press.
 20. Ong, S. T., Nur Syahida Adilah Suri, & Rahim Aman. (2016). Fonologi subdialek Pulau Pinang: Satu kajian Balik Pulau. *e-Bangi: Journal of Social Sciences and Humanities*, 11(1), 186–201.
 21. Sallinen, R., & Braidwood, E. (2009). Distinctive linguistic features of qualitative and quantitative research reporting comparing research papers in nursing science. In M. Ferenčík & J. Horváth (Eds.), *Language, literature and culture in a changing transatlantic world* (pp. 202–216). UP.
 22. Scobbie, J. M. (2005). The defender's perspective: Imperceptible variation and phonological change. *Papers in Laboratory Phonology*, 8, 369–398.
 23. Shahidi, A. H., Rahim Aman, & Ab. Samad Kechot. (2012). Menganalisis akustik dialek: Latar belakang, aplikasi dan cabaran. *Jurnal Bahasa*, 12(2), 231–254.
 24. Stevens, K. N. (1998). *Acoustic phonetics*. MIT Press.
 25. Thomas, E. R. (2011). *Sociophonetics: An introduction*. Palgrave Macmillan.
 26. Wright, R. (2004). A review of perceptual cues and locus equations. In B. Hayes, R. Kirchner, & D. Steriade (Eds.), *Phonetically based phonology* (pp. 34–57). Cambridge University Press.
 27. Zaharani Ahmad. (2006). *Kepelbagaian dialek dalam bahasa Melayu: Analisis tatattingkat kekangan*. e-Bangi: *Journal of Social Sciences and Humanities*, 1(1), 1–18.