Language Literacy: Journal of Linguistics, Literature, and Language Teaching
Volume 9, Number 2, pp: 804-818, December 2025
e-ISSN: 2580-9962 | p-ISSN: 2580-8672
DOI: https://doi.org/10.30743/ll.v1i1.12387

INVESTIGATING THE ARTICULATION DISORDER OF THE ARABIC PHONEME /L/: A CASE STUDY IN POST-ISCHEMIC STROKE PATIENT

Hanifah Nurfitri, Mohamad Zaka Al Farisi, Nalahuddin Saleh
Universitas Pendidikan Indonesia, Bandung, Indonesia
Email: hanifahnurf@upi.edu

Received: 2025-11-10 Accepted: 2025-12-02 Published: 2025-12-10

Abstract

This research investigates the articulation of the lateral phoneme /l/ in an Arabic speaking post-ischemic stroke patient using acoustic phonetic analysis and Praat software. Speech data were obtained from the patient's Qur'anic recitation. The Qur'anic recitation was selected because it serves as a controlled phonetic corpus standardized through the rules of *tajwīd*, ensuring precise and consistent sound production, which makes it highly suitable for acoustic analysis requiring reliable comparison with native-speaker models. The model speaker was Sheikh Mishary Rasyid Al-Afasy. The analysis focused on the production of /l/ in the vocalic contexts /la/, /li/, and /lu/. The analysis of the surrounding vowels /a/, /i/, and /u/ was essential because these vowels provide the coarticulatory environment that directly shapes the articulation of /l/, allowing vowel impairments to explain disruptions in the target phoneme. The vowel /a/ had a certain degree of impairment on the vowel with increased duration and heightened laryngeal tension. The speech parameters that demonstrated /i/ had a reduction in trunk selective control, thus centralising the vowel. Furthermore, production of the vowel /u/, the most devoid of articulation and therefore the most significant impairment, was characterised by reduced precision with respect to the production of the manner of articulation, as well as marked reduction in coordination of the high and low tongue, and the lips. The severity of the impairment was ranked as /lu/, /li/, /la/. The acoustic baseline identified in this study offers a diagnostic basis for developing targeted, step-by-step speech therapy programs for Arabic-speaking post-stroke patients, directly supporting clinical SLP in this demographic.

Keywords: *acoustic phonetics; Arabic phonemes; articulatory disorder; clinical linguistics; post-ischemic stroke.*

1. Introduction

Disorders of speech can result from medical and environmental factors. Medical factors include disorders of the central nervous system and problems with articulation organs (tongue, lips, palate, vocal folds), whereas environmental factors consist of a lack of linguistic stimulation or socially inadequate conditions to foster the development of language (Ali et al., 2023). Among these medical factors, ischemic stroke stands out as one of the most prevalent causes, with 40–80% of survivors exhibiting speech and articulation impairments resulting from disrupted neural networks for motor speech planning and execution. Within the field of psycholinguistics, language is regarded as a highly complex cognitive process involving intricate coordination between the brain and the nervous system in the reception, processing, and production of speech and written text. This activity engages several key regions of the brain, including Broca's area, Wernicke's area, the visual, auditory, and motor cortices, as well as the arcuate fasciculus. Impairment or dysfunction in any of these regions can lead to disruptions in linguistic competence, affecting an individual's ability to comprehend or produce language effectively (Shah, 2023; Wei et al., 2023).

In post-stroke patients, motor impairment, particularly within the articulation system, remains the most problematic. Stroke can weaken coordination of speech muscles, resulting in post-stroke patients struggling to articulate sounds accurately. This circumstance negatively affects the phonological abilities to discern and produce language-governed phonemes (Delvaux et al., 2020). Stroke in itself can be of two types: ischemic, which involves blockage of blood flow to the brain, and hemorrhagic, which is more complex due to ruptured brain blood vessels and can involve aphasia or impairment of language comprehension (Kirshner & Wilson, 2021). The precise ability to identify and produce sounds is not limited to articulatory aspects; it also involves how the brain processes and controls phoneme production and its lateral mechanisms (Syahid & Nurdianto, 2022).

Foreign and domestic research has shown that post-stroke patients' speech disorders are not merely generalised speech weakness; they are precise to the involvement of the tongue in the production of certain sounds. These findings were also reported by Sundoro et al. (2020), who highlighted sounds produced with the tip of the tongue (apical) as the most disrupted, due to the neuromuscular pattern of the tongue with the alveolar ridge. Motoric damage due to stroke leads to specific place of articulation dysfunction, thereby causing unavoidable mispronunciation. Consequently, the clarity of the utterance and the meaning of the words are directly affected. Furthermore, clinical studies have also emphasised that the diseased articulatory disorders are not of specific phonemes, but are rooted in the dysfunction of the tongue's movements after the stroke (Haldin et al., 2020).

Arabic phonology is characterized by a rich consonantal system, including emphatic consonants, gutturals, and a wide range of place-manner contrasts that require precise articulatory coordination (Farisi et al., 2025; Ulpah et al., 2025). In the case of post-stroke ischaemic, the weak control of the tongue muscles can produce sounds that should be silenced, emerging from the mid-tongue, but are released from the front or back of the mouth, resulting in significant phonological errors (Ziegler, 2022). It is for this reason that this study focuses on the analysis of the pronunciation of the phoneme /l/ in the recitation of the Holy Qur'an. The use of Qur'anic recitation as speech data is methodologically justified because its production is governed by the rules of *Tajwid*, which require highly precise, consistent, and carefully controlled articulation. These rules standardise phonetic realisation across readers, creating a culturally relevant and rigorously regulated phonetic corpus. Such standardisation makes Qur'anic recitation an ideal reference for detecting diagnostically meaningful articulatory deviations, as even minor departures from the expected patterns become measurable and clinically significant.

The selection of the phoneme /l/ as the focus of this study is based on two reasons. First, the study's subjects reported having a particular problem with the phoneme in question. Second, from a phonetic perspective, the phoneme /l/ is categorized as a voiced

Language Literacy: Journal of Linguistics, Literature, and Language Teaching
Volume 9, Number 2, pp: 804-818, December 2025
e-ISSN: 2580-9962 | p-ISSN: 2580-8672
DOI: https://doi.org/10.30743/ll.v1i1.12387

alveolar lateral consonant, whose articulation relies heavily on precise tongue movement. Consequently, its production is particularly vulnerable to impairment resulting from post-stroke neuromuscular weakness or other oromotor disturbances. (Simic et al., 2021).

Given the clinical complexity of post-stroke speech impairment, this study employs acoustic phonetic analysis as its primary methodological framework. Acoustic analysis provides objective, quantifiable, and reproducible measurements—such as segmental duration, formant frequencies (F1–F2), and fundamental frequency (F0)—which cannot be reliably captured through perceptual (auditory) evaluation alone. While many studies detail speech production disorders in Indo-European languages using acoustic methods, there is a distinct lack of systematic, acoustic investigation into the articulation of complex phonemes in Arabic post-stroke patients. Specifically, a single-case study rigorously correlating acoustic parameters of surrounding vowels to the production of the lateral /l/ is absent. This study addresses this critical gap. Therefore, this research aims to systematically investigate, via acoustic analysis, the specific articulation impairments (duration, formants, intensity) of the Arabic phoneme /l/ and its co-articulatory vowels in a post-ischemic stroke patient, establishing a quantitative diagnostic baseline.

2. Literature Review

Numerous previous records are concerned with findings on the subject of exponents of the phenomenon designated by the term 'phonology disturbance.' Balinese aphasia Broca patients demonstrated that the alteration of complex sounds was achieved through the simplification of sounds by means of substitution, omission, addition, or simplification (mutation). This was noted as especially true of the phonemes having to do with the place of the articulatory system, serving the function of a phoneme. Notably, however, a different version of the same approach (Wardhana, 2021). Other research sustains evidence that the therapy of reciting short *surahs* in the Qur'an enhances the ability to verbalise on spiritual topics the subject of which motor post aphasia (Purnomo & Jenie, 2020). Findings similar to the preceding are equally documented in children aged 5 and 6 years of the Arab nation of Jordan which belongs to the phonological discharge sub-category of the sample who were aged, with the younger having a lower score dictated by the phonological system, in addition to a regular pattern cognitive system of articulation error (Huneety et al., 2024).

2.1 Neurolinguistics and Acquired Articulation Disorders

An ischemic stroke involves a sudden loss of blood flow to the brain due to a blockage in a blood vessel (artery), resulting in disability and brain damage (Kirshner & Wilson, 2021).This type of stroke is recognized as a significant and common cause of acquired communication disorders, especially those disorders that affect the programming and execution of motor behaviour. This type of stroke disrupts central nervous system functions, affecting the coordination of the articulatory muscles (those involved in speech production, such as the tongue, lips, palate, and vocal folds) and the production of discrete speech sounds.

Dysarthria is one of the most prevalent motor speech disorders which occurs after stroke and refers to a group of speech disorders characterized by neuromuscular problems that affect the speech motor system (Patel et al., 2020). This particular condition also needs to be distinguished from Aphasia, a disorder of language that affects the comprehension, formulation, and expression of language. Aphasia does not affect the physical ability to produce speech sounds (Patra et al., 2022). In dysarthria, brain injuries both in the brain's outer and inner layers damage the ability to plan and execute the motor activities that are necessary for the formulation of speech sounds, leading to speech that is not only imprecise but has changes in its rhythm and melody (prosody) and is not easily understood (Code, 2021).

2.2 Acoustic Phonetics as a Diagnostic Tool.

Accurate assessment of post-stroke articulation deficits requires methodologies that go beyond perceptual evaluation. Acoustic phonetic analysis provides an objective, quantifiable, and reproducible approach to measuring subtle changes in speech production that auditory perception alone cannot reliably capture (Jebahi et al., 2024). Parameters such as segmental duration, fundamental frequency (F0), formant frequencies (F1–F2), vowel space area, and voice onset time offer precise metrics for detecting deviations from normative speech patterns, making them essential for clinical diagnostics and treatment planning.

Several studies have demonstrated the clinical utility of acoustic measures. For instance, acoustic analysis has been successfully applied to quantify articulatory impairments in dysarthria, revealing deviations in vowel formants and temporal organization that correlate with neuromotor deficits (Taiebine & Faris, 2019). In post-stroke populations, these measures allow clinicians to identify minute articulatory changes, document progress over time, and develop targeted therapeutic interventions.

By employing acoustic phonetics, researchers can establish a quantitative baseline of speech production, comparing patient performance to native speaker references. This approach is particularly important for languages with complex phonological systems, such as Arabic, where precise articulation is critical. The resulting objective data not only enhance the reliability of diagnosis but also provide a foundation for evidence-based, stepwise rehabilitation protocols, tailored to individual neuromotor deficits.

2.3 The Phonetic and Phonological Status of Arabic /l/.

Voiced alveolar lateral consonants containing the phoneme lam (ل) are articulatorily defined by the contact involved between the tip of the tongue, or apex, and the alveolar ridge, happening in conjunction with the lateral release of air and formation of a lateral resonant tone. In the production of /l/, to the resonance configuration of the tongue, to the position of the tongue, and the neuromuscular control, hue, and resonance pattern can be produced to shift (Meili et al., 2024). According to manner of articulation, phoneme /l/ has characteristics such that it can be classified into six groups, namely voicing, partial closure, non-velarization, lateral articulation , open oral cavity, and ease of articulation due to the tongue tip (Jaisy, 2021).

This research examines the articulation of the Arabic phoneme /l/ among post-stroke ischemic patients reading the Qur'an, a largely unstudied area in the field of phonology-based clinical Qur'anic reading. The research focuses on the phonetic characteristics of the voiced alveolar lateral /l/, which are particularly related to the regulation of oral motor mechanisms, enabling the determination of the degree of articulatory disturbance and, therefore, making a significant contribution to the development of speech therapy after stroke.

2.4 Case Study Methodology in Neurolinguistics.

Single-case methodology greatly impacts neurolinguistics research due to it's internal validity, and analyzes the micron details of how particular lesions impact linguistic abilities. Single-case designs allow for the interaction to be unmasked between the lesion(s) and the motor-linguistic output. In this way, research is able to examine and describe disorders with low incidence, and those that are very unique to the individual (Centeno, 2023).

In the domain of speech related disorders, and with the loss of speech in particular, single-case studies document the effects that specific lesions to particular neural pathways have in the areas of phonological encoding, motor planning, and the ability to actuate speech. This is critical, as post-stroke speech loss can be very different across patients, and that difference is based on where the lesions are, how many there are, the severity of the lesions, and the patterns in the involuntary muscular responses (Jianu et al., 2022). This also shows that the precise locations of the lesions can be related to specific articulatory deficiencies.

In the articulation analysis of Arabic phonemes after a stroke, this methodological framework is especially important because of the difficulty in cross-dialectal variation and a lack of normative data. Because the present study is centered on one participant, we can generate a high-resolution acoustic profile of lateral /l/ and its co-articulation. This profile yields valuable clinical data that would otherwise be lost in pooled data.

3. Research Method

This study uses a qualitative approach with a case study design (Suganda et al., 2021). Subject observed in context, pronunciation, and reading the Qur'an in juz to 30. Through this approach, researchers can explore in-depth the articulation errors of patterns in PSS, hereinafter referred to as (PSS) and compare them with the pronunciation of a native Arabic speaker Sheikh Mishary Rasyid Al-Afasy, hereinafter referred to as (SMRA). For the known level disturbance, alveolar lateral phonemes are voiced or /l/ in several forms of the vowel, which are *fathah (a)*, *kasrah (i)*, and *dammah* (u).

This study involves a single participant. The subject was chosen using purposive sampling, based on specific relevant criteria, with the objective of the research. Criteria for the election subject covering background behind health, ability to read and write Arabic phonemes with good enough proficiency, as well as a habit of reading the Qur'an. PSS is a 52-year-old male with a high school and religious school background. The medical history subject became a subject post-stroke ischemic light in 2021–2023. Election subject single. This is done because his profile is considered representative for observing the disturbance articulation of the phoneme /l/ in non-SMAR after ischemic stroke, which has an adequate phonetic basis.

Table 2
Identity subject study

Educational History	Age	Gender	Background	Medical history
High school, religious school	52 years old	Male	Ability to recognize, read, and accurately transcribe Arabic phonemes as well as Qur'anic text.	Ischemic stroke mild, Bell's palsy, and pulmonary tuberculosis since 2021-2023

Primary data were obtained by recording the subject's voice immediately after the subject post-stroke read verses of the Qur’an containing the target phoneme. They were then compared with recordings of SMAR as a standard. The data were analyzed, then transcribed phonetically using IPA (International Phonetic Alphabet) symbols (Brierley & Heselwood, 2022). Analysis was done using the device Praat to observe the formant waveforms and spectrograms of the sounds, including intensity, duration, and frequency base (F0) for each variant vowel /a/, /i/, /u/.

Through this strategy, researchers can describe pattern error articulation, irregularity lateral resonance, and level disturbance emerging phonetics consequence limitations, neuromuscular post-stroke analysis done in a comparative thematic way, namely compare subject spectrogram results post-stroke with reading SMAR to find differences in aspects of *makhraj* (place of articulation)*, ṣifāt al-ḥurūf (*manner of articulation*),* as well as characteristics of the acoustic phoneme /l/.

This study emphasizes that the interpretation of the findings is qualitative and descriptive, focusing on identifying patterns of articulatory impairment and their linguistic implications, while the data collection process is strictly quantitative, relying on objective acoustic measurements such as duration, fundamental frequency (F0), and formant values (F1 and F2). By integrating quantitative acoustic evidence with qualitative linguistic interpretation, the study provides a comprehensive and clinically meaningful account of the articulatory deviations observed in the post-stroke subject. This analysis contributes to the field of clinical phonetics in Arabic by elucidating the influence of orofacial motor disorders on the articulation of Qur’anic phonemes, and it further enriches applied *tajwīd* studies by grounding them in phonetic-acoustic principles, offering empirical data that bridges traditional *tajwīd* theory with modern phonetic science within the context of neurological impairment.

4. Results and Discussion

This case study analyzes the articulation of the phoneme /l/ in Arabic pronunciation by a PSS. Analysis focused on the phoneme /l/ with three form vowel /a/, /i/, /u/, each of which is represented through three example readings of the Qur'an in the same position namely at the end of the word. Phoneme /l/ with the */a/* vowel analyzed in the word */al.laj.la/* in Surah An-Naba verse 10, phonemes /l/ with the */i/* vowel in the word */walˈlaj.li/* in Surah Al-Lail verse 1, and phonemes /l/ with the */u/* vowel in the word */ ʔald͡ʒibaːlu /* in Surah Al-Qāri'ah' ah verse 5.

Table 2

List of words

Surah	Sentence analysis	Phonetic transcription	Syakal Category	Vocals
An-Naba /10	وَجَعَلْنَا ٱلَّيْلَ لِبَاسًا	*/al.laj.la/*	*Fathah*	/a/
Al-Lail /1	وَٱلَّيْلِ إِذَا يَغْشَىٰ	*/walˈlaj.li/*	*Kasrah*	/i/
Al-Qari'ah/5	وَتَكُونُ ٱلْجِبَالُ كَٱلْعِهْنِ ٱلْمَنفُوشِ	*/ ʔald͡ʒibaːlu /*	*Dammah*	/u/

Language Literacy: Journal of Linguistics, Literature, and Language Teaching
Volume 9, Number 2, pp: 804-818, December 2025
e-ISSN: 2580-9962 | p-ISSN: 2580-8672
DOI: https://doi.org/10.30743/ll.v1i1.12387

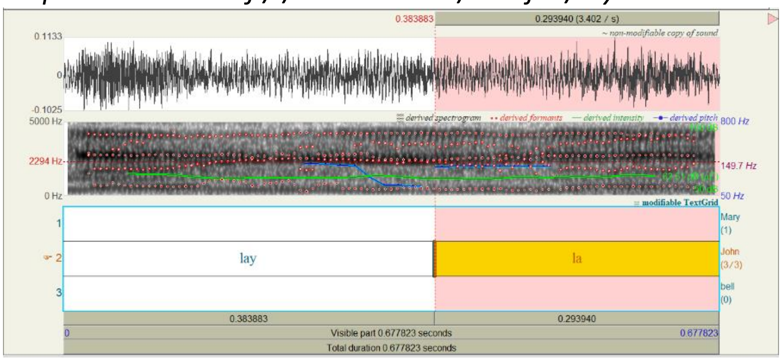
The pronunciation analysis of the three words containing the phoneme /l/ was conducted using Praat version 6.4.46 (Shivaswamy et al., 2025). This app shows a spectrogram of the subject's audio recording while reading, thus allowing researchers to see surface as quality or intensity) the frequency modulated pulsations of air pressure as well as sound duration corresponding to each vowel. Focus was on several phonetic parameters such as duration, fundamental frequency, and characteristics of the sound waves in the spectrogram analysis (Farisi et al., 2025). This acoustic analysis was carried out to compare the subject's pronunciation with that of SMAR and to identify any significant differences in the pronunciation of the phoneme /l/ in Arabic when reading the Qur'an. In addition, this analysis explored possible differences in the points of articulation used to produce the phoneme.

4.1 Acoustic Visualization of the Phoneme /l/ in the *Fathah* Vowel Variation /a/

The following shows a spectrogram illustrating of the phonetic review of SMAR and PSS who pronounce the phoneme /l/ with the */a/* vowel in the word */al.laj.la/.*

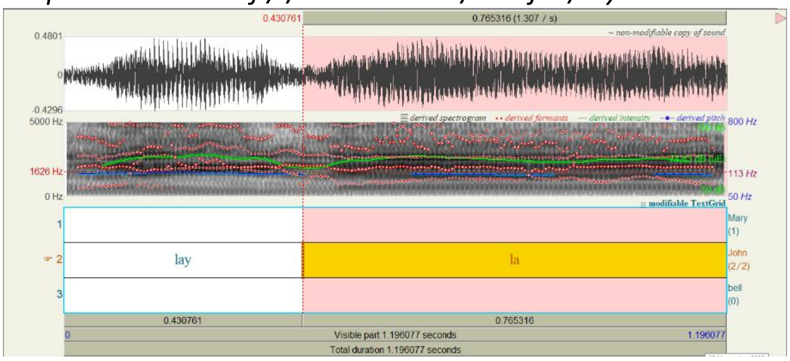
Spectrogram 1

Visualization of the pronunciation of /l/ in the word /al.laj.la/ by SMAR



Spectrogram 2

Visualization of the pronunciation of /l/ in the word /al.laj.la/ by PSS



Producing the phoneme /l/ in the word 'la' shows significant differences in the spectrograms of SMAR (1) and PSS (2). The PSS produced the syllable /la/ in 0.765 seconds, while the SMAR produced it in 0.294 seconds, indicating an increased duration of 260%. This was accompanied by instability in the fundamental frequency (F0) of post-stroke listeners, who had irregularly lower F0s (113Hz) than the SMAR, who was stable at 149.7Hz. Spectrographic analyses show that PSS experienced a wider-than-normal dispersion of voice energy at F1 (800–900Hz) and F2 (1400–1500Hz). Such a condition indicates a misfit of the oral cavity, which should form a partial resonating tube (Fang et al., 2025). Interestingly, the voice of PSS with F0 at 113Hz had a higher amplitude (0.48) than that of regular speakers (0.11). This does not mean the voice of PSS was stronger and more efficient, but shows excessive effort with the breath to compensate for a weak tongue and oral muscles (Ramoo et al., 2024).

From the perspective of Arabic phonology, the vowel /a/ of the tongue should be in a low position. The fronted position with a fully opened mouth so that there can be smooth transitions for the lateral consonant to an open vowel. In Spectrogram 1, the implementation of this place of articulation is reflected in the well-defined and appropriate formant structure with stable F1-F2, signifying high precision in achieving the target articulatory. In contrast, in Spectrogram 2, a nervous disorder caused the weakness of the tongue's intrinsic and extrinsic muscles, resulting in an inability to form intense apical contact and appropriate lateral closure (Shellikeri et al., 2016). This inability is exemplified in the phonetic outcome of the recorded voice, specifically the energy distribution in the sound that is unfocused, the widening of the frequency bandwidth in the voice's spectrum, and the increased length of the articulatory time due to the extra effort of the body to compensate for the deficient movement of the articulators.

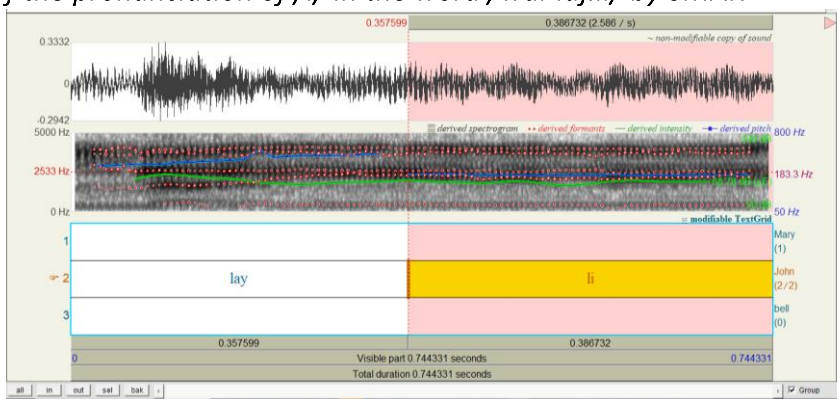
Analysis of *manner* of articulation shows multi-dimensional disruptions in producing the /l/ sound with an /a/ vowel. The voicing feature, along with some pronunciation issues like voice instability (especially in speakers with a history of stroke), was present although voiced quality persisted (more so due to voice disorder). The intermediate stricture feature relates to the level of obstruction during /l/ production, which was enough to cause prolonged sounds. Airflow through the sides of the tongue was sufficient to produce extended sounds. The lateral articulation sub-feature was caused by air fragmenting and escaping horizontally. Instead, the energy output was spread out and unarticulated with the lateral and uncharacteristic block structures missing (Jianu et al., 2021). The closure of the front part of the tongue was fairly normal, as indicated by the /a/ vowel measurements. The open oral cavity was also affected because the oral and pharyngeal cavities were unbalanced. The ease of articulation was most severely affected by the prolonged /l/, which led to unexplained voicing during production.

4.2 Acoustic Visualization of the Phoneme /l/ in the *Kasrah* Vowel Variation /i/

The following shows a spectrogram illustrating of the phonetic review of SMAR and PSS who pronounce the phoneme /l/ with the /i/ vowel in the word */walˈlaj.li/.*

Spectrogram 3

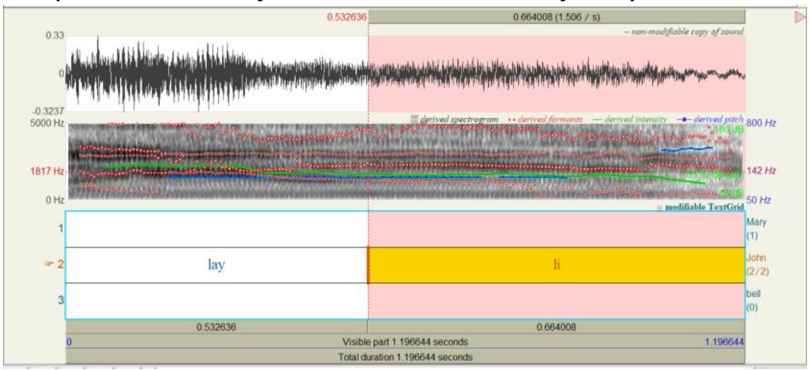
Visualization of the pronunciation of /l/ in the word /walˈlaj.li/ by SMAR



e-ISSN: 2580-9962 | p-ISSN: 2580-8672
DOI: https://doi.org/10.30743/ll.v1i1.12387

Spectrogram 4

Visualization of the pronunciation of /l/ in the word /walˈlaj.li/ by PSS



Acoustic analysis of the pronunciation of the syllable /li/ indicates an articulation disorder. In SMAR, the /i/ vowel is pronounced with a duration of approximately 0.387 seconds and produces a stable, clear sound. In contrast, PSS showed a significantly longer duration 0.664 seconds, about 72% longer than in SMAR. Although this lengthening is less than that of the vowel /a/ (which reaches 160%), the quality of the /i/ sound is much lower due to the difficulty PSS have in lifting the tongue to the required high position. This aligns with research by Lice et al., (2024), who found that PSS with damage to neural structures in the brain (cerebrum) exhibited a more severe lengthening of vowel duration on high sounds because of tongue muscle weakness. From an acoustic perspective, SMAR display a formant pattern typical of the vowel /i/, with a low F1 (~183 Hz) and a high F2 (~2533 Hz). However, in PSS, the F1 value increased (~142 Hz) and the F2 value decreased (~1817 Hz), indicating the tongue's inability to reach the proper high-front position. This pattern of vocal centralization is consistent with Mou et al. (2018), who reported that people with dysarthria tend to produce flatter, more centralized vowels, reducing clarity and distinction between vowels.

From the perspective of the place of articulation theory, pronouncing /li/ requires complex articulatory coordination. The phoneme /l/ is produced when the side of the tongue touches the upper molars, creating an airway on the side of the tongue. Simultaneously, the vowel /i/ requires a high and forward tongue position, approaching the hard palate with a narrow mouth opening (Arjmandi & Behroozmand, 2024). In SMAR, a shift in F2 values from around 1500 Hz to over 2500 Hz indicates rapid, precise tongue movements. However, in PSS, the F2 value only reached 1817 Hz, showing the tongue stopped in a mid-position. This suggests weakness of tongue-lifting muscles, such as the styloglossus and the genioglossus pars superior, caused by damage to upper motor neurons after a stroke (Puttanna et al., 2025). Spectrogram results also reveal a dispersed energy distribution in the voice, along with a broad, unstable formant bandwidth. This indicates that the tongue not only fails to reach the target position but also cannot maintain a stable one. These findings align with Ishikawa & Webster (2023), who stated that related formant bandwidth broadening is closely linked to decreased vocal clarity in post-stroke patients with neurological disturbances. The observed pattern of vocal centralization remains consistent with Mou et al. (2018) who noted that individuals with dysarthria often produce less-defined and more blended vowel qualities in their speech.

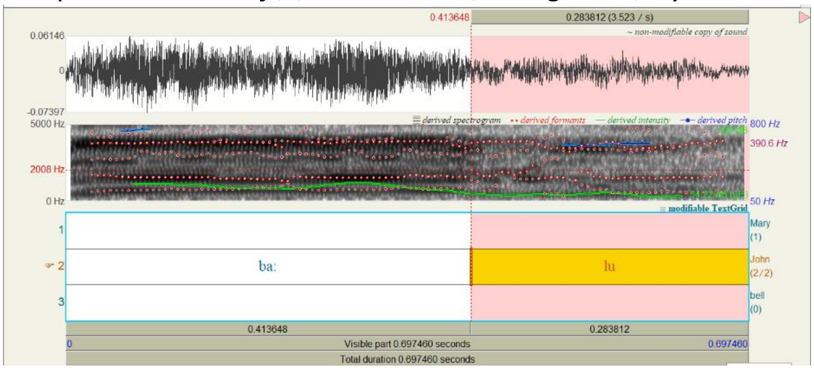
Based on manner of articulation, the /li/ phoneme shows disturbances that could be attributed to the complexities observed in the spectrogram. Voicing sound characteristic may be unstable in nature, however, the fluctuations in amplitude may be suggestive of the irregular movements of the voice box (Yang et al., 2025). The lateral articulation (nature that is characteristic to phoneme /l/ is of loss, resulting in disturbances that is heavy and clearly seen as a form of voice energy that is spatially diffused without a specified lateral constriction. The most notable disruption occurs during the transition of the phoneme's characteristic a low tongue position on /l/ to the tall position. Vowel /i / was not articulated and this is evident with F1 value which was also recorded to be on the extremely high side for vowels. Besides, articulation ease is disturbed with a 72% increase in duration suggesting that the movements, which are expected to be rapid, are instead slowed down and more rigid, thus the disturbance in ease. Allison (2017) indicates that lower precision in the sounding out of elements is a quality of overall dysarthria, particularly with respect to elements that require fast alterations in the positioning of the tongue, like /li/. Overall, the disruption of /li/ reveals inconsistencies compared to the patterns displayed by /la/. The subject, who has suffered a stroke, is left with a tongue that does not fully elevate, and he has disturbances that cause the sounds to become more centralized, and the processes of moving from consonants to vowels to be interrupted.

4.3 Acoustic Visualization of the Phoneme /l/ in the *Dammah* Vowel Variation /u/

The following shows a spectrogram illustrating of the phonetic review of SMAR and PSS who pronounce the phoneme /l/ with the /u/ vowel in the word */ ʔald͡ʒibaːlu/*

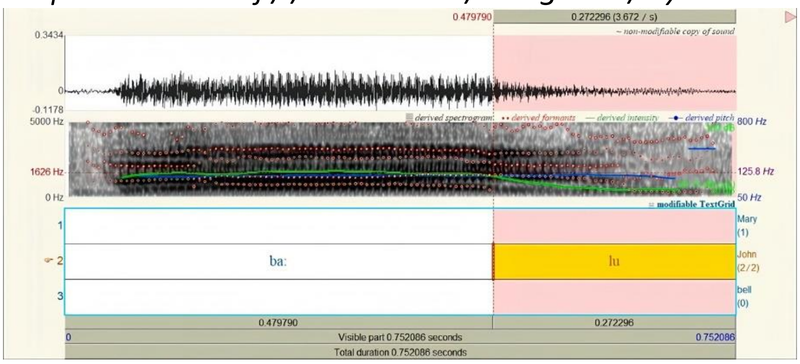
Spectrogram 5

Visualization of the pronunciation of /l/ in the word / ʔald͡ʒibaːlu/ by SMAR



Spectrogram 6

Visualization of the pronunciation of /l/ in the word / ʔald͡ʒibaːlu/ by PSS



In spectrogram 5, the duration of the vowel /u/ reaches 0.284 seconds with a stable and clear sound. In spectrogram 6, the duration is actually shorter, namely 0.272 seconds or about 4% faster. This shortening indicates that PSS are unable to maintain a complex tongue

e-ISSN: 2580-9962 | p-ISSN: 2580-8672
DOI: https://doi.org/10.30743/ll.v1i1.12387

position for the sound /u/ for a long time, this is in accordance with the research of Liu et al., (2022) who explained that damage to the basal ganglia makes it difficult for PSS to maintain a tongue position that involves pulling back and lifting the back of the tongue. Acoustically, the Arabic/u/vowel has a low F1 (~390 Hz) and a low F2 (~2008 Hz), characteristic of high back vowels with rounded lips. In contrast, PSS exhibited very low F1 (~126 Hz) and lower F2 (~1626 Hz), indicating an inappropriate compensatory attempt to achieve a posterior tongue position, while failing to maintain a correct lip shape.

Kinematic coordination from a place of articulation view suggests that the /lu/ combination is the most complex of the three vowel contexts. The phoneme /l/ is produced by the tongue engaging the upper molar. Simultaneously, there is a requirement of the vowel /u/ that a tongue movement is back and up, while rounding the lips (labialization) (Maulani & Alwan, 2023). In this vowel context, SMAR exhibit the movement of the tongue backward, spectrographically visible, as F2 monotonically decreases from about 1500 Hz to 2000 Hz, along with a complete rounding of the lips. Conversely, PSS spectrographically exhibit a formant pattern which is F2 too low, and F1 too low and fluctuating. This indicates that there is, respectively, an impairment of the movement and positional maintenance of the tongue and lips. The post-subjects demonstrated weakness of the back tongue muscles (styloglossus and hyoglossus) and the lip muscles (orbicularis oris) which is indicative of upper motor neuron damage (Lice et al., 2024).

Considering the characteristic /lu/ representation there exist disturbances concerned with the definition of the value of the breadth of the definition. Although the Voicing (voiced) property is preserved, the sound, however, remains significantly lower and does not reach a stabile contour suggesting an incomplete closure of the vent of the vocal folds (Liu et al., 2022). The definition of the property under discussion, lateral articulation, (air stream deflection laterally towards the sides of the tongue) remains unidirectional, and the transition of the tongue from the position low tongue to a posterior position (back) is not completely and adequately carrid out. Moreover, ease of pronunciation is also shallow, and there is an impairment, however, of a lesser deficiency that the time spent on it is short, but PSS are unable to maintain this challenging position. As Allison (2017) explain, those people who have a diagnosis of dysarthria will not correctly reach a designated articulatory position, and it is also clear that they will not maintain this position for an appropriate period of time (Muscat et al., 2025). The sound /lu/ proves to have the greatest disturbances compared to /la/ and /li/, as there is a clear requirement for constant coordination of the back of the tongue, the lips, and the vocal tract. The articulatory demands just placed should also show that the vocal tract behind tall sounds represented by /u/ have the greatest vocal load that is an articulatory difficulty for the subjects of the study who have had a stroke.

4.4 Severity of Articulation Disorders in the Production of the Phoneme /l/ with Three Vowel Forms

Based on the explanation above, it can be concluded that each context of the vowel presents a different level of difficulty in the production of the phoneme /l/ in PSS. The vowel /lu/ shows the most severe impairment because it involves complex multi-articulator coordination and extensive neuromuscular control. The context of *kasrah* /li/ shows moderate impairment, with dominant weakness in front tongue elevation and vocal stability. Meanwhile, /la/ is classified as a mild impairment, where basic articulatory function is still relatively maintained, although there are problems with tempo and phonation efficiency.

In general, this pattern indicates that the greater the complexity of tongue movements and inter-articulator coordination required for a vowel, the more severe the impairment in PSS with post-stroke motor neuron damage. Therefore, acoustic and articulatory analysis in these three vowel contexts can provide an objective picture of the severity experienced by PSS. To clarify this comparison, the following table presents the severity of articulation disorders of the phoneme /l/across vowel contexts and key acoustic findings.

Table 3

Disorders of articulation in the production of the phoneme /l/ with three vowel forms based on Praat

Parameter	/la/	/li/	/lu/
SMAR Duration	0.294 seconds	0.387 seconds	0.284 seconds
PSS Duration	0.765 seconds	0.664 seconds	0.272 seconds
Difference in duration	+160% (2.6x fold)	+72% (1.7x fold)	-4% (shorter)
F1 SMAR	~2294 Hz	~183 Hz	~390 Hz
F1 PSS	~1626 Hz	~142 Hz	~126 Hz
F2 SMAR	~ 149.7 Hz	~2533 Hz	~2008 Hz
F2 PSS	~113 Hz	~1817 Hz (-28%)	~1626 Hz (-19%)

Considering results analysis, acoustic, articulatory, and clinical data across all three contexts, vocals can be arranged in a hierarchy of disorder severity, indicating that certain forms of vowel demand greater motor complexity than others. Hierarchy. This reflects the extent to which the subject's neuromotor system post-stroke is capable of maintaining stability, articulation, and quality phonation in each variation of vocals. To clarify the order mentioned, the following provides a table of articulatory disturbances at the phoneme level for the phoneme /l/across three contexts of the analyzed vowel.

Table 4

Level of disturbance articulation phoneme /l/ in Arabic by subject post-stroke

Vowel	Level of Disturbance
/la/ (*Fathah)*	Mild
/li/ (*Kasrah*)	Moderate
/lu/ (*Dammah*)	Severe

From the hierarchy mapping above, it is evident that the complexity of the movements of the speech organs strongly influences pronunciation difficulty. Sounds with a high position of the tongue and involving Lots of movements, as in / lu / and /li/, indicate more disturbances and are heavier compared to the /la/ sound, which is simpler. This shows that the more complex position of the tongue and lips that must be formed, the greater the possibility of errors in articulation in the subject post-stroke. This can serve as a basis for the gradual compilation step of therapy, starting with easy exercises, such as the pronunciation of simple sounds, and progressing to more difficult sounds.

5. Conclusion

This study finds that level disturbance dysarthria affects the pronunciation of the phoneme /l/ in different Arabic languages, depending on the accompanying vowel. The vowel/u/ in the phoneme /lu/ shows the most serious disturbance because the subject post-

e-ISSN: 2580-9962 | p-ISSN: 2580-8672
DOI: https://doi.org/10.30743/ll.v1i1.12387

stroke is capable of maintaining the proper position of the tongue and lips, as well as experiencing a weak and inaudible voice. Vowel /i/ in the phoneme /li/ classified as moderate, marked with difficulty lifting the tongue part front and sound shifted vowels to middle. Meanwhile, the /la/ is moderately disturbed, because even though the tempo of pronunciation is very slow, the form of his vocals is still relatively straightforward.

This is important for therapy talk on the subject post-stroke sequence level difficulty. This can serve as a base to gradually build a training program, starting with the easiest sound /la/, then the medium /li/, and finally the most difficult /lu/. Every sound has its own focus on different exercises: /la/ for regulating the tempo of speech, /li/ for strengthening the muscles of the front of the tongue, and / lu / for practicing coordination of the tongue and lips.

In a way, theoretical research shows that difficulty speaking is not only caused by the complex position of the speech organs, but also by disorders in the coordination of the brain and muscles following stroke. Complexity sounds reflect the burden the work system nerve imposes on controlling the fine movements of the speech organs. To expand the analysis to other Arabic phonemes, this study can also be extended to the subject post-stroke with different types of lesions, for example hemorhagic stroke or lesions in other areas of the brain to examine a distinct pattern of disturbance in articulation.

References

Al Huneety, A., Al-Omari, M. A. K., Mashaqba, B., & Guba, M. N. A. (2024). Assessing the phonological abilities of Jordanian Arabic-speaking children with phonological disorders. *Communication Sciences and Disorders*, *29*(1), 127–144. https://doi.org/10.12963/CSD.231021

Ali, M., Sanusi, A., Maulani, H., Saleh, N., Khalid, S. M., Supriadi, R., & Al Farisi, M. Z. (2023). Investigating the Arabic /f/ pronunciation: A comparative analysis of acoustic phonetics. *Al-Ta'rib: Jurnal Ilmiah Program Studi Pendidikan Bahasa Arab IAIN Palangka Raya*, *11*(2), 181–196. https://doi.org/10.23971/altarib.v11i2.7234

Allison, K. M., Annear, L., Policicchio, M., & Hustad, K. C. (2017). Range and precision of formant movement in pediatric dysarthria. *Journal of Speech, Language, and Hearing Research.* https://doi.org/10.1044/2017_JSLHR-S-15-0438

Arjmandi, M. K., & Behroozmand, R. (2024). On the interplay between speech perception and production: Insights from research and theories. *Frontiers in Neuroscience.* https://doi.org/10.3389/fnins.2024.1347614

Brierley, C., & Heselwood, B. (2022). Phonetic transcription and the International Phonetic Alphabet. In *Oxford Research Encyclopedia of Linguistics.*

Centeno, J. G. (2023). Neurolinguistic and neurocognitive considerations of language organization and processing in multilingual individuals. In *The Routledge International Handbook.* https://doi.org/10.4324/9781003204213-34

Code, C. (2021). Aphasia. In *The Handbook of Language and Speech Disorders.* https://doi.org/10.1002/9781119606987.ch14

Delvaux, V., Fagniart, S., Huet, K., Piccaluga, M., & Harmegnies, B. (2020). Phonological and phonetic impairment in aphasic speech: An acoustic study of the voice onset time of six French-speaking aphasic patients. *Clinical Linguistics & Phonetics*, *34*(3), 253–276.

Fang, G., Zhuang, R., Wang, C., Zhou, M., & Zhang, Y. (2025). Acoustic correlation with dysphagia in stroke patients. *Dysphagia.* https://doi.org/10.1007/s00455-025-10830-6

Al Farisi, M. Z., Ali, M., Ismail, Z., Maulani, H., Saleh, N., & Khalid, S. M. (2025). Investigation of the pronunciation of the voiceless fricative non-sibilant phoneme /θ/ in Arabic: An acoustic phonetics comparative analysis. *Dirasat: Human and Social Sciences*, *52*(6), 1–14. https://doi.org/10.35516/hum.2025.5447

Faroqi-Shah, Y. (2023). A reconceptualization of sentence production in post-stroke agrammatic aphasia: The synergistic processing bottleneck model. *Frontiers in Language Sciences.* https://doi.org/10.3389/flang.2023.1118739

Haldin, C., Loevenbruck, H., Hueber, T., Marcon, V., Piscicelli, C., Perrier, P., Chrispin, A., Pérennou, D., & Baciu, M. (2020). Speech rehabilitation in post-stroke aphasia using visual illustration of speech articulators: A case report study. *Clinical Linguistics & Phonetics*, *35*(3), 253–276. https://doi.org/10.1080/02699206.2020.1780473

Ishikawa, K., & Webster, J. (2023). The formant bandwidth as a measure of vowel intelligibility in dysphonic speech. *Journal of Voice.*

Jaisy, Y. (2021). *Makhorijul huruf dan sifat-sifatnya matan kaidah mutamad 1.* Itqan wa Tajwid.

Jebahi, F., Nickels, K. V., & Kielar, A. (2024). Predicting confrontation naming in the logopenic variant of primary progressive aphasia. *Aphasiology.* https://doi.org/10.1080/02687038.2023.2221998

Jianu, D. C., Ilic, T. V., Jianu, S. N., & Axelerad, A. D. (2022). A comprehensive overview of Broca's aphasia after ischemic stroke. *Aphasia.*

Jianu, D. C., Jianu, S. N., Petrica, L., & Dan, T. F. (2021). *Vascular aphasias.* London: IntechOpen.

Kirshner, H. S., & Wilson, S. M. (2021). Aphasia and aphasic syndromes. In *Neurology in Clinical Practice.*

Lice, K., Škorić, A. M., & Kraljević, J. K. (2024). Word processing abilities in subjects after stroke or traumatic brain injury. *Acta Clinica Croatica.* https://hrcak.srce.hr/file/474014

Liu, Q., Li, W., Song, Y., Zhao, Z., Yan, Y., & Yang, Y. (2022). Correlation between focal lesion sites and language deficits in the acute phase of post-stroke aphasia. *Folia Pathologia.*

Maulani, H., & Alwan, M. D. (2023). Bilabial articulation pronunciation "B" (L1) and syafatain letters "Ba" (L2): Analysis of the pronunciation of the letter Ba in Surah Al-Fatihah. *Alsuniyat: Jurnal Penelitian Bahasa, Sastra, dan Budaya Arab*, *6*(1), 16–28. https://doi.org/10.17509/alsuniyat.v6i1.54685

Meili, I., Niarti, A. F., & Dewi, L. S. (2024). Analysis of phonetic language disorder in patients with aphasia. *Sintaksis: Publikasi Para Ahli.* https://journal.aspirasi.or.id/index.php/sintaksis/article/view/868

Mou, Z., Chen, Z., Yang, J., & Xu, L. (2018). Acoustic properties of vowel production in Mandarin-speaking patients with post-stroke dysarthria. https://doi.org/10.1038/s41598-018-32429-8

Muscat, C. C., McCabe, S. A., & Morgan, A. T. (2025). Neural mechanisms driving speech and language recovery following childhood stroke: A scoping review. *Disability.* https://doi.org/10.1080/09638288.2024.2390053

Patel, N., Peterson, K. A., Ingram, R., Storey, I., & Cappa, S. F. (2020). The mini linguistic state examination (MLSE): A brief but accurate assessment tool for classifying primary progressive aphasias. *MedRxiv.* https://doi.org/10.1101/2020.06.02.20119974

Patra, A., Traut, H. J., & Stabile, M. (2022). Effortful retrieval practice effects in lexical access:

A role for semantic competition. *Language, Cognition and Neuroscience.* https://doi.org/10.1080/23273798.2022.2027991

Purnomo, S., & Jenie, I. M. (2020). The effect of reciting the Holy Qur'an to the speaking ability and spirituality level of stroke patients with motor aphasia. *Jurnal Keperawatan Padjadjaran*, *8*(3), 200–207. https://doi.org/10.24198/jkp.v8i3.1447

Puttanna, D., Al Harbi, M., & Fernandes, F. L. (2025). Understanding discourse genre and its effects in persons with fluent aphasia: A preliminary investigation. *Audiology and Speech Research.* http://www.e-asr.org/journal/view.php?number=584

Ramoo, D., Galluzzi, C., & Olson, A. (2024). Phonological impairments in Hindi aphasics: Error analyses and cross-linguistic comparisons. *Cognitive Neuropsychology.* https://doi.org/10.1080/02643294.2024.2315825

Shellikeri, S., Green, J. R., Kulkarni, M., Rong, P., Martino, R., Zinman, L., & Yunusova, Y. (2016). Speech movement measures as markers of bulbar disease in amyotrophic lateral sclerosis. *Journal of Speech, Language, and Hearing Research*, *59*(5), 887–899. https://doi.org/10.1044/2016_JSLHR-S-15-0238

Shivaswamy, J., Barman, A., & Maruthy, S. (2025). Pitch and vowel space characteristics of maternal speech to children with and without hearing loss. *The Egyptian Journal of Otolaryngology.* https://doi.org/10.1186/s43163-025-00818-2

Simic, T., Leonard, C., Allendorfer, L. L., Stewart, S., & Rochon, E. (2021). The effects of intensity on a phonological treatment for anomia in post-stroke aphasia. *Journal of Communication Disorders*, *93*, 101–112.

Suganda, D., Adji, M., & Biben, V. (2021). Language competency recovery model using inclusive therapy for post-stroke Wernicke aphasia patients: A neurolinguistic study. *Ilkogretim Online.*

Sundoro, B. T., Oktaria, D., & Dewi, R. (2020). Pola tutur penderita cadel dan penyebabnya: Kajian psikolinguistik. *Kredo: Jurnal Ilmiah Bahasa dan Sastra*, *3*(2), 1–12.

Syahid, A. H., & Nurdianto, T. (2022). Brain lateralization and strategies to improve metalinguistic ability in Arabic language acquisition. *Alsuniyat: Jurnal Penelitian Bahasa, Sastra, dan Budaya Arab*, *5*(2), 184–202.

Taiebine, M., & Faris, M. E. A. (2019). Neurolinguistic and acoustic study of logopenic primary progressive aphasia in Arabic. *Neuropsychologia*, *17*(4), 469–485.

Ulpah, S. M., Al Farisi, M. Z., Saleh, N., & Rachman, Z. T. (2025). Spectrographic characteristics of the elevation phonemes on the pronunciation of apico-dental in Surah Al-Fatihah. *An Nabighoh*, *27*(1), 25–54. https://doi.org/10.32332/an-nabighoh.v27i1.25-54

Wardhana, I. K. (2021). Alterasi fitur fonologis bahasa Bali pasien afasia Broca. *Widyaparma*, *49*(2), 1–12.

Wei, X., Adamson, H., Schwendemann, M., Goucha, T., Friederici, A. D., & Anwander, A. (2023). Native language differences in the structural connectome of the human brain. *NeuroImage*, *270*, 119955. https://doi.org/10.1016/j.neuroimage.2023.119955

Yang, Y., Su, R., Zhao, S., Wei, J., Ng, M. L., Yan, N., & Wang, L. (2025). An audio-ultrasound synchronized database of tongue movement for Mandarin speech. *Scientific Data.* https://www.nature.com/articles/s41597-025-04917-w

Ziegler, W. (2022). A neurophonetic approach to articulation planning: The case of apraxia of speech. *Laboratory Phonology*, *13*(1). https://doi.org/10.16995/labphon.6437