

Analysis of Dental Sound Production /t/ and /d/ by Deaf Speakers

¹Henry Yustanto, ²Muhammad Rohmadi, ³Fatiya Fajar Utami

¹Faculty of Cultural Sciences, Sebelas Maret University, Indonesia

²Faculty of Teacher Training and Education, Sebelas Maret University, Indonesia

³Faculty of Cultural Sciences, Sebelas Maret University, Indonesia

¹henryyustanto@staff.uns.ac.id, ²mamad_r76@staff.uns.ac.id and ³fatiyafajarutami@student.uns.ac.id

HOW TO CITE:

Henry Yustanto, Muhammad Rohmadi, Fatiya Fajar Utami (2026). Analysis of Dental Sound Production /t/ and /d/ by Deaf Speakers. International Journal of Special Education, 41(10s), 354-367.

COPYRIGHT STATEMENT:

Copyright: © 2026 Authors.
Open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

ABSTRACT:

This study examines in depth how deaf children pronounce the dental sounds /t/ and /d/ followed by the vowels /a/ and /i/. The focus is on consonant-vowel articulation patterns, variations in vowel transitions, and deviations resulting from hearing limitations. Six deaf children participated, with segmental phonetic data analyzed by examining substitutions, distortions, and changes in syllable structure. The results showed that hearing loss significantly affects the stability of air pressure in the oral cavity, the accuracy of the point of articulation, and the consistency of formant transitions to the vowels /a/ and /i/. The most common symptoms include changes from dental consonants to alveolar or velar, vowel modification, nasalization, and the appearance of a glottal stop. These findings highlight that dental sound production requires complex articulatory coordination and relies heavily on auditory feedback. This study is expected to serve as a reference for the development of phonetic-articulatory studies and assist in planning more targeted speech therapy for deaf children.

Keywords: articulatory phonetics, articulation deviation, deaf children, dental sounds, speech production, speech therapy, vocal transitions.

A. INTRODUCTION

During the speech process, humans experience a complex collaborative process between the articulation, respiration, and phonation systems. These three systems are interconnected, from airflow and vocal cord vibration to resonance and inhibition through vocal tract movements (Saddhono & Hartanto, 2021; Dewi et al., 2026; Puspitasari et al., 2023). During articulation, control of the tongue, lips, teeth, and palate determines whether the resulting sound meets the target. In Indonesian, dental-alveolar sounds

like /t/ and /d/ are fundamental consonants that maintain speech clarity and language structure.

Phonetically, the sounds /t/ and /d/ are formed when the tip of the tongue presses tightly against the alveolar region or upper teeth, then suddenly releases it to produce a pop. This process requires precise timing—from air pressure, how long it is held, to the moment of opening. Classic phonetic studies (Ladefoged & Johnson, 2015; Kent & Read, 2015) have shown that even a small disturbance in any of these

elements can cause variations in sound, for example, changes in the duration of Voice Onset Time (VOT), a less forceful pop, or a change in articulation position. Control of the production of stop consonants is highly dependent on hearing. Therefore, deaf children often exhibit inconsistent articulation (Kusumaningsih et al., 2024; Mukhibun & Saddhono, 2023).

Hearing is key to controlling the details of consonant production. By listening to their own voice, speakers can calibrate tongue position, the strength of the stop, and even the quality of the transition to the vowel. Deaf children, because they don't receive sufficient auditory feedback, ultimately experience less than optimal calibration. Previous research has shown that children with hearing loss tend to produce stop consonants with unstable air pressure, weak pops, and variable articulation patterns (Osberger & McGarr, 1982; Smith, 1975). They rely more on tactile sensations, vibrations, and the body's ability to sense the position and movement of the vocal tract to compensate (Ling, 1976). Several studies (Sari, 2018; Rahmawati, 2020; Andini & Pratama, 2021; Lestari, 2022) also support this and emphasize the importance of more in-depth acoustic-phonetic research.

Acoustic research also shows that hearing loss affects formant transitions between consonants and vowels. Monsen (1976) and Angelocci et al. (1964) reported that deaf speakers often have large deviations in formant transitions for high vowels such as /i/, because high vowels require more precise tongue control, especially when lifting the tongue palatally. Low vowels such as /a/ are usually more stable because their articulation is more open.

Sari (2018) found that deaf students in special schools tend to weaken stop consonants and change the articulation position of the sounds /t/ and /d/, especially when the sounds are followed by high vowels. Rahmawati (2020) also observed that the production of the high front vowel /i/ in deaf children is often accompanied

by unclear formant transitions, so the clarity of the preceding consonant is also affected.

Based on previous research findings, this study focuses on the production of dental sounds /t/ and /d/ followed by vowels /a/ and /i/. The vowels /a/ and /i/ were chosen because they represent two completely different articulatory positions: /a/ is a low back vowel that is generally easier to pronounce, while /i/ is a high front vowel that requires more complex tongue control. By comparing pronunciation patterns in these two vocalic contexts in deaf speakers, this study aims to delve deeper into the problems of articulatory transitions and the patterns of phonetic deviations that arise. The results of this study are also expected to help develop more appropriate speech therapy interventions for children with hearing loss.

B. LITERATURE REVIEW

1. Theoretical Framework

Sound productionSpeech is a way of speaking using parts of the mouth, such as the tongue, teeth, the alveolar ridge (alveolar ridge), and lips. Sounds like /t/ and /d/ occur when the tip of the tongue touches the back of the upper teeth, causing air to escape sharply. Producing sounds correctly requires good control of the vocal tract and an awareness of sound production and how the parts of the mouth are used.

In the process of sound production, speakers need to understand the existence of basic models. In understanding speech, such as the integrative sensorimotor model, this is necessary to demonstrate that speech involves more than just muscle movement, but also combines hearing and motor skills. Hearing provides information to help identify errors and quickly correct sound production. If a person's hearing is impaired, such as in the case of deafness, this feedback changes and can affect the accuracy of the sounds produced.

Besides an integrative sensorimotor model, the DIVA (Directions Into Velocities of Articulators) model, demonstrates that parts of the nervous system also play a key role in connecting desired sounds with appropriate

movements. This model also uses feedback from hearing and the senses to learn and improve speech.

SuffererDeaf people cannot hear well or may not hear at all. Therefore, they cannot learn or improve sounds through their ears. This is different from people who can hear. Therefore, the way they recognize sounds when learning a language differs between deaf and hearing people. As a result, the way deaf people produce sounds may differ, some may be missing, or even mispronounced.

Problem in producing sounds, deaf people often experience the loss or alteration of sounds due to a lack of auditory feedback. This study will examine how hearing impairment affects deaf people in pronouncing the sounds /t/ and /d/ based on pronunciation and speech models that involve the senses.

2. Recent Previous Studies

Nurfazrianty, et. al.(2025) conducted a Sound and Rhythm Perception Development Program for Dental Consonants. Their observations showed that. There are barriers that affect the ability of deaf children to pronounce consonants such as /d/, /n/, and /t/. The results of the study showed that after participating in the program, their ability to pronounce these consonants improved significantly. This suggests that exercises that combine listening and speaking are crucial to help them improve their pronunciation of sounds like /t/ and /d/.

StudiesA study related to deaf people's pronunciation of vowels and consonants was conducted by Subihah et al. (2024). The findings of this study indicate that most consonants and vowels are pronounced correctly, but there are several errors, such as adding, omitting, or replacing relevant sounds for the dental sounds /t/ and /d/. This finding is important because it can reveal error patterns in how they pronounce sounds, including the sounds /t/ and /d/. Interventions focused on sound perception can help improve accuracy in pronouncing dental sounds, which indicates that sensory abilities have an important role in speaking.

Speech production by people with hearing impairments (deafness) was also studied by Anggraeni (2023). This study used acoustic phonetics methods with deaf students. The findings showed that the ability of people with hearing impairments to understand and pronounce sounds is greatly influenced by their hearing ability.

Mareta (2018) examined segmental sound pronunciation in deaf students. This study investigated how deaf students pronounce vowels and consonants. The results showed that deaf students could pronounce various sounds, but still experienced difficulties, especially with more difficult sounds. This study is very useful for understanding how deaf people pronounce dental consonants.

C. RESEARCH METHODS

This study used a descriptive-qualitative design, with a phonetic-acoustic analysis approach. This study examines the sound patterns /t/ and /d/—particularly in the context of the vowels /a/ and /i/—pronounced by deaf children. Furthermore, this study also looked for deviations, both in terms of articulation and acoustics. This study involved six deaf children (DC1–DC6), aged 10–14 years, from a Special School (SLB). These six children had hearing impairments ranging from moderate to severe. At the time of recording data collection, they did not use hearing aids. They also did not have other speech disorders that could affect speech production.

The research tools (instruments) used in this study include: (a) a word list containing target consonant-vowel (CV) syllables such as /ta/, /ti/, /da/, and /di/, (b) a digital recorder with 44.1 kHz/16-bit specifications, and (c) Praat software used to analyze acoustics, check duration, intensity, burst spectrum, and formant transitions.

Data collection was carried out in the following manner: (a) participants were asked to imitate the researcher's pronunciation in a soundproof room, (b) each target was repeated five times, (c) recordings were made approximately 20 cm

from the condenser microphone, and (d) all recordings were saved in WAV format for easy acoustic analysis.

Data analysis techniques are divided into two. First, articulatory analysis: at this stage, researchers note sound realization patterns based on trained hearing, for example, weakened bursts, changing points of articulation, or distortion in vowel transitions. Second, acoustic analysis, namely measuring Voice Onset Time (VOT) on /t/ and /d/, analyzing the burst spectrum, measuring the F1 and F2 formants at 20%, 50%, and 80% of the vowel duration, and comparing the deviation patterns with normal production according to phonetic literature.

To ensure data validity, researchers compared articulatory and acoustic results, and two independent phonetic analysts also reviewed the analysis. Measurements were also repeated for consistency. Through this method, researchers hope to gain a comprehensive picture of how deaf children produce dental sounds, as well as any patterns of deviation.

D. RESULTS AND DISCUSSION

1. Place of Articulation Substitution

Substitution was the most frequent phonological process across all informants. The patterns that emerged varied. Deaf children appeared to rely more on kinesthetic or articulatory estimation, rather than auditory input, to determine where to place their articulators when producing dental or alveolar consonants such as /t/ and /d/.

a. Dental/Alveolar → Velar

Example:

tas 'bag' → [taʔ],

tanda 'bunch' → [taŋka],

tangan 'hand' → [taka]

When /t/ changes to /k/ or /ŋ/, in this case, it means the informant maintains the air pressure and beat pattern, but the location of articulation is shifted back (retraction). This type of velarization often occurs in deaf speakers because they have difficulty controlling the point of contact of the tongue with the teeth or

alveolum. Usually, they tend to choose a position that is considered "safe," namely dorsal articulation, which feels more stable proprioceptively. In addition, forms such as [taŋka] indicate nasalization that occurs simultaneously with velarization. This event indicates a disturbance in velopharyngeal coordination.

b. Dental/Alveolar → Labial

Example:

tas 'bag' → [la],

tanah 'land' → [ləlab]

The occurrence of a sound substitution to /l/ or other labialized sounds indicates a forward articulation shift. In this case, the stop feature of /t/ is lost and it changes to lateral /l/, which is easier to pronounce because it does not require as strict a release of air pressure as a stop consonant.

c. Dental/Alveolar → Alveopalatal

Example:

tas 'bag' → [taʃ], [taʃ]

This process indicates palatalization or fronting. This typically occurs due to excessive friction during production and unstable segmental control. As a result, the /t/ flap transforms into a fricative /ʃ/. Instead of producing the characteristic short burst of /t/, the informant holds the air pressure longer, ultimately producing a fricative sound. This phenomenon clearly indicates that timing control during stop consonant production is immature.

d. Dental → Uvular/Laryngeal

Example:

tanda 'sign' → [Uʔe],

tiga 'three' → [təʔeh],

nangka 'jackfruit' → [daʔhU]

Glottalization is frequently found in deaf speakers. They rely on laryngeal effort as their primary cue and find it easier to maintain or release air pressure at the glottis than at the oral point of articulation. This phenomenon indicates that supralaryngeal coordination, such

as that of the tongue, alveolum, or velum, is still poor. Glottal stops tend to be easier to produce because control at the glottis is directly felt kinesthetically, in contrast to the contact between the tongue and teeth or alveolum, which is more difficult to perceive. As a result, oral segmental features are reduced and replaced by laryngeal mechanisms. All of these phenomena confirm that deviations in dental or alveolar sound production in deaf children are not simply a matter of phonological errors, but rather an adaptive articulatory strategy due to limited auditory input.

2. Addition of Vowels or Syllables (Epenthesis)

Example:

tas 'bag' → [ətaŋ],

tali 'rope' → [ətaŋəh],

taplak 'tablecloth' → [ləməlah]

Epenthesis—usually a schwa [ə]—often occurs in DC2 and DC3. For deaf children, epenthesis serves several functions: (a) it makes transitions between consonants easier, (b) it reduces the motor load when pronouncing complex syllables, and (c) it maintains a more stable vocal rhythm, as vowels are easier to monitor by touch or sight. This pattern suggests that they maintain syllable structure by inserting additional vowels to “patch in” unstable consonant coordination. The dominance of schwa vowels suggests that they prefer neutral vowels that don't require as precise articulatory positioning. Thus, epenthesis serves as a “shortcut” to maintain syllable structure even when consonant coordination remains unstable.

3. Assimilation and Metathesis

Example:

tangan 'hand' → [taŋka], [taŋəh], [danal]

tanda 'sign' → [danda]

tape 'cassava tape' → [tabəl]

Assimilation and metathesis occur because deaf children cannot yet maintain complex consonant sequences. This means that their articulators

tend to “seek the easiest position,” a motor simplification, because there is insufficient auditory feedback to check that the sequence is correct.

Assimilation is clearly visible in words like *tanda* 'sign' → [taŋka] or *tabel* 'table' → [tapəl], where one segment influences another segment within a word. Phonologically, features of place or manner of articulation appear to “spread out” to make sound production easier. This occurs because they cannot yet maintain the order of distinctive features in a sequence of consonants, and the articulators prefer to stay in one position rather than move quickly.

Metathesis is also seen in this utterance, for example, *tangan* 'hand' → [danal], where the segment order is reversed. This process indicates unstable speech motor planning, so the sequence of segments programmed in the brain sometimes does not come out sequentially. Metathesis in deaf children informs that the phonological representation of words has not yet been truly “broken down” serially, so word production follows the ease of articulation rather than the target phonotactic rules.

4. Voicing and Devoicing

a. Voicing (/t/ → /d/)

Example:

tali 'rope' → [dali],

tanda 'sign' → [danda],

tanah 'land' → [dana]

The voiceless stop consonant /t/ often changes to a voiced /d/ for several reasons: vocal cord vibration occurs too quickly, inadequate control of glottis opening, or deaf children simply prefer a sound that feels “stronger” in the neck. The trigger for this is usually an uneven synchronization between glottis opening and the release of air pressure in the mouth, coupled with a tendency to prefer the more pronounced sensation of neck vibration, as well as an effort to maintain a sound that they consider “steadier.”

b. Devoicing (/d/ → /t/)

Example:

dapur 'kitchen' → [tapUr],

dada 'chest' → [tata]

Devoicing usually occurs because they cannot maintain vocal cord vibration, or because oral air pressure is too high, making it difficult to maintain a voiced sound. These two processes, voicing and devoicing, clearly demonstrate that control of the [±voice] feature in deaf children is highly fluctuating. This is in line with clinical findings in phonetics that the contrast between voiced and voiceless sounds is indeed one of the most easily "shaken" aspects in deaf speakers.

5. Segment Reduction (Deletion)

Segmental reduction typically occurs when initial consonants like /t/ or /d/ are lost. Phonologically, this demonstrates the vulnerability of dental or alveolar stops in the speech systems of deaf children. Some examples can be seen in the following words:

tisu 'tissue' → [igu]

tirai 'curtain' → [La ah]

disel 'diesel' → [edal]

When oral inhibition is difficult to maintain and vowel transitions become more prominent, initial consonants eventually disappear. These children tend to rely on vocalic patterns to maintain speech rhythm. This highlights how easily dental or alveolar consonants are eliminated in their speech. As a result, syllabic structures become simpler, often consisting of only vowel or semi-vowel patterns, while complex consonantal segments suffer.

Overall, these data suggest that the speech production of deaf children can be characterized by several things: (a) they utilize vowel-based compensatory strategies such as epenthesis and segment reduction, (b) they simplify segmental sequences through assimilation or metathesis, and (c) their laryngeal control is often unstable, resulting in inconsistent voicing or devoicing. In other words, the resulting sound deviations are not simply "errors," but rather systemic

adaptations to the limitations of auditory feedback.

E. ANALYSIS PER INFORMANT (DC1)

If we look at the production of DC1 utterances, there is a strong dominance of velar substitution and epenthesis. For example:

tanah 'land' → [tana]

talas 'taro' → [taŋə]

tanaman 'plant' → [taŋkapel]

tangki 'tank' → [takəŋ]

This suggests that DC1 consistently shifts dental/alveolar consonants dorsally, while adding neutral vowels to support the syllabic structure. This strategy clearly appears to be a form of articulatory motor adaptation, especially given the limited auditory feedback.

1. Substitution /t/ → Velar (/k/) or Nasal Velar (/ŋ/)

In the example: *tanah* 'land' → [tana], *tangki* 'tank' → [takəŋ], the velarization event indicates that DC1 has difficulty finding the dental/alveolar articulation point. He compensates by relying on the more proprioceptively stable dorsal articulation. As a result, a consistent backing pattern appears in almost all tokens. The realization of [ŋ] also shows unstable velum closure, so air escapes through the nasal cavity. From a phonological perspective, the +coronal feature on /t/ fails to be maintained, replaced by the +dorsal feature. Meanwhile, the -sonorant feature is often weakened or lost.

2. Stability of Vowels /a/ and /i/

What's interesting about this scenario is that, despite the consonant fluctuations, the vowel remains stable. This indicates that DC1 has much better control over the vocal aperture. The vowel also provides clearer tactile and visuomotor feedback, with jaw opening and lip position all more pronounced. DC1's production system appears to be vocal-centric; the vowel serves as a rhythmic and structural anchor in his speech. Thus, the production

disturbance here is not generalized, but rather specific to certain consonantal segments, particularly dental/alveolar stops.

3. Epenthesis as a Support for Syllabic Structure

Examples such as [taŋə] and [takəŋ] show DC1 actively using epenthesis of the schwa vowel [ə]. This epenthesis has several functions: (1) smoothing the articulatory transition between consonants, (2) reducing the motor load on complex segment sequences, and (3) maintaining the continuity of speech rhythm, by prioritizing the vocal flow. Thus, DC1 is still aware of syllabic structure, but cannot yet realize consonantal segments precisely without the help of additional vowels.

4. Progressive Nasalization

In the example of *tanah* 'tanah'l → [taŋa], Velopharyngeal coordination appears suboptimal, nasal airflow is difficult to control, and nasal consonants eventually spread to subsequent vowels. These findings align with reports by Lee (2017) and Haraguchi (2019), which state that deaf speakers rely more on articulatory proprioception than auditory feedback. Therefore, their sound production patterns are more influenced by motor factors than acoustic phonetics.

In DC1, a typical pattern of early deaf speakers is seen: the dominance of velarization and epenthesis as compensatory strategies. Several main features are clearly visible: (1) velarization dominates as a substitute for coronal articulation, (2) vowel epenthesis supports the syllabic structure, (3) vowels are much more stable than consonants, and (4) progressive nasalization occurs because velopharyngeal control is weak. It can be seen that DC1 speech production shows a systemic, motor-based adaptation, achieving articulatory and rhythmic stability becomes a priority rather than the target phonological accuracy.

F. PER INFORMANT: DC2 – DC6

DC2 – Dominance of Epenthesis, Assimilation, and Devoicing

Informant DC2 clearly demonstrated a tendency towards highly vowel-oriented production. The process that frequently occurred was epenthesis—the insertion of an additional vowel or syllable—followed by assimilation of place of articulation and devoicing. This can be seen in the data: *tas* 'bag' → [ətaŋ], *tali* 'rope' → [ətaŋəh], and so on. DC2 almost always inserts extra vowels to maintain the smoothness and rhythm of speech.

a. Dominance of vowel/syllabic epenthesis

Epenthesis, especially schwa [ə], appears in almost all words spoken by DC2, both at the beginning (onset) and in the middle of words. From a phonetic and articulatory perspective, this epenthesis serves several purposes: (1) stabilizing the transition between consonants, especially when changing places of articulation quickly, (2) reducing the motor load when pronouncing complex syllables or consonant sequences, and (3) creating a more consistent vocal rhythm, easier to monitor through jaw opening and oral sensation.

Thus, the predominance of epenthesis in DC2 demonstrates how he maintained syllable structure: not by eliminating segments or drastically simplifying them, but by adding vowels. This is evidence that he was quite aware of word structure, even though his phonetic realization often missed the mark.

b. Assimilation of place of articulation

Assimilation of place of articulation also appears clearly, for example in the word *tangan* 'hand' → [taŋəh]. In this case, the final consonant "n" influences the initial consonant in terms of place of articulation. Phonologically, this means that DC2: (1) has difficulty maintaining the coronal vs. dorsal contrast sequentially, (2) prefers to maintain one articulatory position longer to be more motorically efficient, and (3) tends to produce speech based on the principle of motor simplification, not phonotactic accuracy.

c. /d/ → /t/

Devoicing is also seen in DC2. For example, the word *dada* 'chest' is pronounced as [tata]. DC2 cannot maintain vocal cord vibration when

producing voiced consonants. The factors that cause this are usually: (1) high oral air pressure, (2) unstable glottal synchronization, and (3) not relying heavily on auditory feedback to monitor voicing. Thus, the [+voice] feature in DC2 is easily lost, and for the sake of fluency, voicing is often sacrificed.

d. Minimal glottalization compared to DC5–DC6

Unlike DC5 and DC6, who frequently use glottal stops for stabilization, DC2 rarely uses them. He prefers to add extra vowels (epenthesis), maintain a smooth flow of speech, and avoid glottal closure, which requires precise laryngeal control. Thus, it appears that DC2 is more comfortable with an oral-vocal (supralaryngeal) strategy than a laryngeal one.

Overall, DC2 shows the profile of a deaf speaker with a strong vocal orientation. This is evident from: (1) epenthesis as the primary strategy for maintaining syllable structure and speech rhythm, (2) assimilation of place of articulation as a form of motor simplification, (3) consistent devoicing because glottal control is not yet stable, and (4) minimal glottalization, and is very different from informants whose laryngeal strategy is dominant.

DC3 – Combination of Epenthesis, Metathesis, and Labial Substitution

DC3's pattern is somewhat different. It combines several strategies: epenthesis (additional vowels), metathesis (switching segments), and labial and lateral shifts in articulation. Overall, the DC3 pattern is somewhat similar to DC2, except here the instability of the order and the shift in sound class are more extreme.

a. Vowel and syllabic epenthesis

Vowel and syllable epenthesis remains a mainstay of DC3, this can be seen in examples such as the speech of *tanab* 'land' → [lɔlab], *tabung* 'tube' → [lɔbu], and *taplak* 'tablecloth' → [lɔməlab]. Similar to DC2, DC3 also uses schwa [ə] to maintain smooth articulation. The function of the emergence of the schwa [ə] sound is clear: (1) the lack of complexity of the

consonant transition, (2) the stability of the speech rhythm, and (3) providing extra time for motor planning before moving on to the next segment. The dominance of epenthesis in DC3 indicates that he still understands the syllable structure, but is not yet able to pronounce the target phonotactic structure without the help of additional vowels.

a. Labial and lateral substitution

Labial and lateral substitutions also frequently occur in DC3. For example, the word *tanda* 'sign' is pronounced as [lalab], in which case /t/ changes to /l/. This shift occurs from a dento-alveolar sound to a labial/lateral sound. From a phonetic perspective, this means that DC3: (1) has difficulty controlling the tongue-alveolar contact point, (2) prefers an articulation that is easier and more tactilely clear (lips or sides of the tongue), and (3) is willing to sacrifice the stop and sonorant features of /t/ for smoother production.

b. Voicing Instability

DC3 also exhibits fluctuating voicing, sometimes /t/ becomes /d/, sometimes not. Thus, glottal timing control is not yet fully established. Vocal cord activation comes and goes, difficult to predict. The ±voice feature is also not yet fully integrated into DC3's phonological-productive system.

In contrast to DC2, which tends to consistently devoicing, DC3 actually switches back and forth—sometimes voiced, sometimes not. This clearly indicates that his laryngeal control is still immature. In general, it can be said that DC3 is a typical deaf speaker profile: (1) often uses epenthesis to stabilize speech, (2) metathesis appears because his sequential motor control is weak, (3) often substitutes labials and laterals because of difficulty maintaining dento-alveolar articulation, and (4) his voicing is inconsistent, a sign that glottal control is still shaky.

DC4 – High Variation, Fluctuating Voicing, and Partial Velarization

DC4 speech is much more phonologically varied than DC2 or DC3. DC4 does not rely on a single compensatory strategy. It combines

several processes—voicing-devoicing, partial velarization, assimilation, and syllable reduction—all of which occur alternately. This pattern suggests that the DC4 speech production system is in transition. Some control mechanisms are beginning to form, but they are not yet fully stable.

a. Switched voicing and devoicing

Voicing and devoicing in DC4 also fluctuate. In the example, the word *dapur* 'kitchen' becomes [tapə] (devoicing), while the word *tali* 'rope' is pronounced [dali] (voicing). This alternation between voicing and devoicing causes DC4 glottal timing to feel very fluctuating. Phonetically, several things are visible: the synchronization between vocal fold activation and air release is not yet mature, the laryngeal configuration is difficult to maintain from one token to the next, and reliance on auditory feedback is still limited to checking $\pm$ voice features.

Unlike DC2, which tends to consistently devoicing, DC4 alternates between voicing and devoicing. This indicates that DC4's laryngeal control is more developed, but not yet automatic.

b. Partial velarization

Partial velarization also occurs in DC4, such as when pronouncing the word "tas" 'bag' as [takə] or [təjkə]. Sometimes DC4 follows the pattern of DC1 by shifting the articulation of /t/ dorsally. However, unlike DC1, which consistently velarizes, DC4 velarizes only in certain cases. Often, some of the target structure is still maintained (e.g., the vowel is still correct), and the effort to maintain coronal features has not yet fully stabilized. Thus, DC4 is in the transition stage from a dorsal to a coronal strategy, with articulatory control starting to improve but not yet consistent.

c. Homorganic assimilation

Homorganic assimilation can also be seen when DC4 pronounces "tape" 'cassava tape' as [tabə]. In this case, the nasal/bilabial consonant influences /p/ or /t/, which in this case indicates a process of homorganic assimilation.

Phonologically and phonetically, this phenomenon indicates simpler articulatory movements. This means that DC4 tends to maintain one articulatory configuration longer and appears to have difficulty controlling rapid transitions between different places of articulation. This assimilation is local and contextual, so it is not a primary strategy, but it adds to the pattern diversity in DC4.

d. Final syllable reduction

The final syllable reduction event in the word "tanya" 'ask' to [ta] occurs because speakers have difficulty maintaining the segmental coda. Syllable-final segments are often lost because production focuses more on the onset and core of the vowel, articulatory control in the final phase is weak, and speakers tend to favor rhythmic fluency over syllable complexity. Ultimately, the open syllable (CV) structure remains the most stable pattern in DC4.

In general, DC4 shows: (1) high phonological variation and inter-token inconsistency, (2) variable voicing-devoicing because the glottal timing is still unstable, (3) partial velarization as a remnant of the dorsal strategy, (4) homorganic assimilation for motor efficiency, and (5) coda reduction to simplify syllable structure. It can be said that DC4 truly reflects a transitional phase in the speech development of deaf speakers. Motoric and phonological control are starting to develop, but are not yet fully integrated.

DC5 – Dominant Glottalization, Excessive Voicing, and Deletion

DC5 had the most extreme speech production pattern compared to other informants, particularly regarding stop consonants. Almost all of DC5's utterances were dominated by laryngeal mechanisms—glottalization and excessive voicing—plus the omission of oral segments when controlling the free supralaryngeal articulators. Essentially, DC5 shifted the center of speech control to the larynx, rather than the oral cavity.

a. Strong glottalization as a primary strategy

Glottalization is a key strategy for DC5. This can be seen in the pronunciation of the word "tas" 'bag' as [taʔ], and the word "tape" 'cassava tape' as [taʔəh]. In this case, the glottal stop [ʔ] appears in place of the oral stop. From a phonetic-articulatory perspective, the glottis is easier to control than closing the mouth (for example, between the tongue and the alveolum). Glottalization also provides strong kinesthetic feedback—a sensation of pressure in the larynx—and DC5 ultimately relies on its most stable motor mechanism, especially when hearing is limited.

b. Voicing /t/ → /d/

Voicing in DC5 also changes; /t/ often becomes /d/. This can be seen in the pronunciation of the word "tanda" 'sign' [danda], or the word "tali" 'rope' [dali]. DC5 tends to overvoicing, so the vocal folds are over-activated, even in positions that should be voiceless. This happens because laryngeal activation occurs too early and lasts too long, the vibrational sensation in the neck becomes the primary articulation key, and DC5 has difficulty precisely timing the glottis opening.

c. Initial consonant omission

Sometimes DC5 directly drops the initial consonant. For example, the word "tisu" 'tissue' is pronounced as [isu] or [igu]. DC5 chooses to drop the initial stop consonant. Phonologically, this shows how vulnerable dental/alveolar stop consonants are, which causes the vowel to become the main support for speech rhythm, and there is a simplification strategy to maintain fluency. Deletion in DC5 is not just an occasional mispronunciation, but it is a systematic strategy when the oral mechanism is not functioning.

d. Nasalization spreads to the vowels

In DC5, nasalization extends to the next vowel, for example, in the word "tanab" 'land', where it is pronounced [danə]. Nasalization from consonant to vowel indicates poor velopharyngeal coordination. Sometimes the velum doesn't close completely, or closes too slowly, so airflow into the nose lasts longer than

it should, and the nasal configuration becomes a default, difficult-to-deactivate configuration.

In general, DC5 has the following main characteristics: (1) glottalization replacing stop consonants, (2) excessive voicing due to the dominance of laryngeal vibration, (3) systematic deletion when oral control falls, and (4) widespread nasalization due to fragile velopharyngeal coordination. DC5 is an example of a deaf speaker who relies heavily on laryngeal control, with laryngeal motor stability taking precedence over oral phonological accuracy.

DC6 – High Segment Deletion, Glottalization, and Syllable Structure Reduction

DC6 is the most "extreme" informant in terms of sound reduction. DC6's speech tends to lose many segments, often replacing stop consonants with glottal stops, and its syllable structure is simplified to the point of being completely minimal. This clearly shows that DC6's articulatory control is very limited, both above and around the larynx. These speakers prefer to sacrifice phonological structure in order to continue speaking.

a. Massive deletion at the beginning and middle positions

Segmental omissions, especially at the beginning and middle of words, frequently occur in DC6. For example, the word "tisu" 'tisu' becomes [igu], the word "tirai" 'curtain' changes to [la ab]. Segments in onset and medial positions, especially oral stop consonants such as dentals or alveolars, are frequently omitted. From an articulatory perspective, this is due to DC6's difficulty maintaining precise oral closure. The vocal flow is more dominant in DC6, as this is easiest for him, and coordination between air pressure and articulatory release often fails.

b. Mixed Glottalization as a Substitute for Oral Obstruction

Glottalization in DC6 is seen in the word "tas" 'bag', which is pronounced as [aʔ]. The glottal stop [ʔ] appears as a partial replacement for the sound when oral closure is not possible. This situation is different from DC5, which

consistently uses glottalization. DC6 uses the glottal unstable, sometimes appearing, sometimes not, often only as a residual inhibitory mechanism to mark the speech boundary. This indicates that DC6's laryngeal control is still weak, glottalization is not yet a primary strategy.

c. Syllable simplification

Syllable structure is also often simplified. Many word realizations ultimately become only VC, unstable VCV, and sometimes even just V. This pattern clearly indicates that the CV structure that underpins the phonotactics of the target language cannot be maintained. Phonologically, onset is no longer mandatory, the vowel becomes the center of production, and word structure is simplified, with almost no other components remaining.

d. Voicing and devoicing occur randomly

Voicing and devoicing in DC6 also appear randomly, without a pattern. Sometimes the sound is voiced, sometimes not, without any predictable pattern. This means that glottal timing control is very weak—vocal fold activation is inconsistent, and the voicing feature no longer serves as a stable phonological contrast at all. In contrast to DC2, which consistently devoices, or DC5, which actually overvoices, DC6's voicing appears as a side effect of production. It can be said that DC6 is characterized by massive deletions at the onset and medial, mixed and inconsistent glottalization, a completely simplified syllable structure, plus random voicing and devoicing due to very limited laryngeal control.

Comparison of Results for Each Informant

The analysis showed that although all informants produced the same targets (/t/ and /d/), the phonological strategies used varied significantly. This variation reflects differences in levels of articulatory control, motor preferences, and sources of feedback (proprioceptive vs. laryngeal vs. vocalic).

Informant	Main Features	Phonetic–Phonological Interpretation

DC1	Velarization & nasalization	Dorsal articulation dominance and weak velopharyngeal control
DC2	Schwa & nasal epenthesis	Strong vocal orientation for rhythm stabilization
DC3	/l/ substitution	Shift of sound class to a lateral that is easier to produce
DC4	Closest to target	Articulatory control is relatively more mature but fluctuating.
DC5	Voicing /t/ → /d/	High dependence on laryngeal vibration (overvoicing)
DC6	Strong glottalization	Extreme reduction and substitution to the laryngeal mechanism

G. CONCLUSION

From the analysis of the production of dental sounds /t/ and /d/ after vowels /a/ and /i/ in six deaf children, it is clear that hearing loss has a significant impact on the stability of articulation, the way they organize their place of articulation, and the accuracy of segmental features. These children, in general, rely more on feedback from bodily sensations (tactile-proprioceptive) than on auditory control. As a result, they form sound patterns that are consistent, but still different from the norm of normal speakers.

The most striking finding was the substitution of place of articulation. Many of them replaced dental or alveolar sounds with velar, labial, and even alveopalatal consonants. In DC5 and DC6, glottal stops also appeared, indicating they tended to choose articulation strategies that were

physically easier for them. Epenthesis, or the addition of schwa vowels and syllables, frequently appeared in DC2 and DC3. These results indicate that they needed extra time or "help" to stabilize the syllable structure before pronouncing dental stops.

Another finding of this study is the presence of assimilation and metathesis processes. Some children tend to simplify pronunciation by shifting /t/ or /d/ toward the nasal or velar, especially when the surrounding sounds are similar. Meanwhile, variations in voicing and devoicing, such as /t/ changing to /d/ or vice versa, frequently occur in DC5 and DC6. This indicates weak control of laryngeal features, especially without access to vocal feedback.

Segmental omissions are also common, for example in words like tissue, curtain, and value. In these cases, stop consonants at the beginning of words are most often lost, especially when articulation coordination is less stable.

Comparing the informants, DC1, DC2, and DC3 predominantly used velar substitution and epenthesis patterns. Meanwhile, DC4, DC5, and DC6 displayed a wider variety of articulations, ranging from glottalization and devoicing to segment omission. These patterns suggest that the greater their reliance on non-auditory mechanisms, the greater the likelihood of

pronunciations that are further from the phonetic target.

This study confirms that dental sound production in deaf children is not solely influenced by motor-articulatory factors. The compensatory strategies they develop to address the lack of auditory feedback also play a crucial role. These findings could provide a strong foundation for the development of multimodal phonetic interventions, ranging from articulation visualization, tactile vibration, to air pressure coordination training, to improve the accuracy of dental sound production in deaf children.

CONFLICT OF INTEREST

The author declares that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

FUNDING

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

BIBLIOGRAPHY

- Abbas, N. H., Mustafa, M., & Zulitrah, Z. (2024). Pengaruh penerapan metode audiolingual dalam meningkatkan kemampuan artikulasi huruf konsonan siswa tunarungu di SLB Arnadya. *Jurnal Inovasi Pedagogik dan Teknologi*, 2(2), 12–19.
- Andini, M., & Pratama, Y. (2021). Produksi bunyi obstruen oleh peserta didik tunarungu: Analisis akustik. *Jurnal Kajian Fonetik*, 6(1), 34–48.
- Andini, R., & Pratama, D. (2021). Acoustic characteristics of stop consonants produced by Indonesian deaf students. *Jurnal Linguistik Indonesia*, 39(1), 45–60.
- Andriyan Verrysaputro, E., Fitriana, T. R., & Utami, T. (2023). Analisis konstruk sintaktik bahasa Jawa pada anak tuna rungu wicara (disphasia) di Yayasan Rehabilitasi Tuna Rungu Wicara Surakarta. *Fonologi: Jurnal Ilmuan Bahasa dan Sastra Inggris*, 1(4), 242–250. <https://doi.org/10.61132/fonologi.v1i4.326>
- Anggraeini. (2023). Speech production in English by students with hearing impairment: An acoustic phonetic approach. *Lire Journal (Journal of Linguistics and Literature)*, 7(1), 56–71. <https://www.researchgate.net/publication/369060372>
- Angelocci, A. A., Kopp, G. A., & Holbrook, A. (1964). The vowel formants of deaf and normal-hearing boys. *Journal of Speech and Hearing Disorders*, 29(2), 156–170.
- Carol, A., & rekan. (2023). An early intervention program to optimize articulation skills in deaf children who experience speech delays. *Journal of Education and Special Development*, 2(1).

- Casoojee, A., & rekan. (2025). Communication outcomes of children with hearing loss: A comparative study on intervention approaches. *Audiology Research*, 15(2), 27. MDPI.
- Dewi, M. F., Saddhono, K., & Suryanto, E. (2026). Gastro-toponymy perspective of Jenang at the Tingkeban tradition in Karanganom Village, Trenggalek Regency, East Java, Indonesia. *Food Research*, 10(2), 275-284.
- Elhakeem, E. S., Elmaghraby, R. M., & Ibrahim, S. M. (2023). Objective measurement of prosodic features of speech of hearing-impaired Egyptian children with cochlear implants. *The Egyptian Journal of Otolaryngology*, 39, Article 41.
- Farquharson, K., & Apuzzo, M. (2022). Auditory experience and speech sound production growth: Relationships among speech perception, production, language, hearing loss, and age in children with impaired hearing. *Journal of Speech, Language, and Hearing Research*, 65(5), 1437–1450.
- Haraguchi, S. (2019). *Articulatory variability in deaf speakers: A phonetic and phonological perspective*. Tokyo University Press.
- Herdianty, R. S. (2024). *Strategi pembelajaran berbasis linguistik dalam meningkatkan kemampuan artikulasi anak dengan hambatan pendengaran* (Doctoral dissertation, Universitas Pendidikan Indonesia). UPI Repository. <https://repository.upi.edu>
- Jarollahi, F., Fallahnezhad, T., & Aslibeigi, F. (2025). The effect of sign language on the language development of deaf and hard-of-hearing children: A systematic review. *Journal of Modern Rehabilitation*, 19(4), 346–357.
- Kusumaningsih, D., Saddhono, K., Rahayu, N. T., Hanafi, H., Saputra, A. D., & Murtini, D. M. (2024). Refining Contextually Vulgar Word Choices in the Lyrics of Campursari Song "Gubug Asmoro": A Semiotic Analysis. *Theory and Practice in Language Studies*, 14(4), 1142-1150.
- Kent, R., & Read, C. (2015). *The acoustic analysis of speech* (3rd ed.). Cengage Learning.
- Ladefoged, P., & Johnson, K. (2015). *A course in phonetics* (7th ed.). Cengage Learning.
- Lee, J. (2017). Articulatory strategies and proprioceptive compensation in deaf speech production. *Journal of Deaf Studies and Deaf Education*, 22(4), 456–470.
- Lestari, D. (2022). Transisi formant vokal tinggi pada ujaran anak tunarungu. *Jurnal Fonologi Nusantara*, 4(2), 77–90.
- Lestari, M. (2022). Articulatory patterns of deaf children in Indonesian special schools. *Jurnal Pendidikan Khusus*, 18(2), 101–115.
- Lighterink, M., & Geurts, B. (2024). Consonant articulation accuracy in paediatric cochlear implant users. *International Journal of Speech-Language Pathology*, 26(2).
- Ling, D. (1976). *Speech and the hearing-impaired child: Theory and practice*. Alexander Graham Bell Association for the Deaf.
- Majorano, M., & rekan. (2025). A quantitative and qualitative analysis of the phonetic features influencing speech intelligibility in children with cochlear implants. *Disabilities*, 15(4), 81. MDPI.
- Mareta. (2018). Analisis pelafalan bunyi segmental pada siswa tunarungu SMPLB B SLBN 7 Jakarta. *AKSIS: Jurnal Pendidikan Bahasa dan Sastra Indonesia*, 2(2). <https://journal.unj.ac.id/unj/index.php/aksis/article/view/9548>
- Maspupah, E. (2024). Leveraging visual media to improve articulation skills in deaf children: A qualitative study. *Al-Athfaal Journal*, 7(2).
- Monsen, R. B. (1976). Normal and reduced phonological space: The production of English vowels by deaf adolescents. *Journal of Phonetics*, 4, 189–198.
- Mukhibun, A., & Saddhono, K. (2023). The Indonesian Confix/Pe-+an/in Thammasat University Student Descriptive Text: Allomorph, Usage, and Grammatical Meaning. *Aksis: Jurnal Pendidikan Bahasa dan Sastra Indonesia*, 7(2), 117-127.
- Nagari, N. G. S., Ngayuningtyas, P., & Zusfindhana, I. H. (2024). Pengaruh metode phonetic placement untuk kemampuan artikulasi konsonan velar/dorsovelar (k) anak disabilitas rungu ringan kelas VI di SLB Negeri Patrang. *JOEAI (Journal of Education and Instruction)*, 7(2). <https://doi.org/10.31539/joeai.v7i2.12530>
- Nurfazrianty, et al. (2025). *Penerapan program pengembangan komunikasi persepsi bunyi dan irama terhadap peningkatan kemampuan mengucapkan huruf konsonan dental /D/N/T/ pada anak tunarungu* (Thesis, Universitas Pendidikan Indonesia). <https://repository.upi.edu/136532/>

- Osberger, M. J., & McGarr, N. S. (1982). Speech production characteristics of the hearing impaired. In N. Lass (Ed.), *Speech and language: Advances in basic research and practice* (Vol. 7, pp. 221–283). Academic Press.
- Perkell, J. (2012). Movement goals and feedback in speech production: A neurophonetic approach. *Journal of Neurolinguistics*, 25(5), 383–406.
- Porcar-Gozalbo, N., López-Zamora, M., Valles-González, B., & Cano-Villagrasa, A. (2024). Impact of hearing loss type on linguistic development in children: A cross-sectional study. *Audiology Research*, 14(6), 1014–1027. MDPI.
- Purwanto, A., & rekan. (2024). Learning of spoken language for deaf children with reflective maternal method. *Diajar Journal*, 3(3).
- Puspitasari, A. S. D., Setyaningsih, A. O., Imani, A. N., Handayani, D. A. P., Utama, S. S., Saddhono, K., & Barroso, U. (2023). Indonesian Spelling for Village Officials in Donorojo Village, Magelang Regency. *Pengabdian: Jurnal Abdimas*, 1(4), 202-209.
- Rahmadhani, D., & Martias, Z. (2023). Improving pronunciation of alveolar consonants /r/ and /n/ in deaf children using the phonetic placement method. *Jurnal Pendidikan Tambusai*, 7(1), 1111–1116. <https://doi.org/10.31004/jptam.v7i1.5396>
- Rahmawati, A. (2020). Articulation errors in deaf students: A study of speech organ functionality. *Jurnal Linguistik Terapan Indonesia*, 2(1), 45–57.
- Rahmawati, S. (2020). High vowel production in deaf students. *Jurnal Pendidikan Khusus Indonesia*, 5(1), 23–34.
- Roohparvar, R., Karimabadi, M., Ghahari, S., & Mirzaee, M. (2024). Acoustic comparison of fricatives and affricates in Persian-speaking children with cochlear implants. *Audiology & Vestibular Research*.
- Rosidah, M. A., & Febriani, I. (2021). Phonological disorders in deaf children at SLB AB Kemala Bhayangkari 2 Gresik. *Artikulasi: Jurnal Pendidikan Bahasa dan Sastra Indonesia*, 1(2).
- Saddhono, K., & Hartanto, W. (2021). A dialect geography in Yogyakarta-Surakarta isolect in Wedi District: An examination of permutation and phonological dialectometry as an endeavor to preserve Javanese language in Indonesia. *Heliyon*, 7(7).
- Sari, D. (2018). Stop consonant production in deaf children. *Jurnal Linguistik Terapan*, 12(2), 89–98.
- Sari, N. P. (2018). Stop consonant production in deaf children at SLB X. *Jurnal Pendidikan Khusus*, 14(2), 122–131.
- Smith, C. R. (1975). Residual hearing and speech production in deaf individuals. *Journal of Speech and Hearing Research*, 18(4), 795–811.
- Sreekumar, S. P., Susheel, S. C., & Shameer, S. (2024). Speech sound errors in adolescents with congenital hearing loss. *World Journal of Advanced Research and Reviews*, 24(1), 202–211.
- Subihah, et al. (2024). Analisis gangguan berbahasa pada penyandang tunarungu. *Jurnal Bastaka (BJT)*, 7(1). <https://jurnal.pbsi.uniba-bpn.ac.id/index.php/BASATAKA/article/view/425>
- Sugden, E., & Cleland, J. (2022). Using ultrasound tongue imaging to support phonetic transcription of childhood speech sound disorders. *Clinical Linguistics & Phonetics*, 36(2), 129–149.
- Waldstein, R. S. (1990). Effects of postlingual hearing loss on speech production: Implications for auditory feedback. *Journal of the Acoustical Society of America*, 88(5), 2099–2114.
- Wermke, K. (2025). Melodic and articulatory development in deaf infants: Long-term observational evidence. *Scientific Reports*. Springer Nature.