ISSN 1798-4769
Journal of Language Teaching and Research, Vol. 16, No. 5, pp. 1537-1544, September 2025
DOI: https://doi.org/10.17507/jltr.1605.10

The Impact of Articulatory Organs and Acoustic Features on Shaping the Distinctive Features of Emphatic Closure Sounds

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***Abstract*—Emphasis is considered a strong feature of some sounds that distinguishes them from others. Ancient and modern Arab linguists agree that emphasis is an inherent feature of the four sounds (ص /sˤ/, ض /ðˤ/, ط /tˤ/, and ظ /ðˤ/. However, emphasis in these sounds does not occur at the same degree, as the articulatory organs for each sound differ from the others. Additionally, other sound features affect the degree and type of emphasis. This study examines the factors influencing the degree and type of emphatic consonants, which are related to the articulatory organs of the sound or the sound's features. The study uses a descriptive-explanatory approach to describe the articulatory organs of these sounds, their phonetic features, and their impact on emphasis, exploring the requirements of emphasis. The study's results revealed that the emphasis on the sounds ض and ط is explosive and non-continuous, with a high resonance due to the explosion, while the emphasis in ص and ظ is continuous due to friction, with a lower resonance. Nonetheless, the sound ص is stronger than ظ in terms of audibility due to the strength of the hissing, making its emphasis more resonant.**

***Index Terms*—articulation, closure, emphatic consonants, explosives, occlusion, organs of articulation**

I. Introduction

Arabic language sounds share some common general features that give them a suitable form in line with the eloquent spoken language inherited from their Arab ancestors (Al-Jezawi et al., 2023; Alkhaldi et al., 2023; Al-Saidat, 2023; Essa et al., 2023; Rababah et al., 2024). However, each sound must have specific features that distinguish it, as it is not reasonable for all sounds to be common in all features and features. Such commonality would lead to complete similarity between all sounds, limiting the language to a few sounds. This study explores the sounds of occlusion (ص، ض، ط، ظ), highlighting the subtle differences in their articulatory organs, general features, and the resulting variations in emphasis type and degree. The International Phonetic Alphabet (IPA) for the Arabic sounds (ص /sˤ/, ض /ðˤ/, ط /tˤ/, and ظ /ðˤ/) is:

- ص (/sˤ/) - Voiceless alveolar emphatic fricative
- ض (/dˤ/) - Voiced alveolar emphatic plosive
- ط (/tˤ/) - Voiceless alveolar emphatic plosive

- ظ (/ðˤ/) - Voiced alveolar emphatic fricative

The significance of the research lies in illustrating the secondary features of emphasis in the sounds ص /sˤ/, ض /ðˤ/, ط /tˤ/, and ظ /ðˤ/ and their respective types. It relies on both articulatory organs and general features, establishing the connection between general and specific features and demonstrating their impact on shaping the distinctive features of each sound.

II. Methods

The study aimed to collect the opinions of ancient and modern Arab linguists and phoneticians, and analyze them relying on the science of articulatory phonetics to discern the distinctive features of each emphasized sound ص /sˤ/, ض /ðˤ/, ط /tˤ/, and ظ /ðˤ/. The research employed a descriptive-explanatory methodology to analyse the data.

III. Literature Review

Al-Aqtash (2010) explored emphasis in terms of concept, terminology, applicable sounds, and the semantic and grammatical value of emphasis. However, he did not provide a detailed analysis of these aspects. Maki's (1996) study delved into the sounds of emphasis, asserting that emphasis is inherent in occlusive sounds but not obligatory for other sounds like /r, ر/ and /l, ل/. It also discussed the emphasis being obligatory for /ل/ in the phrase "الله" if preceded by a fatḥa or ḍamma. In the same vein, Al-Marashi (2008) studied emphasis, its definition, applicable sounds, and the requirements of occlusion and elevation, aligning with this research. However, it did not address the impact of sound features on the degree and type of emphasis, which this study investigates, in addition to their articulatory organs.

Al-Hamd's (1987) study explored emphasis and lenition, emphasizing that elevation is a requirement for emphasis, agreeing with previous scholars. It asserted that the sounds ص /sˤ/, ض /ðˤ/, ط /tˤ/, and ظ /ðˤ/ are inherently emphasized, while ل and ر are not. The study also echoed Al-Marashi's view that the degree of emphasis depends on the degree of occlusion or elevation.

IV. Analysis

A. Emphasis Linguistically and Terminologically

Linguistically, "*Tafkhim*" (emphasis) means magnification and enlargement. It is to magnify or enlarge. A man who is "*fakhm"* (great) is one of great stature (Ibn Manzoor, 1990, p. 449). Technically, tafkhim means "pronouncing a letter with thickness or heaviness, filling the mouth with its resonance," while tarqiq is "pronouncing a letter thinly without filling the mouth with its resonance" (Jabal, 2006, p. 197). Bishr (2000) stated that "tafkhim is an auditory effect resulting from intertwined physiological factors, wherein we perceive two important factors. First, the elevation of the back of the tongue toward the soft palate, causing a change in the oral cavity, creating audible resonance. Second, the retraction of the tongue backward faster than during the pronunciation of light sounds, as if *tafkhim* (emphasis) has two aspects: an organic aspect (the position of the tongue and its surroundings in the mouth) and an auditory aspect with distinctive features. Thus, we can consider two positions for the pronounced sound, its original position accompanied by the second position, which is the tongue's position during pronunciation. For example, the sound of the letter ط /Ṭāʾ/, in its original articulation is classified generally with the sounds of the upper teeth and the gum, and with *tafkhim*, it can be related to the emphatic sounds, attributed to the furthest point of the tongue and the soft palate" (Bishr, 2000, p. 394).

Also, linguistically, "*Tafkhim*" (emphasis) means magnification and amplification. In Arabic, it is stated: "Something is فَخُم (*fakum*), and the female is فَخْمة (*fakhma*), and a man is فَخْم (*fakhm*) with a ḍamma means magnified and a man فَخَّمه (fakh-khamahu) means magnified or dignified" (Ibn Manzoor, 1features, 12/449). Terminologically, emphasis in pronunciation means "uttering a letter thickly or forcefully, filling the mouth with its resonance," while lenition is "uttering a letter thinly without filling the mouth with its resonance" (Jabal, 2006, p. 197).

Bashar (2000) explained that emphasis is an auditory effect resulting from overlapping physiological factors. It involves the elevation of the back of the tongue towards the soft palate, causing a change in the oral cavity and creating audible resonance. The second factor is the rapid retraction of the tongue backward, faster than during the pronunciation of lenited sounds. Thus, emphasis has two aspects: an organic aspect (the position of the tongue and what follows it in the mouth) and an auditory aspect with a distinctive characteristic. Therefore, the emphasized sound can be considered in two positions of pronunciation: its original position, accompanied by the second position, which is the position of the tongue during pronunciation. For example, the sound of "Ṭāʾ" has its original exit classified generally with the sounds of the upper teeth and the gum. With emphasis, it can be attributed to the short sounds, to the utmost of the tongue, and the utmost of the palate" (Bashar, 2000, p. 394).

Al-Hamad (2004) stated that "emphasis is a phonetic quality resulting from the elevation of the back of the tongue to its utmost and its retreat towards the posterior wall of the throat. He explained that there is a correlation between emphasis and these two features (occlusion and elevation)" (Al-Hamad, 2004, p. 210).

From the previous definitions, the following observations can be made:

1. The emphasis is considered from two perspectives:

- An organic aspect resulting from the elevation of the back of the tongue and its retreat backward. This tongue position is crucial for producing emphasis, creating a cavity and space in the mouth that allow the sound to generate the desired resonance and the degree that distinguishes the sound from others.
- An auditory aspect resulting from the organic structure of the mouth created by the tongue's movement backward and upward towards the utmost palate. This produces a thick, resonant sound that differentiates it from other sounds.

2. Emphasis requires an appropriate space for resonance to occur. This space is created when the back of the tongue, its front, and the center are raised and arched, a position referred to as occlusion. Additionally, this space is created when the back of the tongue is raised towards the upper palate, known as elevation.

In other words, both occlusive and elevated sounds are emphatic, but the degree of emphasis differs between them. The emphasis in occlusive sounds is greater than in elevated sounds because the tongue in occlusion rises to its utmost with its front, confining the air in the center. In elevation, the tongue only rises to its utmost, and, consequently, the air is not confined in a cavity as in occlusive sounds.

B. Articulatory Organs for Occlusive Sounds

Ancient and modern Arab scholars agreed that the occlusive sounds are (ص، ض، ط، ظ). Occlusion means that the back of the tongue is raised towards the corresponding upper palate, and the front of the tongue is raised with an arched center, taking the form of a dish (Sibawayh, 1988, p. 436). The occlusive sounds differ in their articulatory organs, as the shape of the tongue varies when pronouncing each sound, in addition to general and specific features:

(a). The Sound صṣād

It is a distinctive sound in Arabic, characterized by a bell-like resonance. Regarding its articulation, Anis (1980) stated, "When pronouncing ṣād, the tongue takes a position opposite to its position with س /sīn/. The tongue is arched and occluded against the upper palate, with the utmost part of the tongue ascending and its tip towards the palate, like all occlusive sounds" (Anis, 1980, p. 69).

Jabal (2006) pointed out, "With ṣād, the breath is expelled without vibration, the utmost of the tongue ascends, its center is arched, and its front also rises, creating a cavity where the palate acts as a dish. This enhances the hissing and emphasizes it. It is muted, soft, occluded, elevated, and silent" (Jabal, 2006, p. 125). From the previous statements, it is evident that the articulation of ṣād relies on the shape of the tongue, which forms a dish in its center when it ascends upwards with its arching. This articulatory configuration undoubtedly produces emphasis. It is known that emphasis requires a void and cavity, and the higher the void and cavity, the greater the degree of emphasis. Examining the sound of ṣād, we find that the tip of the tongue rises to the front of the palate without touching the teeth, meaning that the void and cavity extend from the utmost palate to the front of the palate. This extended space is what produces the distinctive resonance of ṣād, in addition to other features like hissing, which will be discussed separately.

The air carrying vibrations and frequencies, when it reaches the oral cavity, encounters an obstruction resulting from the elevation of the back of the tongue towards the upper palate. This obstruction has the effect of limiting the flow of air toward the dish, which is responsible for creating phonetic emphasis. Once the air fills the concavity occurring in the center of the tongue, it continues its path toward the second obstructive region, which serves the function of filtering the air exiting the mouth and reducing its speed. This process allows the creation of suitable emphasis in the cavity formed in the center of the tongue and the corresponding upper palate.

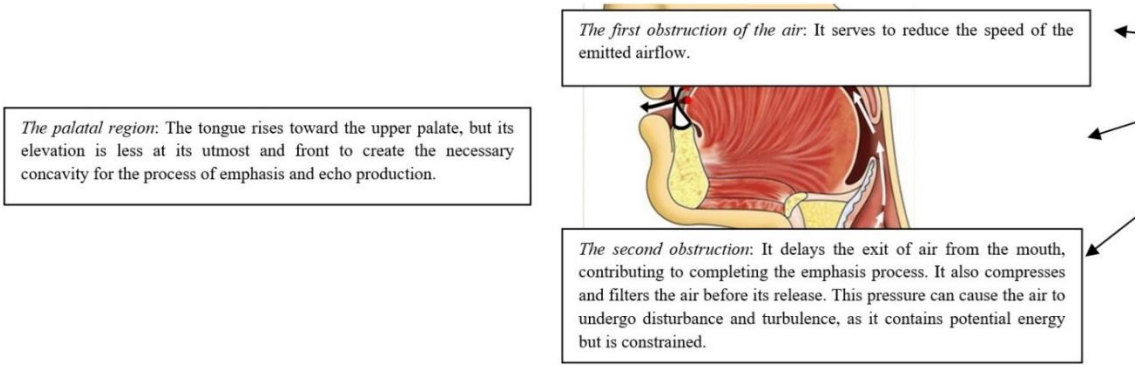

Figure 1. The Articulation of the Sound ص ṣād

(b). The Sound "Dhad" ض

The sound of "Dhad" ض /ðˤ/ is distinctive in the Arabic language, so it is called the language of "Dhad" as it is a sound unique to Arabic pronunciation, distinguishing its speakers. This sound has been a major concern for scholars due to the evolution that has made its pronunciation different from before. Regarding its recent pronunciation, Anis (1980) described it as a strong, voiced sound where the vocal cords vibrate and the air is trapped when the tongue tip meets the

upper palate. When the tongue separates from the palate, we hear an explosive sound, which is the "Dhad," as pronounced in Egypt (Anis, 1980, p. 51).

Brosnahan and Malmberg (1975) pointed out that, "Dhad ض /ðˤ/ starts from the exit of the sound د /Dāl/, and the tongue takes its concave shape, closure to the upper palate, to form Dhad." Al-Sa'ran (1988) stated, "The voiced counterpart of ط Tā' is Dhad. There is no difference between Dhad ض /ðˤ/ and ط Tā', except that the former is voiced and the latter is voiceless. There is also no difference between Dhad and Dāl, except that Dhad is 'closured,' and Dāl has no closure. Therefore, Dhad is a silent, voiced, dental, closure explosive" (Brosnahan & Malmberg, 1975).

From the above statements, it becomes evident that, in modern pronunciation, Dhad is produced with the elevation of the edges of the tongue and their closure to the upper teeth, creating a closed area that prevents air from escaping. The tongue is concave in the middle, preserving the airflow formed by the flow and leakage outside the oral cavity. The air remains confined in the palatal area, leading to the emphasis on the sound. This process of air containment necessarily results in emphasizing the sound, as the confinement precedes the explosion, making the explosion more resonant when the release occurs.

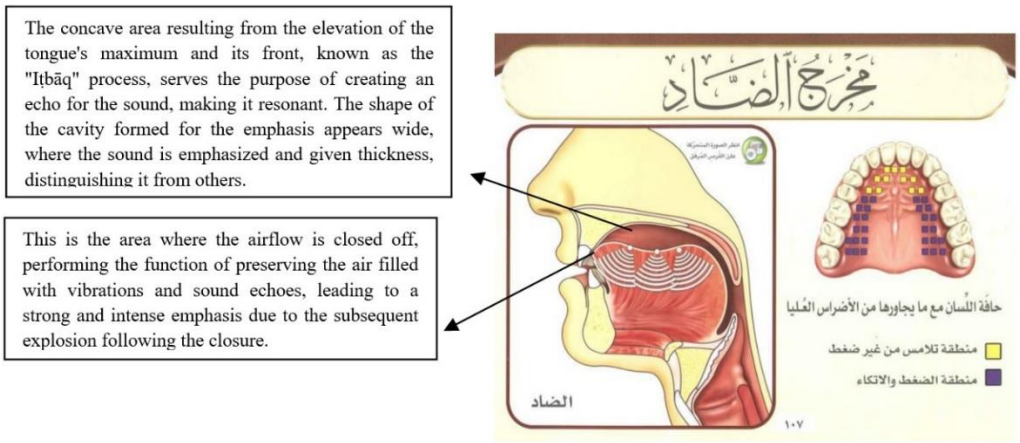

Figure 2. The Articulation of the Sound "Dhad" ض

(c). The Sound ط/Ṭāʾ/

The pronunciation of the sound ط /Ṭāʾ/ was described by Jibal (2006, p. 120) as follows: "It is produced by the meeting of the front and tip of the tongue with the roots of the upper incisors, the gums, and the upper surface of the palate. This occurs with the elevation of the tongue's maximum and the curvature of its center because it is a raised, closure sound. The sensation of its pronunciation encompasses the entire tongue".

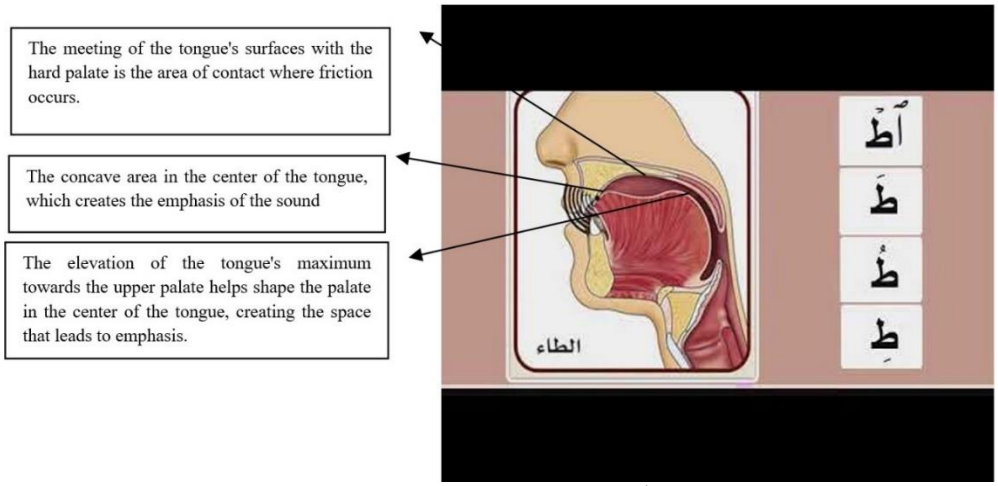

Figure 3. The Articulation of the Sound ط /Ṭāʾ/

As observed in the figure, the cavity formed for emphasis in the center of the tongue and the upper palate has taken on a somewhat flattened extension. This is in contrast to the cavity in the sound of ض /Ḍād/. The elongated shape in ط /Ṭāʾ/ occurs because its pronunciation requires the tip of the tongue to extend slightly more forward than in the sound of Dhad "Ḍād," despite both being explosive sounds. Therefore, this cavity in the sound of "Ṭāʾ" contributes to the formation of an emphasis that is different from others. It is characterized by being less thick than "Ḍād," but the explosion that follows increases its strength, making the emphasis powerful but not thick. By thickness, we refer to the high resonance.

(d). The Sound ظ /ðˤ/

Bishr (2000) stated that "The tongue, with ظ /ðˤ/, rises backward toward the upper palate as it slightly retracts, causing emphasis (emphatic sound), as is the case in pronouncing Ṣād and Ḍād" (p. 299). Likewise, Jabal (2006) pointed out that "With ظ /ðˤ/, air passes between the vocal cords as a buzzing sound until it reaches the first cavity of the mouth. The maximum of the tongue rises, its center concaves, and its tip extends between the upper and lower incisors. The air passes between the sides of the tongue and between it and the teeth" (Jabal, 2006, p. 128).

From the above statements, it is evident that the sound of ظ /ðˤ/ shares with other emphatic sounds the elevation of the back and front of the tongue, along with the curvature of its center. However, it differs in that the tip of the tongue extends between the upper and lower incisors, causing audible friction when pronounced, as illustrated in Figure 3.

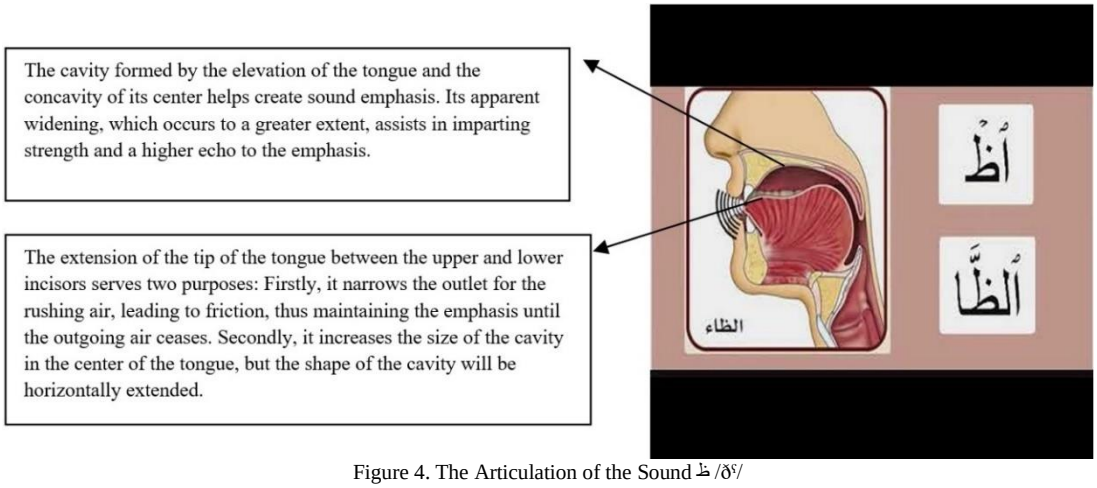

Figure 4. The Articulation of the Sound ظ /ðˤ/

C. The Effect of Acoustic Features on the Emphasis of Affricates

(a). The Sound Sad (ص)

The sound Sad is characterized by whispering, meaning that air is forcefully propelled without encountering any obstruction before the oral cavity. This forceful propulsion contributes to emphasizing the sound because the air particles are in an excited state due to the high speed until they reach the region of the upper palate, where they are intercepted and compressed in the alveolar region. In addition, Sad is characterized by laxity, meaning there is no air obstruction during sound articulation. The term "laxity" implies that the air remains continuous in its exit path without interruption. This continuous flow is referred to as a continuous sound, contributing to making the emphasis more audible. If the air were not continuous in its exit, it would lead to the confinement of air particles carrying the intensified tone, resulting in less forceful emphasis. However, laxity is considered a weakness for the sound, as no air obstruction occurs, depriving the sound of the sonic burst that achieves the highest levels of auditory strength.

The sound Sad is also characterized by hissing. Brosnahan and Malmberg (1975) stated, "Because the sound is distinctly clear in hearing due to the intense friction in the outlet, a truthful description for three affricates: the sound 'Seen' (س), Zay (ز), and Sad (ص)." This characteristic imparts additional strength to the sound, making it more audible. Sad differs from other hissing sounds (س, ز) in that it is an explosive sound. The explosion contributes to giving the hissing a noticeable resonance, making Sad's emphasis resonant.

Additionally, the sound Sad is characterized by stoppages. Stoppages imply that the sound exits with weight. Ibn Duraid (1987, p. 45) explained, "Al-Akhfash says: The letters were named 'Muthlaqah' because their action is at the tip of the tongue, and the tip of everything is 'muthlaqah' (smooth or slippery). They are the lightest letters and the best at mingling with others. The others were named 'musamata' because they had fallen silent and specialized in structure when their letters increased to avoid sticking to the tongue." Sad is a silent sound that is not easily emitted. In contrast to the sounds referred to as "muthlaqah," which are (ب, ل, ن, م, ر, ف), the sound 'Sad' being a silent sound means it exits with weight, requiring effort to be emitted. This makes the emphasis in Sad a heavy emphasis.

In conclusion, the emphasis on Sad can be described as continuous, audible due to hissing, and heavy due to stoppages. The sound of Sad is distinguished by four strength attributes: "Itbaq" (إطباق - closure), "Ismat" (إصمات - stoppages), "Istila'ah" (استعلاء - elevation), and "Siffir" (صفير - hissing).

(b). The Sound Dhad" ض /ðˤ/

The sound Dhad ض /ðˤ/ is characterized by voicing, where the vocal cords vibrate during its pronunciation. This vibration reduces the intensity of the air rushing toward the oral cavity. Voicing strengthens the emphasis because the vibrations generated by the vocal cord oscillation provide additional power to the emphasis. Dhad is also distinguished by an explosion involving complete air confinement at the closure area. When the outlet is closed, the air-carrying

vibrations resulting from vocal cord oscillation is trapped in the alveolar region, filling the space for emphasis. As soon as the outlet opens, the air is forcefully released, creating a powerful and thick emphasis.

Moreover, Dhad is characterized by stoppages. Dhad is not among the sounds that are easily emitted. Arab linguists have coined the term "Dhalaqah" for sounds (ف ر م ن ل ب) because they are easily emitted, requiring less effort than other sounds. Dhad is a heavy sound that requires effort to pronounce, adding substantial weight to the emphasis. Dhad is further characterized by closure. Closure means that the tongue is raised upward with curvature, forming a concave shape, as shown in Figure 3. This concave shape or cavity gives the sound greater strength, resulting in a resonant and highly frequented sound.

(c). The Sound Taa (ط)

The sound Taa (ط) /tˤ/ is characterized by voicing, where the vocal cords vibrate during its pronunciation, contributing to its additional strength. Vibrations start forcefully from the vocal cord area, generating oscillations and an indistinct bell sound. These vibrations then move to the emphasis area in the middle of the tongue and the upper palate, increasing power and thickness, resulting in a stronger emphasis. The sound Taa is marked by an explosion, where air is confined when the tip of the tongue meets the hard palate. When the exit is closed, an explosion occurs rapidly as the air is released, producing a loud sound. This explosion only happens if it occurs quickly, making the emphasis powerful but brief, ending rapidly with the conclusion of the explosion.

Taa is also characterized by stoppages, requiring effort to be pronounced. Stoppages make the emphasis seem heavy, and this effort results from the maximum elevation of the tongue and its front towards the upper palate, with curvature in its middle, and the meeting of the tongue's front with the gums. All of these aspects require effort. The sound Taa is distinguished by the tongue taking the shape of a concave, which plays a vital role in creating emphasis. However, the concave shape or cavity differs in these sounds. In Taa, its shape extends forward more, with less curvature. The reason is that the tip of the tongue extends forward more in Taa than in Dhad. This means that the concave shape here is horizontally wider.

(d). The Sound Dhaa (ظ) /ðˤ/

The sound Dhaa ظ /ðˤ/ is characterized by voicing. Voicing is a strong feature of the sound, so the emphasis on the sound of Dhaa gains energy and strength, making it distinctive. Frequencies originate from the vocal cords and resonate in the oral cavity, increasing the effect of emphasis and providing additional strength. The sound Dhaa is distinguished by friction because the extension of the tongue between the upper and lower molars does not completely close the exit. Instead, it narrows it in front of the rushing air from the emphasis area. This friction carries with it the sound frequencies and their high pitch, a result of two strong features: voicing and emphasis. Both features complement each other to produce this distinctive bell sound. Following the friction is the closure that gives the emphasis the characteristic of continuity, as the emphasis only ends when the airflow from the narrow exit ceases.

Dhaa is also characterized by stoppages, as the articulatory processes involved in its pronunciation require effort. The maximum elevation of the tongue, its curvature, and the extension of its tip between the upper and lower molars all involve movements that require effort, giving the emphasis a heavy appearance. The sound Dhaa features closure, similar to the previous sounds. However, the shape of the concave differs for this sound. The tip of the tongue extends between the upper and lower molars, meaning that the shape of the concave here is horizontally wider. Dhaa is the only sound among the closure sounds in which the tip of the tongue extends between the upper and lower molars, increasing the cavity space in the mouth. Still, it takes on a more horizontal shape than a curvature. This space strengthens the emphasis.

D. Requirements for Emphasis

Understanding the mechanics of emphasis and the organic structure in the articulated sounds (ص، ض، ط، ظ) required for their production reveals that emphasis necessitates specific articulatory conditions, summarized as follows:

1. *The presence of a cavity or a specific-shaped concave, varying from one sound to another*: The bell sound of emphasis is determined by the shape of this cavity. A larger cavity produces a thicker emphasis, while a smaller one results in a less bell-like emphasis. To achieve this cavity, the tongue, the main organ forming and controlling its size, adopts specific positions in the sounds of closure. These positions can be explained as follows:
   - In Saad (ص), the tip of the tongue rises to the maximum, and its front moves towards the palate, curving its center. The front of the tongue extends forward, approaching the lower molars, allowing air to escape from the lower molars' sides. The air flows freely, creating the necessary friction.
   - In Dhad (ض), the shape of the cavity is similar to that of Saad, but with a difference in that the front of the tongue is closer to the inside than in Saad. This means that the size of the cavity that produces the emphasis is smaller than in Saad. However, this is compensated by the explosion that occurs after the articulators separate. However, it is a rapid emphasis, not continuous like in Saad.
   - In Dhaa (ظ), the tip of the tongue rises to the maximum, and its front moves upwards with a curvature in its center. The extension of the tongue's tip between the upper and lower molars does not close the exit, generating strong friction in the articulation area. This friction carries the sound frequencies and their high

pitch, resulting from the combination of two strong features: voicing and emphasis. Following this is the friction, which gives the emphasis a continuous characteristic. The emphasis only ends when the airflow from the narrow exit ceases.

- In Taa (ط), the tip of the tongue rises to the maximum, and its front moves upwards with a curvature in its center. The meeting of the tongue's tip with the hard palate is a tight closure that blocks the airflow path. An explosion occurs after the articulators separate, creating an explosive emphasis with a high resonance. However, this emphasis ends quickly with the end of the explosion.

2. *Strong features in the sound, such as voicing, hissing, and plosive (explosion)*: Each of these features affects the degree of emphasis. Voicing's strength lies in the oscillation generated in the lungs. Hissing's strength lies in the exit area when air passes through the narrowing area, colliding with the teeth. Plosive or explosion strength lies in the propulsive force of the air after being confined in the closure area. The sounds can be arranged according to the following table:

TABLE 1
PHONETIC FEATURES OF THE EMPHATIC SOUNDS

Sound/ Feature	Hissing	Voicing	Concavity	Stoppages	Hissing	Explosion	Friction
ط		Strong	Thick	Heavy	-	Not Continuous	-
ض		Strong	Thick	Heavy	-	Not Continuous	-
ص	Not Strong	-	Thick	Heavy	Resonant		Continuous
ظ		Strong	Thick	Heavy	-		Continuous

V. CONCLUSION

The present study addressed the articulation feature of velarization in the sounds of Sad ص /sˤ/, Dhad ض /ðˤ/, Taa ط /tˤ/, and Thaa ظ /ðˤ/. It attempted to elucidate the additional features acquired and influenced by two factors: the articulatory mechanisms of the sounds and the general features associated with changes in the structure of airflow and its intensity. The study revealed that velarization in the mentioned sounds varies in shape for each sound. In Sad ص /sˤ/, it appears strong due to hissing, the intensity of airflow towards the articulator, and the absence of any prior obstruction in the articulator, resulting in continuous friction. In Thaa ظ /ðˤ/ the hissing is less intense compared to Sad due to friction with a soft articulator and the voicing resulting from the constriction of the vocal cords, reducing the intensity of airflow toward the articulator. The velarization in Dhad ض /ðˤ/ exhibits thicker hissing compared to Sad and Thaa due to the explosion resulting from the closure of the articulator and the concavity in the mid-tongue region, as well as the heavy voicing. Taa's ط /tˤ/ velarization is strong due to the explosion, thick due to the shape of the cavity in the middle of the mouth, and heavy due to voicing. It was observed that the strongest velarized sound is Taa, followed by Dhad, as both have four strong features. What distinguishes Taa from Dhad is the shape of the cavity formed during velarization, which makes Taa stronger and thicker. Next is Sad, as it possesses three strong features: constriction, voicing, and hissing. Sad is characterized by continuous velarization with a distinct resonance due to hissing. Thaa comes last, being the weakest sound in terms of velarization, as it has three strong features similar to Sad, but Sad is distinguished by the hissing feature, which plays a significant role in giving the sound its audible tonal quality. Both Thaa and Sad exhibit continuous velarization.

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