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AUTOMATIC PROCESSING OF PHONETIC PHENOMENA IN THE HOLY QUR'AN: SURAT AR-RAHMAN AS A MODEL

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Abstract
Recent advancements in Natural Language Processing have made it possible to perform more accurate analyses of sound and rhythm with respect to the Qur'anic Texts. The analysis presented here uses computational methods to examine the phonetic characteristics of the Qur'an. The case study will focus on Surah "Ar-Rahman". Phonetic characteristics revealed through this synthesis of analysis will to include: Stress-loading, Pauses, and Intonation. The preliminary findings provide evidence that computational means can aid in revealing precise locations at which to place pauses during recitation, identifying types of stresses within words, as well as providing intonational patterns. Ultimately, this has helped provide a greater understanding of phonetic and rhythmic structures within the Qur'anic Texts. Furthermore, it will also demonstrate the utility of computational methodologies when preserving and systematically analyzing the phonetic heritage of the Qur'anic Texts.

Keywords: Natural language processing, Arabic language, phonetic phenomena, stress, pause, intonation, the Holy Qur'an, Surah Ar-Rahman.

Introduction

Due to many of the architecture, phonetic structure, and vocabulary associated with the unique way the Arabic language is constructed will continue to be improved by the use of technology, as well as by technological developments that have allowed for increased and advanced linguistic research at all levels of analysis of a language using computer technology. Technological progress in computing has played a crucial role in strengthening the presence of Arabic within the diverse fields of computational linguistics.

Undoubtedly, Arabic is among the languages that have benefited most from the application of computational technologies, as systems and software have been adapted to suit its phonetic, morphological, syntactic, and semantic characteristics. Arab researchers—both linguists and computer scientists—have achieved notable accomplishments, including speech representation and processing, automatic text generation, word analysis and formation, computational sentence parsing and grammatical analysis, as well as the development of electronic dictionaries, terminological databases, tools for correcting linguistic errors, and digital platforms for teaching Arabic.

The evidence that Arabic has been successfully supported using technology to overcome linguistic issues using scientific methodologies to provide effective tools for analysing the Arabic language via technical means includes the ability to analyse, generate, translate and teach Arabic using established systematic criteria combining linguistic and technical aspects of

the language; therefore, the focus of this project is to study the phonetic elements in the Qur'an through a practical case study of Surah Al-Rahman based on stress, intonation and pause.

1. Definition of Sound:

a. Linguistic definition: Ibn Manzur defined it as: "Ṣāṭ, yuṣāṭ, ṣawtbih meaning *to call*; and ṣawt also means *making a sound*" (Ibn Manzur, 2003, p. 302).

b. Technical/terminological definition: Tammam Hassan defines it as: "The auditory effect that produces a continuous vibration, even if its source is not a living sound-producing device. What we hear from wind or string musical instruments is also considered sound, just as the human sense perceives it as sound" (Tammam Hassan, 1979).

Thus, the auditory effect does not necessarily require a living sound source; sounds produced by musical instruments are also included.

2. Phonetic Phenomena

2.1 Stress (Al-Nabr):

a. Linguistic definition: According to *Lisan al-Arab*: "Al-nabr in speech means emphasis or raising. Anything that is elevated is said to be *nabr*. A man described as *nabbār* is eloquent in speech" (Ibn Manzur, 2003, p. 239).

b. Technical/terminological definition: Tammam Hassan defines stress as: "Prominence or emphasis, which is the pressure on a syllable within a word that makes its meaning stand out audibly compared to the surrounding parts" (Tammam Hassan, 1994, p. 170).

Anīs (2010, p. 176) explains that stress involves increased clarity on a part of the word during elevation, depending on the proportion of air expelled from the lungs, and it is not related to pitch or musical tone. In short, stress is a rise in sound determined by the airflow from the lungs.

2.2 Types of Stress (Al-Nabr):

a. Word-level stress: Also called single-word stress, this refers to stress associated with the morphological form of a word: "If a word consists of a single syllable, the stress falls on that syllable" (Al-'Issa, 2011, p. 36). For example, in the word mina, the consonant represents the consonant sound and the vowel represents the vocalic element; the stress is applied to one of its syllables. The purpose of word-level stress is to emphasize meanings such as surprise, disapproval, or other expressive functions. Scholars further classify this type into stress of intensity and stress of duration.

b. Sentence-level stress:"This is stress applied to one of the elements of a sentence—a word—intended to indicate emphasis, interrogation, or exclamation. Sentence stress is the relative emphasis on a word within the sentence, making it the most prominent part of the utterance" (Al-Jalil, 2009, p. 126). It is related to the auditory effect the sentence produces on the listener, reflecting on their perception. This type is considered easier and more effective than word-level stress, as it emphasizes a complete word, whereas word-level stress focuses on a single syllable. Word-level stress does not impart the same rhythmic or psychological effect on the listener as sentence-level stress.

To distinguish stressed syllables, symbols are used to indicate the most prominent part of the stressed segment, as explained by Al-Jalil (2009, p. 126).

Stress Symbols:

- /Λ/indicatesprimary stress
- /-/indicatessecondary stress
- /|/indicatesweak stress

These syllables are determined by the intensity of the sound, where the stressed syllable causes a rise in the musical pitch resulting from the stress, in contrast to other syllables. This

difference can be observed because the stressed syllable typically lasts longer than the other syllables.

2.3 Pausing (Waqf):

A. Linguistically: It is defined as follows: "The letters *wāw* and *qāf* form a single root indicating remaining or staying in something, from which are derived expressions such as *waqaftu* (I stopped), *waqfan* and *wuqūfan* (I paused or stood)" (Fāris, 2003, p. 13).

B. Terminologically:"It is the interruption of the voice on a word, accompanied by a breath, with the intention of resuming recitation—not with the intention of abandoning it. It occurs at the ends of verses or within them, but not in the middle of a word" (Al-Suyūṭī, 2009, p. 89). Thus, *waqf* is a performative act carried out by the reciter to reveal the meanings contained in the word at which the pause occurs; it is a phenomenon no less important than the preceding one.

Types of Waqf:

- **Compulsory (involuntary) pause:** Attributed to an incidental condition affecting the reciter, such as coughing or shortness of breath.
- **Optional pause:** A pause permitted by scholars of Qur'anic recitation, performed by the reciter voluntarily and not due to any external cause (Belqasim, 2003, p. 158).
- **Test pause:** Used to assess whether the reciter masters proper pausing during recitation; it is employed for teaching or examination purposes (Hadi, 2011, p. 229).

Third: Applied Study of Sūrat al-Raḥmān:

Identification of sound samples:

The sound samples are determined through Qur'anic recitation by following the reading of Nāfiʿ according to the narration of Warsh, including stress, intonation, and pausing.

The required samples are then recorded according to the following steps:

- Recording the sound sample as it naturally occurs in everyday linguistic usage.
- Recording the sound sample as recited according to Imam Nāfiʿ in the narration of Warsh, as it represents the ثابت reference against which variations in actual Qur'anic recitation are measured.
- Converting the recorded audio from a CD-ROM into a specific audio file format (wave mode) used for acoustic analysis (S-P).

Part One: Represents the acoustic waveform of the sample, highlighting variations on the vertical axis (i.e., frequency), while time is represented on the horizontal axis in seconds.

Part Two: Represents the spectrographic (spectral) image of the sample sound on a coordinate system, where frequency variation appears on the vertical axis in Hertz (Hz), and time appears on the horizontal axis in seconds.

Model1 :

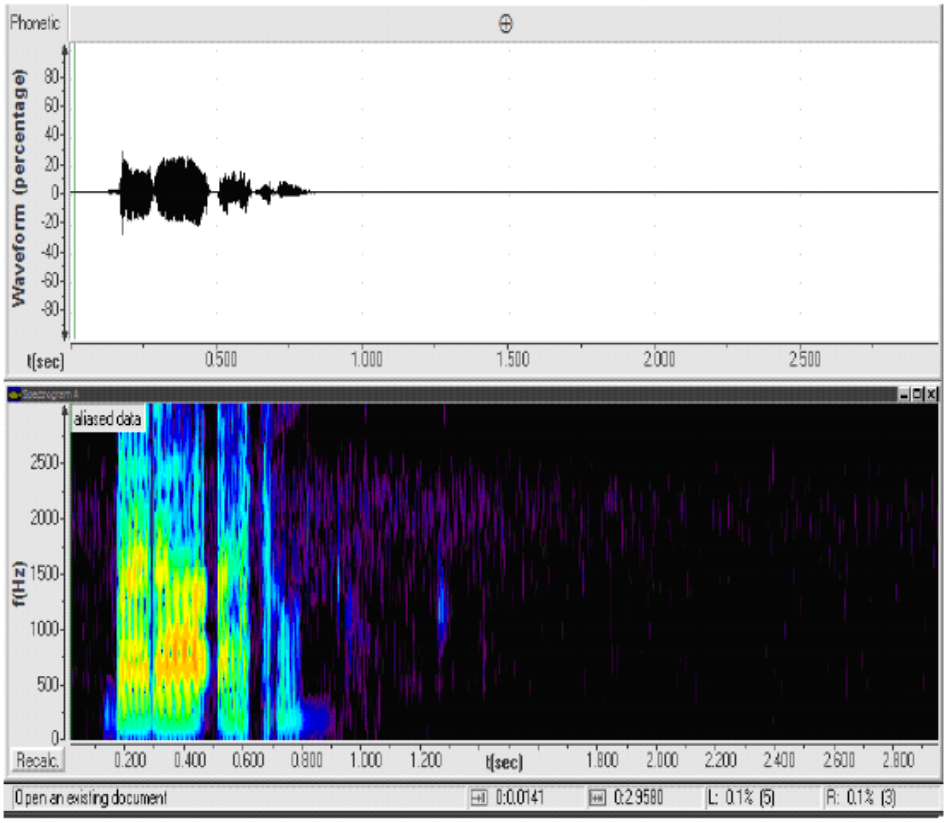


Figure1. Graphical and Spectral Representation of Sound: Frequency and Time Analysis in the Audio Sample

Audio samples of the Qur'an are recorded for various phonetic phenomena using the voice of the reciter Imam *Mahmoud Khalil Al-Husary*, according to the narration of Warsh from Nāfiʿ, with Sūrat al-Raḥmān as an applied model. These samples are then analyzed to extract the phonetic phenomena they contain.

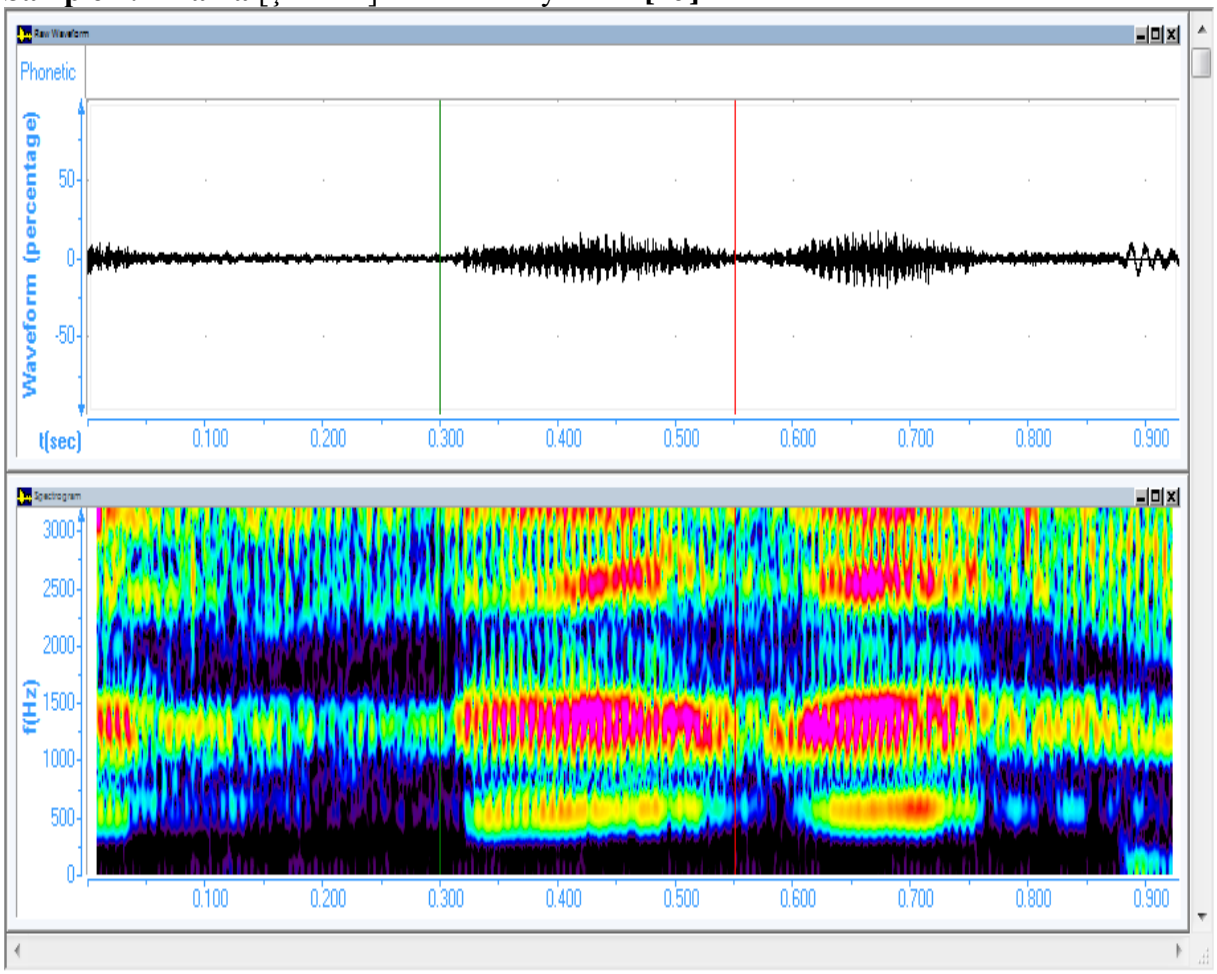
Stress (Accent): We previously discussed stress in its two types: lexical stress and sentential stress. Lexical stress is related to a sound within the word, whereas sentential stress concerns the word itself within the broader context of the sentence. Accordingly, the following table illustrates this:

Table 1. Positions and Types of Stress in Some Verses of Surah Ar-Rahman

Verse No.	Word (Stress)	Analysis
01	**Ar-Rahman**	Stress occurs on the geminated **"r"**, which consists of two letters: the first is silent and the second is vowelled. Stress also occurs on the syllable **"ma"**: the first syllable shows **gemination stress**, while the second syllable shows **vowel length stress**.
02	**ʿAllamaAl-Qur'an**	In "ʿAllama", stress falls on the geminated **"l"**, which is **gemination stress**. In "Al-Qur'an", stress falls on **"ā"**, which is **vowel length stress**.
03	**YaʿlamuAl-Kitab**	Stress falls on the first syllable of the first word, which is **word stress**, due to three successive short open syllables (CV pattern). In the second word, stress falls on **"sā"**, which is **vowel length stress**.

04	ʿ**AllamahuAl-Bayan**	In "ʿAllamahu", stress falls on the geminated **"l"**, which is **gemination stress**. In "Al-Bayan", stress occurs on **"yā"**, which is **vowel length stress**.
09	**LāRūḥHīza**	In "Lā", the stressed **"l"** represents **sentential stress**. In "Rūḥ", stress falls on **"r"**, lengthened by **wāw**, which is **word stress**. In "Hīza", stress occurs on syllables **"hī"** and **"zā"**, lengthened by vowels (**mīm** with **yā'**, **zāy** with **alif**), which is **word stress**.
13	**Fa-bi-ayyiTukadhdhibān**	In "Fa-bi-ayyi", the geminated **"y"** carries **gemination stress**, and stress also falls on **"ā"** and **"lā"**, which is **word stress**. In "Tukadhdhibān", stress falls on the geminated **"dh"** (first silent, second vowelled) and on **"bā"** (lengthened by a vowel); the first is **gemination stress**, the second is **word/vowel length stress**.

From this, it becomes clear that stress (accentuation) achieves a sense of rhythmic harmony, and it also produces a psychological effect on the listener, giving artistic justice elegance and beauty. It contributes significantly to expressing emotions and situations, as each word carries a distinctive signature intended to influence the listener's psyche and draw their attention.
Allah says: ﴿ʿAllama Al-Qur'an﴾(Verse 2 of Surah Ar-Rahman)
Sample 1:ʿ**Allama** [çallama] → stressedsyllable: **[lla]**



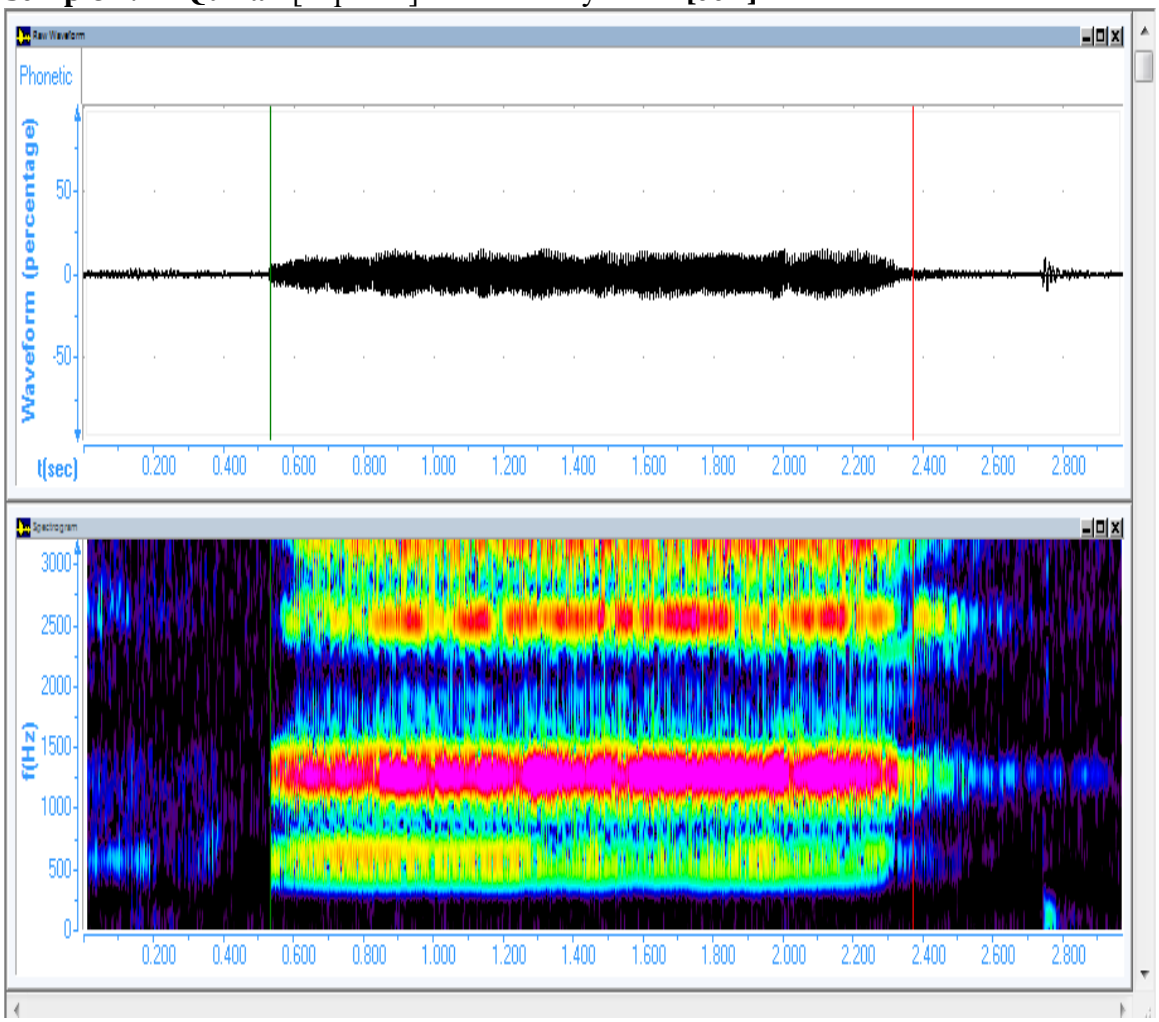
1- Graphical Representation:
From the illustrated graph, we observe that the stress falls on the "l" in ʿAllama. The stress

here is strong because the word ʿAllama carries a significant phonetic meaning. The duration of the stressed "l" syllable is approximately 0.250 seconds, and the pitch variation reaches about 210 Hz [0.250 s, 20 dB].

2- Spectral Analysis:

The spectral analysis shows a **convergence of formants**, which explains the phonetic significance of the word ʿ**Allama**.

Sample 2:Al-Qur'an [alqur'ān] → stressedsyllable: **[aàn]**



1- Graphical Representation:

We observe that the stress falls on "ā", and its type is vowel length stress. The stress is clearly audible and strong, with a duration of approximately 1900 ms, and the peak reaches about 20 dB [1900 ms, 20 dB].

2- Spectral Analysis:

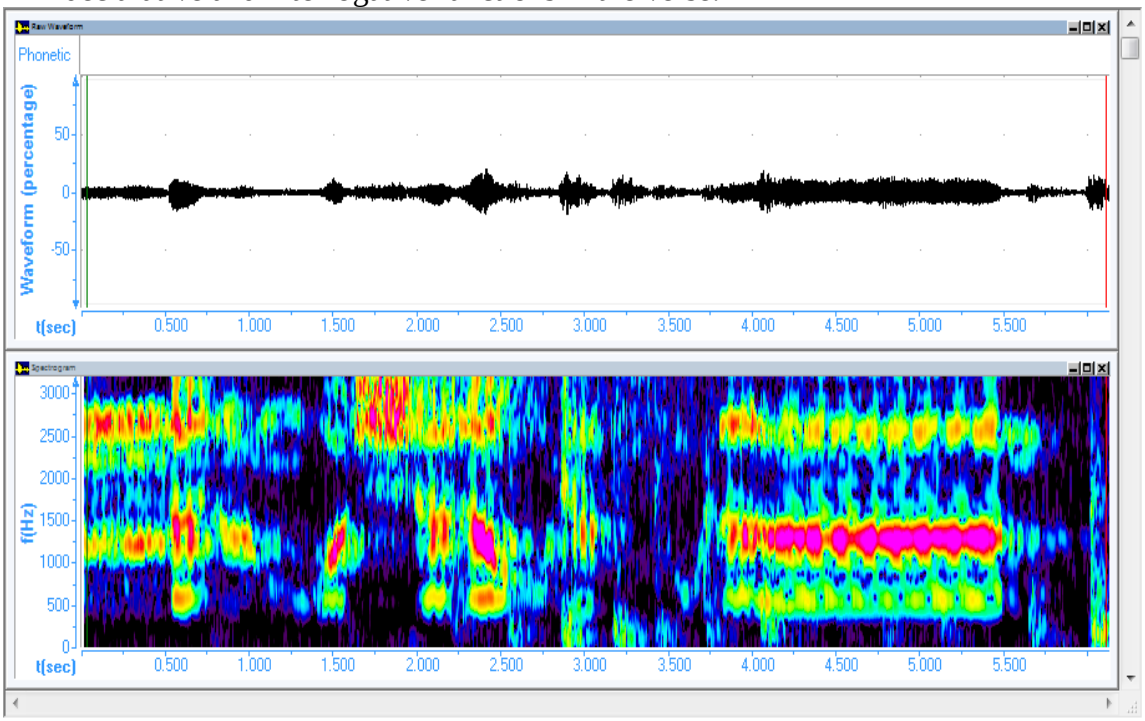
The spectral analysis shows a convergence of formants, which is due to the strong articulation of the stress on the word Al-Qur'an. This highlights the phonetic significance and importance of the word.

Intonation:

- **Bismillah Ar-Rahman Ar-Raheem**
  Allah says:)Bismillah Ar-Rahman Ar-Raheem((↑), in this verse the rising pitch peakoccurs on "Ar-Rahman", and itforms a declarative sentence.
- Allah says:)ʿAllama Al-Qur'an((→), in this verse the level pitch peakoccurs on "Al-Qur'an", whichis a declarative sentence referring back to the previousstatement, showingcontinuitywithit.

Allah says (Intonation Analysis):

- ﴾Yaʿlamu Al-Qur'an﴿(→) – In this verse, the level pitch peakoccurs on "Al-Qur'an". It is a declarative sentence referring back to the previousstatement, showingcontinuity.
- ﴾ʿAllamahu Al-Bayan﴿(↓) – Here, the falling pitch peakoccurs on "Al-Bayan", whichalso relates to the previous verse "Ar-Rahman", and the tonefallsat the final full stop.
- ﴾AmruwaNahi﴿(↓) – In this verse, the falling pitch peakoccurs on the verb, forming a command and prohibition simultaneously, with a final complete pause.
- ﴾Al-Khabar﴿(↑) – The rising intonation peakoccurs on the main noun, forming a declarativestatement.
- ﴾Al-Khabar﴿(↓) – The falling intonation peakoccurs on the main verb, forming a declarativestatement.
- ﴾Yaʿlamu Al-Qur'anwaMaḥyā﴿(↑) – The rising pitch peakoccurs on the stressedsyllable, forming a declarativestatement.
- ﴾Fa-Bi-Ayyi﴿(↓) – The fallingpeakoccurs on the emphasizedsyllable, forming an interrogative sentence for negation.
- ﴾Level Intonation﴿(→) – The levelpeakoccurs on the verb, forming a declarative sentence of affirmation.
- ﴾Rising Intonation﴿(↑) – The rising pitch peakoccurs on the stressedsyllable, forming a declarative and affirmingstatement.
- ﴾Falling Intonation﴿(↓) – The fallingpeakoccurs on the interrogative syllable, forming a sentence of negation.
- ﴾Two-Level Peaks﴿(→→) – In this verse, there are twolevelpeaks:
  - First: on the interrogative clause, forming a question.
  - Second: on a declarative clause, forming a statement.
- ﴾Falling Intonation﴿(↓) – The falling peak occurs on the main verb, forming a declarative and affirming statement.
- ﴾Al-Qur'an﴿(Verse 6) – The analysis shows pitch movements corresponding to declarative and interrogative functions in the verse.



1- Graphical Analysis:
From the audio sample of the verse, we observe that intonation occurs, with a falling pitch peak on "yasjudān", as it is a declarative sentence. This intonation lasted approximately 6100 ms, and the peak variation reached about 25 dB [6100 ms, 25 dB].
2- Spectral Analysis:
The spectral analysis shows a convergence of formants, which is due to the presence of rising, falling, and level intonations in the verse.
Pausing (Waqf):

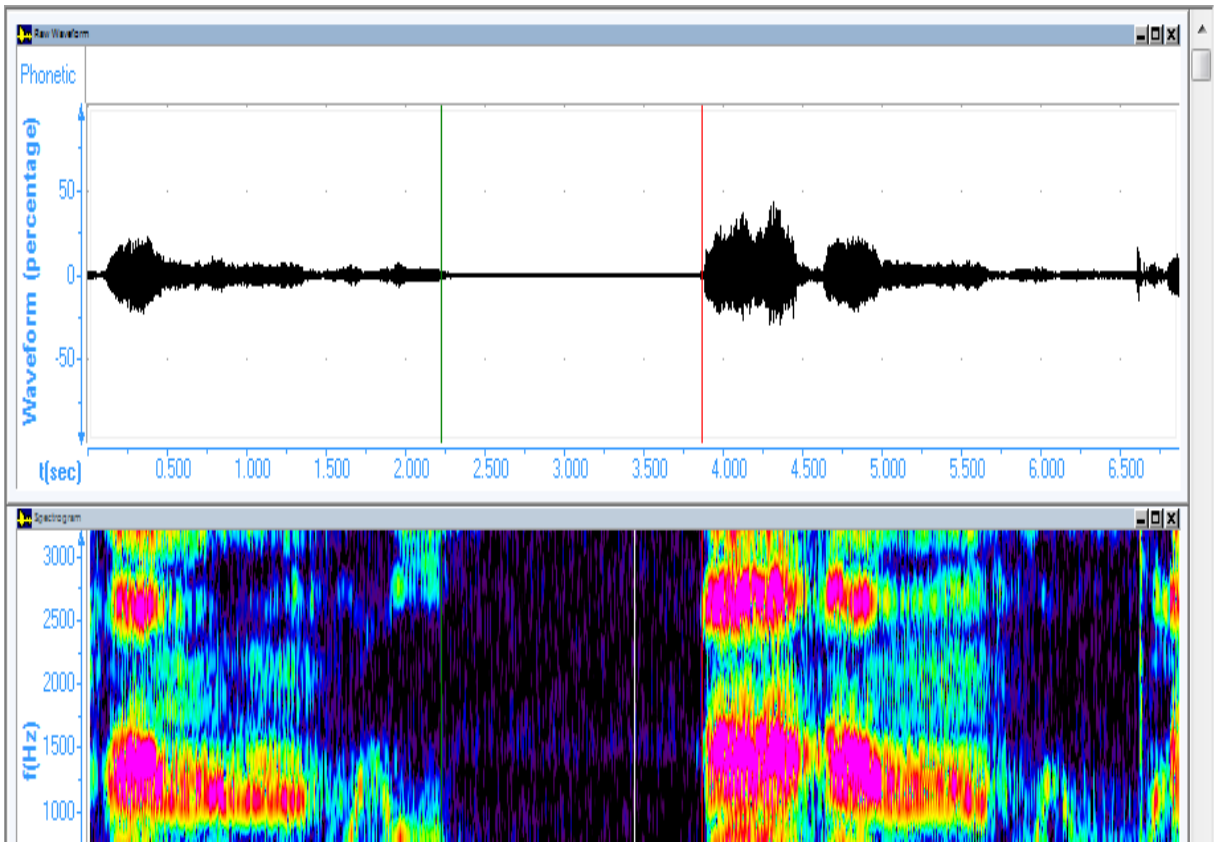
- **Pause Locations:**
  a/ Complete Pause: The most important pause positions agreed upon by Al-Ashmuni, Al-Anbari, Al-Nahhas, and Al-Dani:

 Allah, Exalted is He, says: "'Alamu al-Bayan'" (Verse 4); because the meaning and the wording are complete according to Al-Ashmuni, Al-Nahhas, and Al-Dani.
 Allah, Exalted is He, says: "'Wa al-hubbdhu al-'asfiwal-rikhan'" (Verse 12); because the meaning and wording are complete provided that "al-hubb" is pronounced with a ḍammah, and this is according to Al-Ashmuni, Al-Anbari, Al-Nahhas, and Al-Dani.
 Allah, Exalted is He, says: "'Faba'aillarabbikumatakdhiban'" (Verse 13); according to Al-Ashmuni, Al-Nahhas, and Al-Dani, as long as what precedes it is not connected to what follows.
 Allah, Exalted is He, says: "'Yumassiru al-jinni wal-insa in istata'tum an tunfidhu min aqtar al-samawatwal-ard'" … "fa la tunfidhuillabisultanin" (Verse 33); the pause here at "fa-anfithu" completes the meaning according to Al-Ashmuni, Al-Anbari, Al-Nahhas, and Al-Dani.
 Allah, Exalted is He, says: "'Yursilu 'alaykumashuwata min narinwanuhasifalatantasiran'" (Verse 35); the completion of meaning for the four imams is at "tantasiran" because both words are grammatically joined with ḍammah according to Al-Ashmuni.
 Allah, Exalted is He, says: "'Yatufufunabaynahumawabaynahameem 'an'" (Verse 44); it is complete in meaning and wording according to Al-Anbari, Al-Nahhas, and Al-Dani, while for Al-Ashmuni it is sufficient.

B/ Good Stopping (Ḥusn al-Waqf):
It is a stopping point that is preferable to pause at due to the lack of strong connection with what follows. The most important places where it is recommended to stop are as follows:

- The Almighty's saying: *"He taught him eloquence (clear expression)"* (verse 4).
  It is a good stopping point according to al-Anbari.
- The Almighty's saying: *"Do not transgress within the balance"* (verse 8).
  It is a good stopping point if it is considered the place of a new clause (i.e., *"that you do not transgress"*) according to al-Anbari.
- The Almighty's saying:
  "O company of jinn and mankind, if you are able to pass beyond the regions of the heavens and the earth, then pass. You will not pass except by authority" (verse 33).
  The stopping point here is considered good according to al-Anbari.

The verse is repeated for emphasis:
"You will not pass except by authority" (verse 33).
Note: The stopping is at the word *"pass" (fa-nfudhū)*.



Graphical and spectral analysis: There is a complete absence of both the graphical curve and the spectrum because this stop is a full stop accompanied by a break in breath. The pause occurs at the word *"pass" (anfidhū)* to complete the meaning, and this is what is known as a complete stop (waqftāmm).

Conclusion

A detailed analysis of the study's areas of investigation provides a number of significant findings, which may be briefly summarized below:

Computational linguistics aims to produce an objective scientific assessment of our natural languages, while making use of complex and cutting-edge hardware and software solutions. Natural languages include Arabic, and hence this area of research involves the transformation into a technologically advanced and digital form of all of the language elements, including grammatical, morphological, semantic, etc.

The most prominent and advancing area of computational linguistics is the area of Natural Language Processing (NLP); and NLP is providing many beneficial services to the Arabic language through the preservation of its intellectual heritage and through the creation of programs that are specifically designed to serve the needs of our present day technology.

The results of the applied study conducted on Surah Ar-Rahman show that phonetic elements of a language can be automatically detected and measured by using a variety of computational methods. Specifically, the phonetic attributes of Surah Ar-Rahman were examined to identify waqf, assess word and sentence stress, and determine the pitch contour/intonation of the musical structure of this surah. All three of these elements of Surah Ar-Rahman were measured by computational methods in order to reveal that Surah Ar-Rahman has phonetic correspondence and consonance in its rhythm.

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